
# RESULTS

TECHNOLOGY IN BIOACTIVATION

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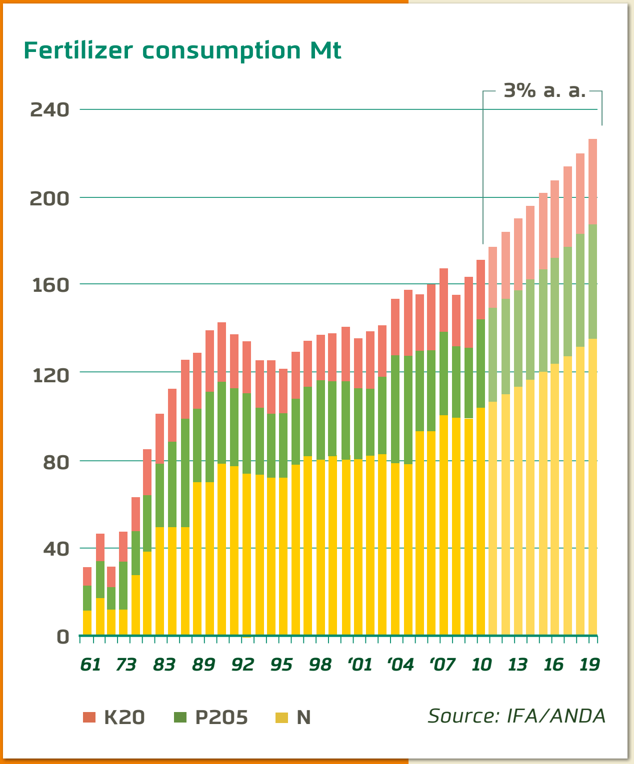
# What are we after?

We live in a constantly changing environment, which generates challenges related to social, political and environmental issues. Regulation of these issues is a basic premise for the formation of a healthy, balanced and prosperous society, capable of respecting and preserving scarce resources of our planet without endangering future generations.

Currently one of the biggest challenges of world agriculture is to develop sustainable agriculture systems that are financially viable, which can produce food, fiber and energy in sufficient quantity and quality, with a reduced impact on natural resources. In this sense, the adoption of models and technologies of alternative and innovative production that result in the optimization for the use of inputs with high economic and environmental impact may represent a viable strategy for producers who are seeking to adopt more sustainable and productive systems.

The use of technologies that increase the efficiency of the use of water, light and nutrients available to plants, constitutes a quantum leap in the pursuit of more productive, balanced and less polluting processes.

In this edition, you will find valuable information that is revolutionizing agriculture in Brazil and the world.




# What is Penergetic®?

**Penergetic®** is a natural bioactivation technology, unique in the world, developed and produced in Switzerland by the company Penergetic® International AG, which allows the copy and transfer of specific information from original substances (IC's – Information Carriers) to a substance carrier, through the process of energizing electromagnetic waves in a reduced spectrum.

These pieces of information are transferred through this energetic charge and contain specific properties, harmless to any living organism, capable of promoting increased biological activity of soil and plants, revitalizing disturbed ecological processes (an example is our present agriculture, an intensive monoculture), by treating the cause and not the consequence of such disturbances, bringing quality standards and biological balance closer to nature. This action promoted by Penergetic®, we call **BIOACTIVATION**.

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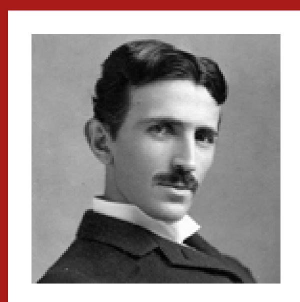
# How does **Penergetic**® technology work?

The mode of action of the Penergetic technology is based on the practical principles of biophysics and chemistry and natural science.

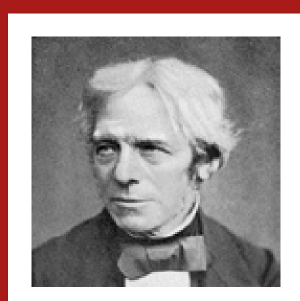


All atoms and molecules, compounds or substances have a specific electromagnetic frequency (= wave), measurable with the Tesla scale. Using electromagnetic induction under controlled conditions these frequencies can be transferred to a carrier material.

The Penergetic Technology can transfer any bio-electromagnetic frequency of solid, liquid or gaseous natural substances to carrier materials.

This process changes the state of the electrons of the carrier material and when put to use the previously transferred bio-electromagnetic frequencies are emitted to the area of application.

Scientists:
Nikola Tesla (above) &
Michael Faraday (below)



Some of the proven effects of the use of Penergetic Products in agriculture are improvements in the biological activity in the soil and absorption and utilization of plant nutrients, reduction of biotic and abiotic stress, as well as promotion of plant growth and plant protection.

In part the Penergetic Technology utilizes the theories of frequency modulation of Michael Faraday (1846) and James Clerk Maxwell (1864).

Based on the works of Faraday and Maxwell, Nikola Tesla in the mid-1900s developed the first methodology of frequency transmission without the use of wires, on which also the Penergetic Technology is based in part.

Today the following equation applies to the Penergetic Technology:

$$\sum_{i=1}^{m} W_P^{IC} = f\left(W_{Pi}^{OS}, E, H_{1,2}, \O_{1,2}, t_E, t_{H_{1,2}}, OS_{A,d}^{n}, \overline{OS^n\, IC^o}, f_{H_{1,2}}; f_{H_{1,2}}^{Profil}\right)$$

In short: **The *Penergetic*® Technology is capable of activating biochemical processes and modulating the activities of microorganisms and plants, which then in turn stimulate or activate biochemical processes in the various systems and the environment.**

# Why Penergetic®?

Several studies on the activation of soil microbiota and the photosynthetic process in plants through the use of electromagnetic energy, attest that this science is not merely theoretical, but practical and real. The current literature presents a large number of studies demonstrating the effect of utilizing electromagnetic energy on soil microbial activity, insect guidance and feeding, and crop productivity.

The use of Penergetic® technology and other bioactivation tools must not only be seen as an innovation, but as an immediate need for promoting agriculture that is unquestionably more economic, viable and environmentally friendly.

As is always said by our friends and skilled farmers, Piero and Fabio, from the Poggio di Camporbiano farm, in Tuscany, Italy: "In the struggle against nature, you always lose. It is up to each one to choose which side he will take. "

# The **Penergetic**® Technology for the Bioactivation of Agroecosystems

Antônio Teixeira

The practical realization of the need to maintain high biological activity in agricultural lands was the result of a natural maturation of the industry. Dissatisfaction with the current chemical model stimulated agronomists, technicians, researchers, businesses and producers to seek answers for the following questions, among others:

1. Why are crops increasingly vulnerable to pests and diseases, as well as climatic variability, even though there have been a vast number of technological and genetic advances?

2. Why is there an increasingly common lack of correlation between increased amounts of fertilizer and increased productivity?

3. Why do the results of soil and leaf analyses often seem to lack an explanation for what we actually see in clinical examinations of crops?

Reductionist and Cartesian approaches have been unable to meet the current demands of the agricultural sector and society as a whole. The best answers encountered for these questions so far, arise from biological studies related to a systemic understanding of the natural processes involved in agricultural production.

A multitude of serious scientific work conducted in agricultural systems around the world point in the same direction: **the dominant agricultural model dramatically reduces system life in quantity, diversity and activity. This reduction increasingly makes the system hostage to external inputs, since they reduce the natural forces working to keep it sustainable and productive.**

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On the other hand, the agro-ecological concepts serve well to demonstrate that by preserving and enhancing life and diversity of the soil-plant system, we obtain better results for all those involved because:

1. The profits of the producer improve
2. The quality of the food improves
3. The impact on the environment decreases

Therefore, the current challenge is: how do we preserve, enhance and harmonize organisms in this multi-species living system called the crop?

Currently, the sector of agricultural inputs manufacturers around the world is searching for the solutions. All of them bet on products. The products launched on the market in recent years are numerous, in order to meet this urgent need. When analyzing the modes of action and the effects produced by them, we can see different strategies, such as:

1. Providing the system with live microorganisms in hopes that they will establish and reproduce more than the existing ones;
2. Replacing mineral fertilizers with organic fertilizers or organominerals in order to provide nutrients for plants less aggressively;
3. Providing organic substances, such as acids, enzymes, amino acids, extracts algae, etc., in order to stimulate the system's life

The research, in turn, works to test different management practices to reach the same goal: increasing the system's life.
Below we highlight two of them:

1. Management combining crops, livestock and forests;
2. Those that use sequences of different crop, managing cocktail cover plants.

In this context of management that seeks to increase the life of the soil-plant system, we highlight the use of the Penergetic® technology, associated with the management of cover crops, as the most promising alternative until now.
The tropical farming systems are much more dependent on microorganisms and biomass production than the cold climate ones. The big difference between Penergetic® and other technologies is the fact that Penergetic® promotes increased life naturally and enduringly.

Penergetic® activates the biological systems, harmonizing the environment with its electromagnetic field, rather than throwing external organisms into a system unable to maintain them. After all, trying to increase life, without understanding the reasons that led to its decline, does not seem to be the best strategy.
The Penergetic® technology is therefore a coherent strategy to bioactivate soil-plant systems. The best effects have been observed when it is combined with other actions consistent with the proposed objective.

Reduce that which is destroying the system lifecycle, and increase that which is encouraging growth: this seems to be the key for better days in food production.

# What **challenges** us?

Always based on agronomic principles, but clearly understanding soil fertility far beyond its chemistry, what challenges us is the awareness that it is possible to make a more economic, sustainable, intelligent and rational agriculture.
What challenges us is understanding thoroughly that agricultural production systems we work with consist of a large natural and fragile structure, which needs balance and moderation in all production processes.

The **Penergetic®** technology brings to the market a unique opportunity to produce more at a lower cost and in a sustainable and safe manner. We invite you to take a look at some of the official results obtained from the use of this technology in its various aspects.

# Penergetic® K as Bioactivator of Microorganism Growth in vitro

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**Cléber Witt Saldanha** Forest Engineer, PhD in Physiology

## INTRODUCTION

In a state of equilibrium, the soil is inhabited by a number of microorganisms that affect its fertility (STAMFORD et al., 2005) by providing biological, physical and chemical transformations that promote agricultural sustainability (SOTTERO, 2003). Fungi of the genus Trichoderma sp. are microorganisms that occur naturally in diverse types of soil and are considered to be biostimulators of root growth and to aid in the solubilization and absorption of nutrients (HARMAN, 2000; HARMAN et al., 2004). According to Delgado et al. (2010), some of the species of this genus also are able to make nutrients from the rizosphere available thus reducing the need for fertilizer. The GL growth medium was developed to identify microorganisms capable of increasing phosphorus availability to plants through processes of phosphorus mineralization and solubilization.

## OBJECTIVE

The objective of this study was[AP1] to evaluate the effect of adding[AP2] Penergetic® K on the development of three isolates of Trichoderma sp. in GL medium containing insoluble phosphorus (inorganic phosphate precipitate).

## METHODOLOGY

Mycelial disks (9mm in diameter) of three isolates of Trichoderma sp. grown in PDA medium (Potato Dextrose Agar) during 15 days were transferred to the center of Petri dishes (90 mm diameter) with GL medium containing inorganic phosphate precipitate with or without the addition of Penergetic® K. This growth medium is used to select microorganisms that solubilize phosphorus as it is composed of an insoluble form of phosphorus, calcium hydrogen phosphate ($CaHPO_4$) (BRADLEY-SYLVESTER et al., 1982). The treatments evaluated were: GL medium containing CaHPO4 with and without addition of Penergetic® K (2.08g.L-1). Three Trichoderma isolates were tested, identified as: 04, 21 and 30. None of the isolates presented phosphorus-solubilizing capability, in agreement with previous assays. After autoclaving the GL medium, 50 mL of $K_2HPO_4$ (10%) and 100 mL of $CaCl_2$ (10%) were added, thus forming an inorganic phosphate precipitate ($CaHPO_4$). **Table 1** shows the constituents of each solution.

**Table 1.** Solutions used to prepare GL medium containing $CaHPO_4$ (BRADLEY-SYLVESTER et al., 1982).

| Solution | Reagent | Quantity (g) (Qty.) | Total volume |
|---|---|---|---|
| GL Medium | Glucose | 10 | 850 mL |
| | Yeast extract | 2 | |
| | Agar | 15 | |
| Solution 1 | $K_2HPO_4$ | 5 | 50 mL |
| Solution 2 | $CaCl_2$ | 10 | 100 mL |

After homogenization of the three solutions constituting the GL medium containing $CaHPO_4$, Penergetic® was added to the medium under completely aseptic conditions. The experimental units were distributed randomly inside the acclimatized chamber (25 +/- 2° C; 12-hr. photoperiod). After 72 and 120 hours of incubation, the dishes were analyzed for growth of fungal isolates.

## RESULTS

Relevant visual differences were observed in relation to the growth of the three fungal isolates, grown in medium with Penergetic® K, in comparison to those grown without it. **After 72 hours of incubation, the isolates n. 4 and 21 presented a visibly superior growth rate when grown in medium with Penergetic® K (Figure 1).**

With Penergetic®

Without Penergetic®

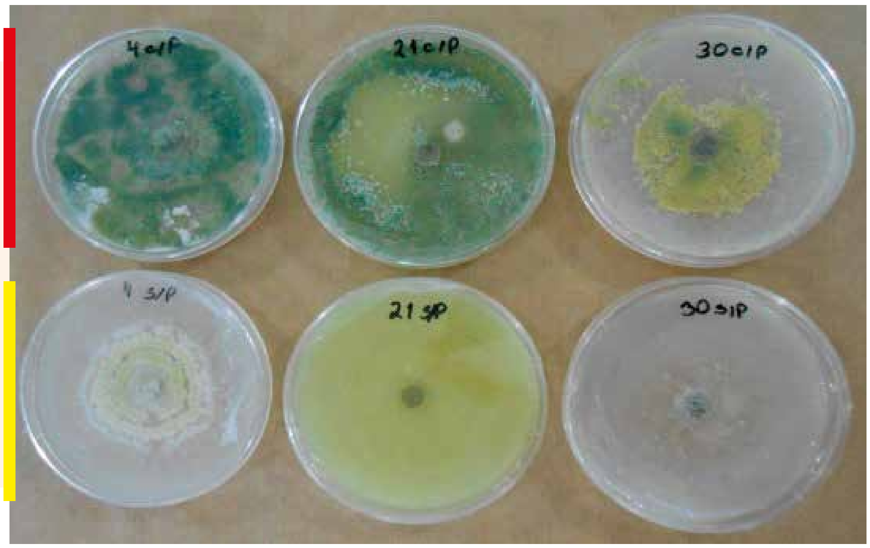
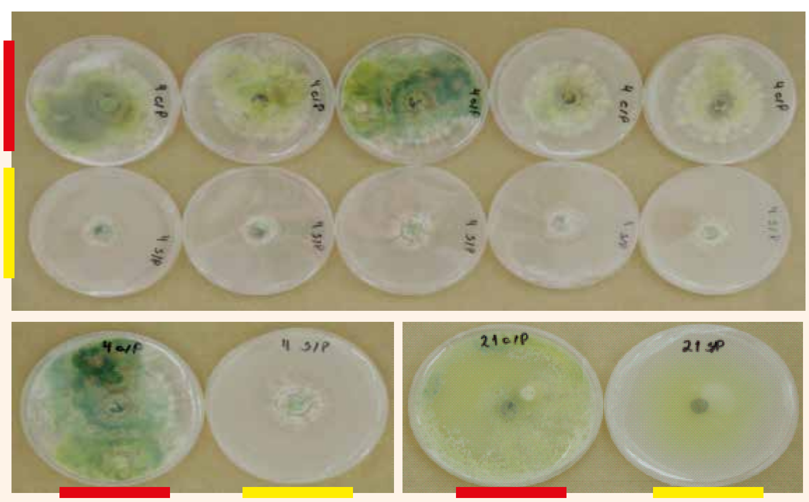


**Figure 1**. In vitro growth of fungal isolates of Trichoderma sp. (n. 4 and 21) in GL medium containing $CaHPO_4$ with and without addition of Penergetic® K after 72 hours of incubation.

After 120 hours of incubation, isolate n. 30 also presented in growth and sporulation due to the addition of Penergetic® K in the growth medium **(Figure 2).**

With Penergetic®

Without Penergetic®



With Penergetic® Without Penergetic® With Penergetic® Without Penergetic®

**Figura 2.** In vitro growth of three fungal isolates of Trichoderma sp. (n. 4, 21 and 30) in GL growth medium containing $CaHPO_4$ with and without the addition of Penergetic® K after 120 hours of incubation.

**Based on the results observed in the growth of isolates of Trichoderma sp. after 72 hours of incubation, it was found that both the growth and mycelial sporulation of isolates grown in the presence of Penergetic® K were significantly higher than that observed in isolates grown in the absence of the product (Figures 1 and 2). The increases in growth and sporulation of isolates grown in medium with Penergetic® K were maintained over time, since even after 120 hours of incubation, the isolates grown in the absence of Penergetic® K presented growth and sporulation notably inferior, probably due to the reduced supply of essential nutrients for their development, which in this case is phosphorus.**

## CONCLUSION

The addition of Penergetic® K to the GL growth medium containing calcium hydrogen phosphate increased growth and sporulation of fungal isolates of the genus Trichoderma sp. in vitro.

# Effects of Penergetic® P application on leaf chlorophyll content in soybean and tomato plants

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**Joseila Maldaner** - Biologist, PhD in Vegetal Physiology.

**Cléber Witt Saldanha** Forest Engineer, PhD in Physiology

## INTRODUCTION

Relative leaf chlorophyll content is the parameter most used to indicate the level of leaf nitrogen (N) levels in order to determine whether top dressing is needed. This method is based on the positive correlation between chlorophyll content and N content in plants (SORATTO et al, 2006;. Barbosa Filho et al, 2008, 2009). Chlorophyll content is important to the extent that it determines the photosynthetic potential of the plant by controlling the amount of solar radiation that the leaf absorbs (BLACKBURN, 2007; HATFIELD et al., 2008). One possibility for quick and non-destructive quantitative determination of chlorophyll content, based on its spectral signatures, is the use of chlorophyll meters, which are active sensors of the intensity of the color green in the leaves and operate by combining transmittance and absorbance properties of chlorophylls (SHADCHINA and Dmitrieva, 1995; Blackburn, 2007). Indirect readings taken by the portable chlorophyll meter correspond to the relative chlorophyll content in the leaf (Takebe and Yoneyama, 1989; Chapman and Barreto 1997). Chlorophyll content may be altered by various factors, such as stressful conditions, nitrogen fertilization or application of alternative bioinductors.

## OBJECTIVE

The objective was to verify whether foliar application of Penergetic® P changes chlorophyll content in the leaves of soybean and tomato plants in a greenhouse.

## METHODOLOGY

The experiment was conducted in a greenhouse utilizing soybean and tomato plants grown in plastic cups containing the commercial substrate Carolina Soil (Figure 1). Twenty-seven days after sowing, five plants of each crop received Penergetic® P solution applied to the aerial part at a dose of 1.9 g of Penergetic® P per L of water. Each plant received 2.5 mL of the solution, applied using a manual sprayer.

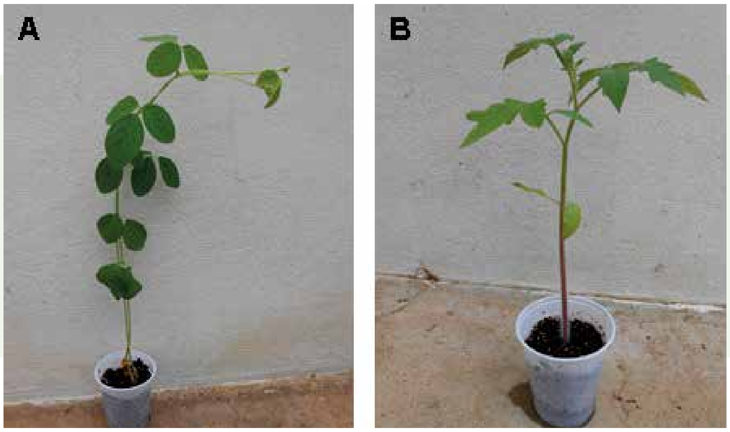



**Figure 1:** Soybean (A) and tomato plants (B) 27 days after sowing, grown in plastic cups containing the commercial substrate Carolina Soil.

Treatments were with and without Penergetic® P application and five replicates per treatment were used for each plant species (soybean and tomato). The plants were kept in a greenhouse for seven days. A daily reading of chlorophyll content was taken at the same hour with a ClorofiLOG CFL 1030 chlorophyll meter (Falker, 2008). Readings were conducted at one point of the foliar limb from the first pair of fully expanded leaves from the apical meristem, sampling one plant in each repetition.

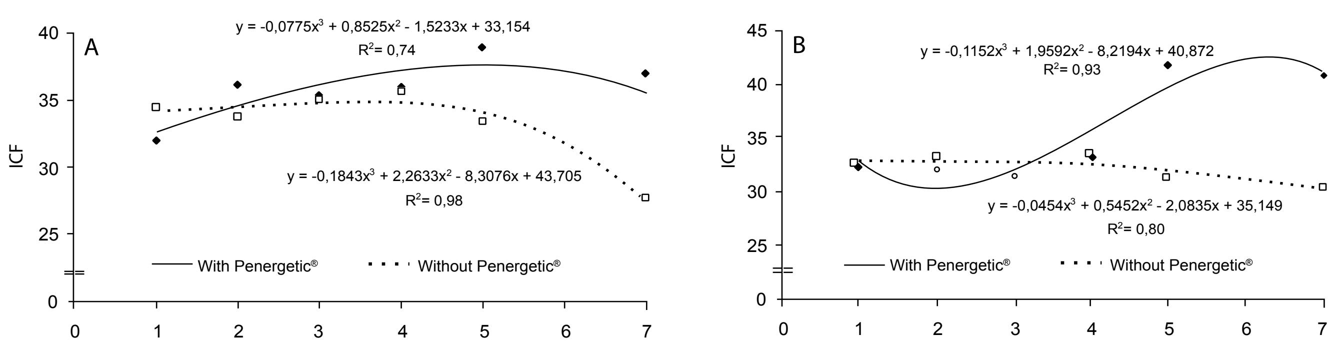
## RESULTS

Different behaviors were observed between the soybean and tomato plants that received Penergetic® P application and those that did not. For the soybean plants, two days after product application, chlorophyll content of the Penergetic® P group showed increases when compared to control plants. Following the fifth day of application, this difference became significantly higher (Table 1, Figure 2A).

**Table 1**. Means of leaf chlorophyll content determined in soybean and tomato plants with or without addition of Penergetic® P to the aerial part. Average of five repetitions. (n = 5).

| Day | Leaf Chlorophyll Content | | | |
|---|---|---|---|---|
| | Soy | | Tomato | |
| | With Penergetic® | Without Penergetic® | With Penergetic® | Without Penergetic® |
| **1** | 32,02 | 34,44 | 32,04 | 32,56 |
| **2** | 36,10 | 33,68 | 31,52 | 33,16 |
| **3** | 35,36 | 35,02 | 31,40 | 31,74 |
| **4** | 35,88 | 35,64 | 33,04 | 33,36 |
| **5** | 38,88 | 33,40 | 41,60 | 31,42 |
| **7** | 35,32 | 27,66 | 40,68 | 30,24 |

**Figure 2.** Chlorophyll Falker Index (ICF) observed in soybean (A) and tomato (B) plants after Penergetic® P application.




Between the fifth to seventh day of evaluations, a decrease in chlorophyll production occurred in the soybean plants (Figure 2A), which was probably due to the increase in temperature inside the greenhouse during the experimental period. In the tomato plants, there was a slight decrease in the chlorophyll content in the first two days after application in the plants that received Penergertic P application. However, 72 hours after application, these plants presented chlorophyll levels significantly higher than those observed in control plants. **On the seventh day after application, the increase in chlorophyll content in plants that received Penergetic® P application reached 25.88% when compared to control plants. In these plants, a temperature effect was also observed, although with reduced intensity. However, this effect was not observed in plants that received Penergetic® P (Figure 2B).** Notably, it is possible that the high temperatures recorded on the 5th to 7th day (over 37° C) caused a reduction of chlorophyll levels in both plant species. Nevertheless, it is important to highlight the difference observed between the plants that received Penergetic® P application and those that did not. The first presented a milder reduction than those that were not treated with the product. These results suggest that an important application of this product may serve as a shield for pigment systems, even though the mechanism of action still requires further study. The results presented in Figure 2 allow us to infer that the product **Penergetic® P promoted a higher photosynthetic** rate with regard to the increase in chlorophyll content

## CONCLUSION

The application of Penergetic® P (1.9 g/L-1) in the aerial part of the soybean and tomato plants promoted increases in leaf chlorophyll content.

# Effect of the Bioactivators Penergetic® P e Penergetic® K on the vegetative development of the coffee tree in cultivated and bare soil, in association with phosphate fertilizers and cattle manure.

## INTRODUCTION

The commercial product Penergetic is a soil and plant bioactivator with potential to promote increased positive effects on plant vitality, with a balance between soil/plant, by optimizing the use of added fertilizers or existing fertility in the soil. It operates by releasing fixed phosphorus unavailable to plants and promotes the rebalancing of microorganisms by providing greater energy in the photosynthetic process. Previous studies in coffee farming have been published with positive results in the reduction of the amount of inputs applied to soils of average to high fertility, indicating that Penergetic® promotes better use of already existing fertility and natural resources.

## METHODOLOGY

The study was performed from December 2013 to July 2014 (6 months) in the city of Araguari (Mato Grosso state), in the Izidoro Bronzi experimental field, belonging to the Araguari Association of Coffee Growers. Pots were arranged in a greenhouse covered with polypropylene mesh, with 50% of shade and sprinkler irrigation with 70.0 L h -1 flow (MATIELLO et al., 2010). The following treatments evaluated were:

**T1** – Virgin savanna soil (VSS/SVC);

**T2** - Virgin savanna soil with Penergetic® P and K (VSSP/SVCP);

**T3** - Virgin savanna soil with single superphosphate (VSSSS/SVCSS);

**T4** - Virgin savanna soil with single superphosphate plus Penergetic® P and K (VSSSSP/SVCSSP);

**T5** - Virgin savanna soil with phosphate from Araxá (VSSPA/SVCFA);

**T6** - Virgin savanna soil with phosphate from Araxá plus Penergetic® P and K (VSSPAP/SVCFAP);

**T7** - Virgin savanna soil with cattle manure (VSSCM/SVCEC);

**T8** - Virgin savanna soil with cattle manure plus Penergetic® P and K (VSSCMP/SVCECP);

**T9** - Virgin savanna soil with single superphosphate and cattle manure (SVCSSE);

**T10** - Virgin savanna soil with single superphosphate and cattle manure plus Penergetic® P and K (VSSSSCMP/SVCSSECP);

**T11** - Virgin savanna soil with phosphate from Araxá and cattle manure (VVSPACM/SVCFAEC);

**T12** - Virgin savanna soil with phosphate from Araxá and cattle manure plus Penergetic® P and K (VVSPACMP/SVCFAECP);

**T13** - Soil from crops cultivated for 10 years (CS/SLC);

**T14** - Soil from crops cultivated for 10 years with Penergetic® P and K (CSP/SLCP);

**T15** - Soil from crops cultivated for 10 years with cattle manure (CSCM/SLCEC);

**T16** - Soil from crops cultivated for 10 years with cattle manure plus Penergetic® P and K (CSCMP/SLCECP).

The evaluated treatments were arranged in a completely randomized fashion, with four repetitions totaling 64 experimental units. Each unit consisted of a a pot containing three plants. Twenty-liter pots (perforated plastic buckets) were filled with substrate in accordance to the treatments evaluated. In each pot, three plants of the cultivar Catuaí Vermelho IAC 144 were planted, each with three pairs of leaves and bare roots to avoid interference from the seedlings' original substrate. In all pots, 25 g of potassium chloride were applied. The top nitrogen fertilization was carried out with ammonium sulfate and urea in accordance with Procafé MAPA foundation recommendations, in effect for the region, which were followed for all other crop and phytosanitary procedures as well.

Management of water resources was in accordance with Santinato & Fernandes 2012, maintaining 80% field capacity in the pots. Penergetic K was applied via soil at a dose of 600 g / ha and Penergetic P was applied via leaf, divided into three applications at

a dose of 200 g / ha in months 1, 3 and 5. Single superphosphate and Araxá phosphate were applied at doses of 300 g pot-1 (1.5t / ha) and 500 g pot-1 (2.5 t / ha). Cattle manure was applied at a dose of 2.0 L per pot, corresponding to 5.0 t / ha.

The treatments were evaluated six months after planting for plant biometry, dry matter, nutritional parameters and soil fertility. The data were submitted to analysis of variance and, when significant, to Tukey's test, both at a significance level of $P < 0.5$. The results are shown in the Figures below.

**RESULTS**

Biometric and dry matter variables presented significant differences in the analysis of variance and Tukey's test, as can be seen in Figures 1.1 and 1.8. **All treatments that utilized Penergetic® presented higher results when compared to the control and other treatments**, regardless of the substrate used. The highest levels of biometric parameters were found in treatments 4, 8, 12, 14 and 16. Penergetic® treatments presented mean increases of 18, 17, 10, 21, 8 and 49% for plant height, canopy diameter, stem diameter, root length, branch number and leaf number, respectively. It is important to note that even with the low natural fertility of savanna soils and in the absence of any phosphate fertilization, Penergetic promoted increases in all of the biometric parameters evaluated. The results were higher in the soils that received organic and phosphate fertilization. With regard to soil fertility parameters, there was a higher content of $Al^{+3}$ and m% in the treatments with no Penergetic. This occurred because Penergetic acts in the release of $Ca^{+2}$ and $Mg^{+2}$ present in the soil, mainly in the soil fertilized with cattle manure. $Ca^{+2}$ and $Mg^{+2}$ are released gradually and form compounds with aluminum, thus neutralizing it. This also affects m% and V%, with an increased base saturation in the Penergetic® treatments. Penergetic®. **Application brought about an increase in phosphorus content and availability, as shown in Figure 2.1.** P is the main nutrient for coffee tree crop development, mainly due to its role in the formation and expansion of the root system and the increases in biometric parameters were probably due to its increased supply. The greatest difference between treatments with and without Penergetic® was found in the virgin savanna soil fertilized with Araxá phosphate, which presented approximately 28% of citrate soluble $P_2O_5$ and low efficiency in the supply of phosphorus when compared to other sources (MALAVOLTA et al., 2006). Penergetic added to Araxá phosphate potentialized its efficiency, allowing greater release of $P_2O_5$.

**CONCLUSION**

It can be concluded that Penergetic acts to release nutrients, such as Ca, Mg and P, from the soil or mineral and organic fertilizers, making greater quantities available to plants. The more efficient utilization of nutrients brought about by the use of Penergetic leads to improved growth in plants.

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## GRAPHICS BIOMETRIC PARAMETERS

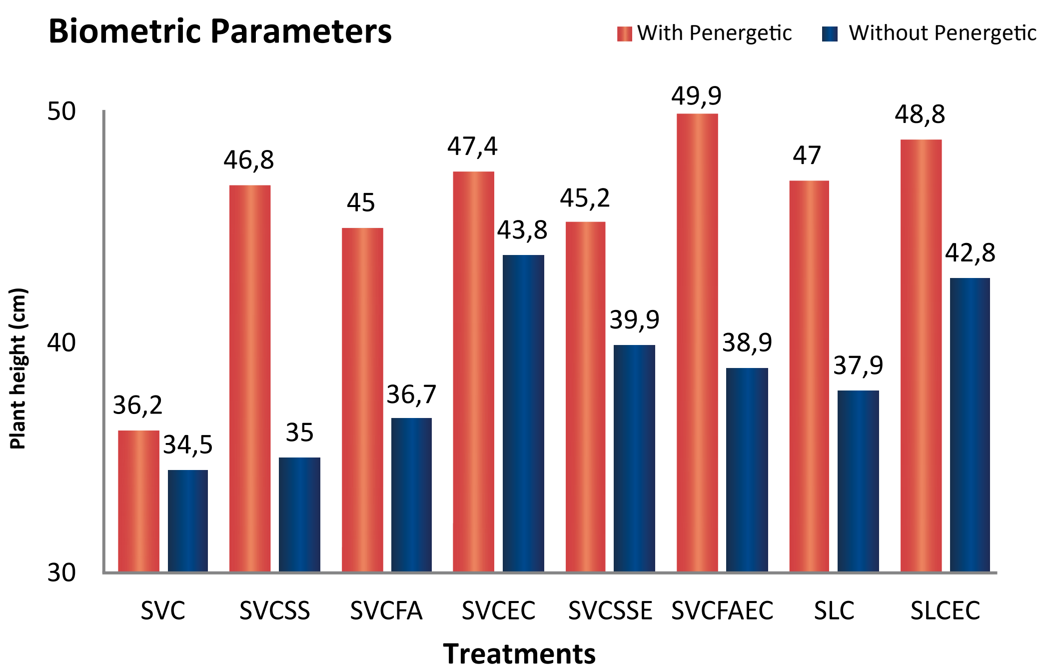


**Figure 1.1** Coffee plant height in cm, Araguari, 2014

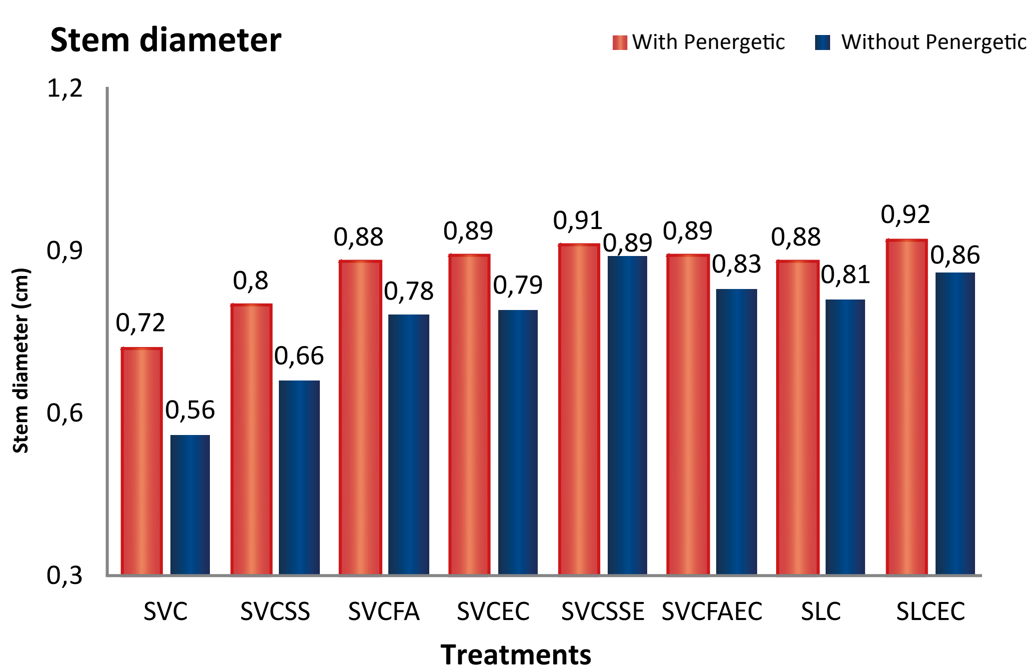


**Figure 1.2** 2 Coffee plant stem diameter in cm, Araguari, 2014

**FIGURE LEGEND**
**VSS/SVC** = T1 and T2: Virgin savanna soil
**VSSSS/SVCSS** = T3 and T4: Virgin savanna soil with single superphosphate
**VSSPA/SVCFA** = T5 and T6: Virgin savanna soil with phosphate from Araxá
**VSSCM/SVCEC** = T7 and T8: Virgin savanna soil with cattle manure
**VSSSSCM/SVCSSEC** = T9 and T10: Virgin savanna soil with single superphosphate and cattle manure
**VVSPACM/SVCFAEC** = T11 and T12: Virgin savanna soil with phosphate from Araxá and cattle manure
**CS/SLC** = T13 and T14: Soil from crops cultivated for 10 years
**CSCM/SLCEC** = T15 and T16: Soil from crops cultivated for 10 years with cattle manure

## GRAPHICS BIOMETRIC PARAMETERS

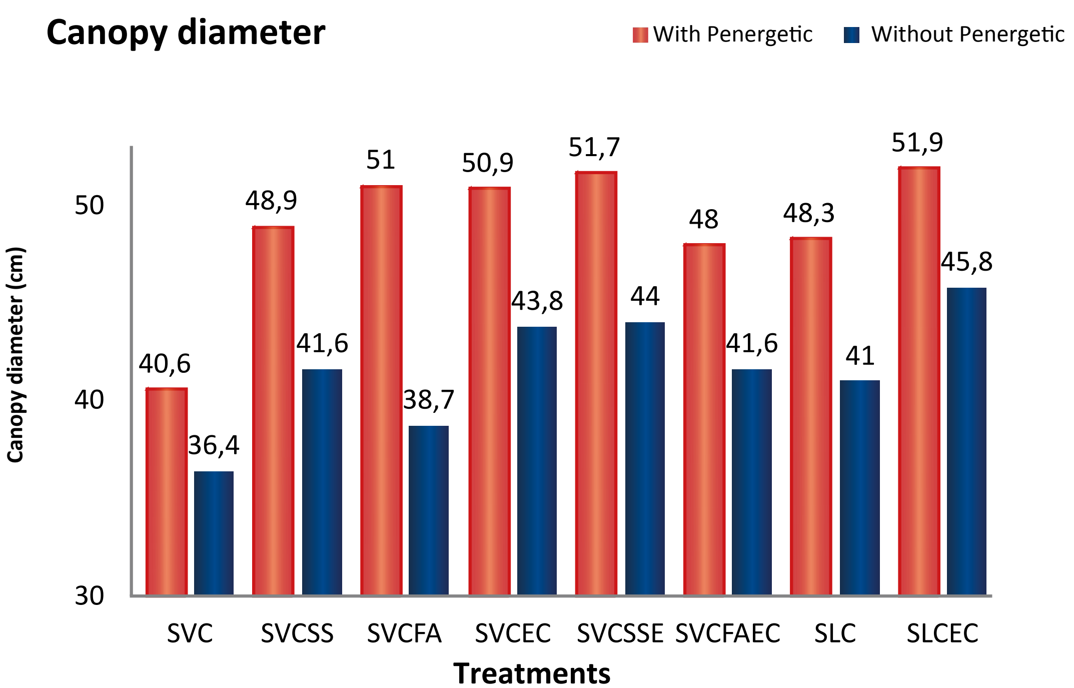


**Figure 1.3** Coffee plant canopy diameter in cm, Araguari, 2014

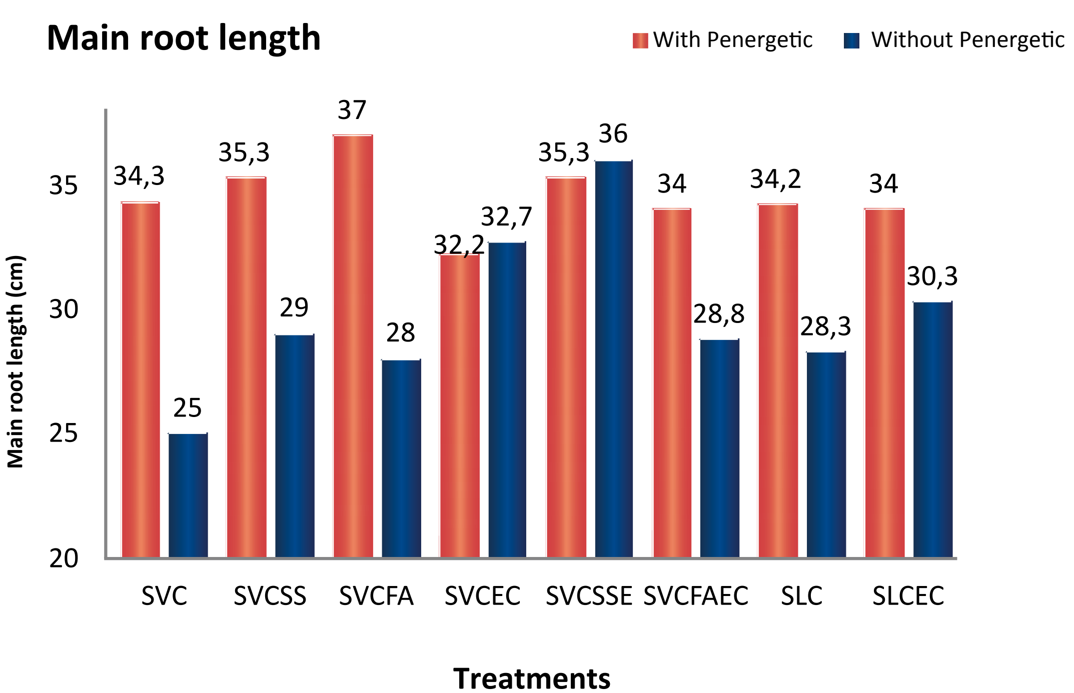


**Figure 1.4** Coffee plant main root length in cm, Araguari, 2014

## GRAPHICS BIOMETRIC PARAMETERS

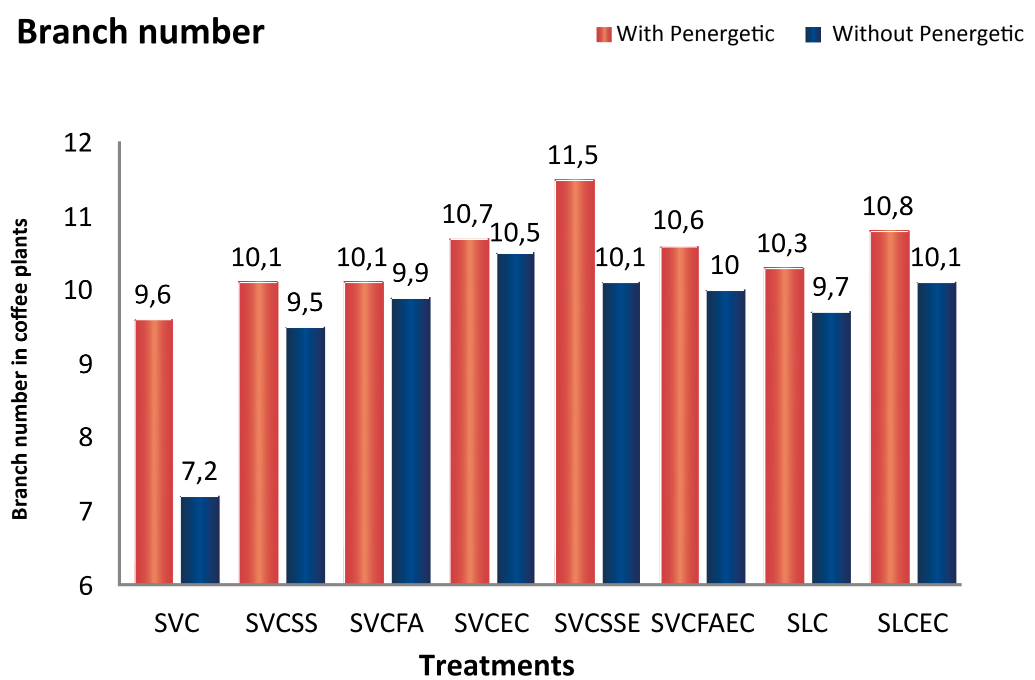


**Figure 1.5** Coffee plant branch number, Araguari, 2014

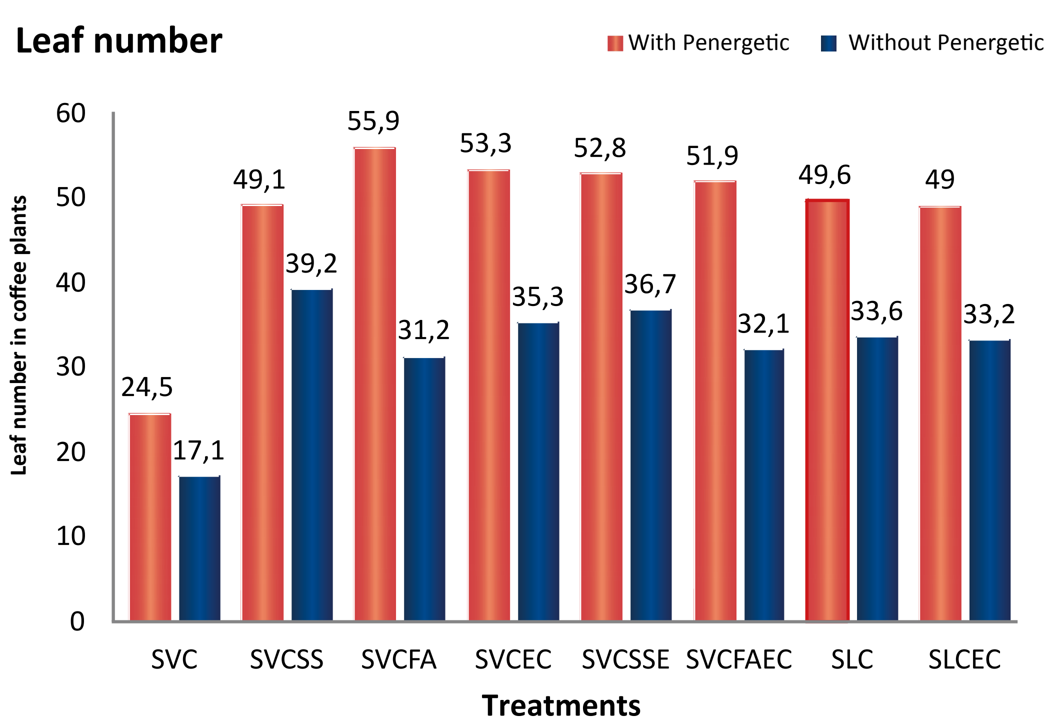


**Figure 1.6** Coffee plant leaf number, Araguari, 2014

## GRAPHICS BIOMETRIC PARAMETERS

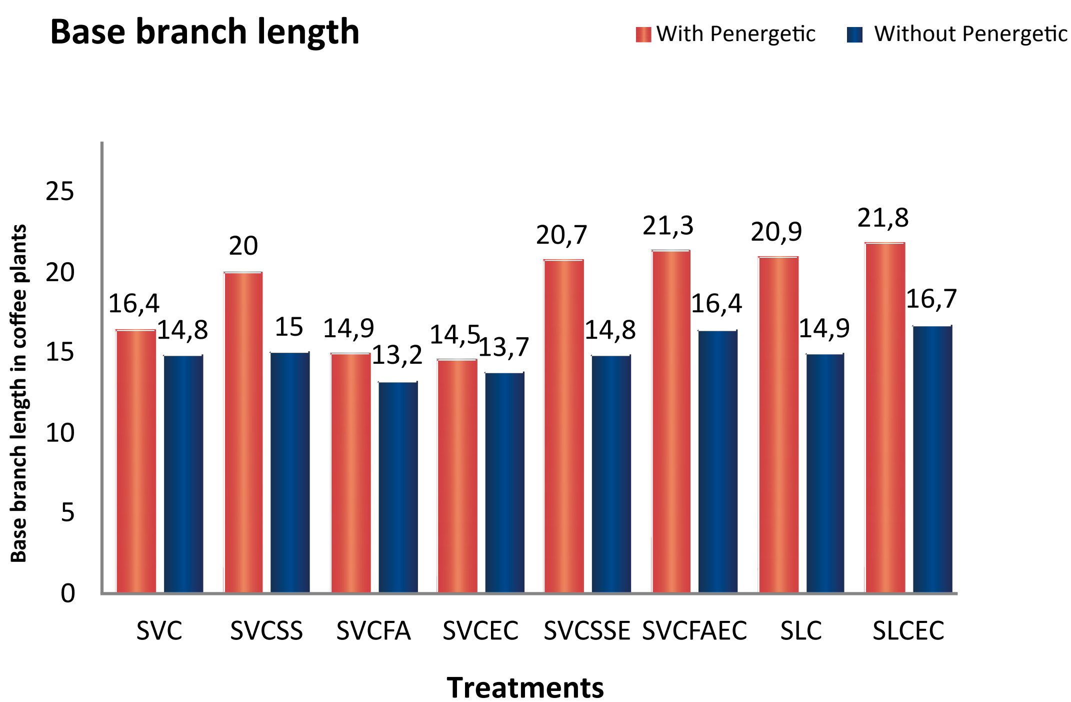


**Figure 1.7** Coffee plant base branch length, Araguari, 2014

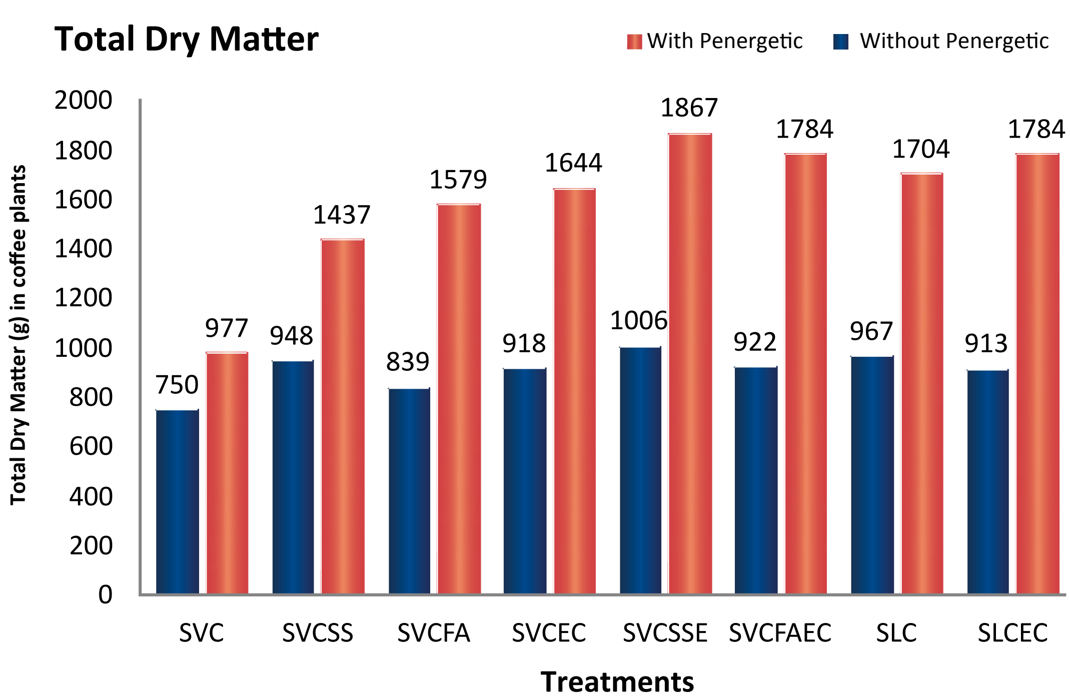


**Figure 1.8** Coffee plant Total Dry Matter in grams, Araguari, 2014

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## SOIL FERTILITY PARAMETERS

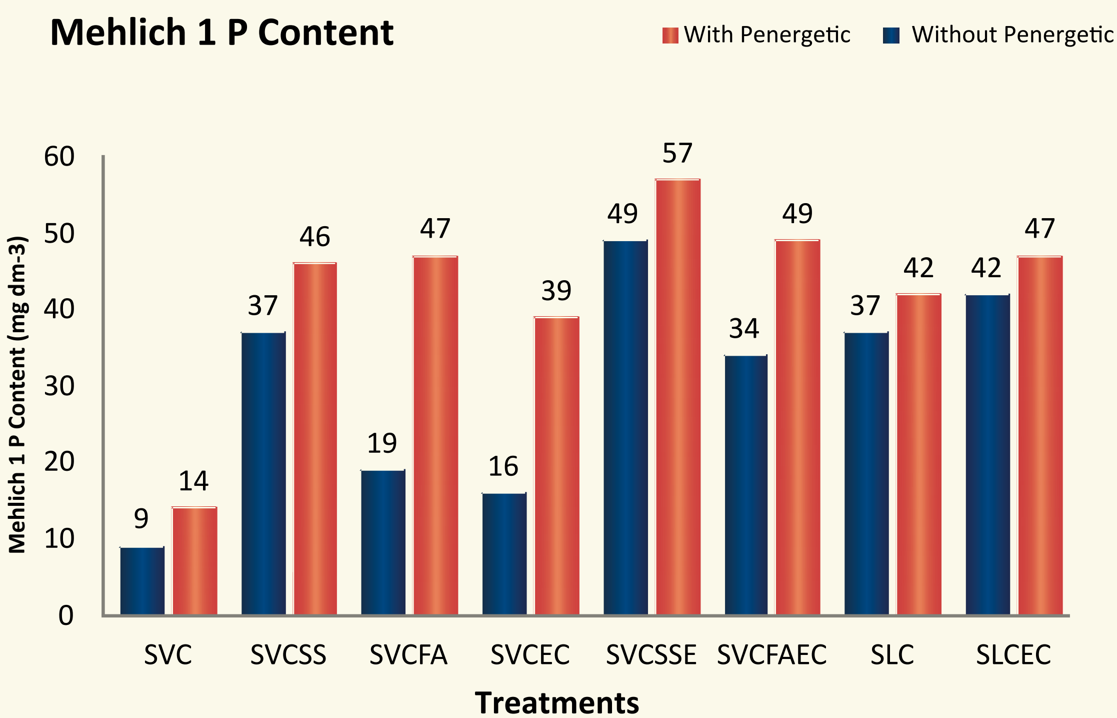


**Figure 2.1** Mehlich 1 P Content (mg dm-3) in the Soil, Araguari, 2014

**FIGURE LEGEND**
**VSS/SVC** = T1 and T2: Virgin savanna soil
**VSSSS/SVCSS** = T3 and T4: Virgin savanna soil with single superphosphate
**VSSPA/SVCFA** = T5 and T6: Virgin savanna soil with phosphate from Araxá
**VSSCM/SVCEC** = T7 and T8: Virgin savanna soil with cattle manure
**VSSSSCM/SVCSSEC** = T9 and T10: Virgin savanna soil with single superphosphate and cattle manure
**VVSPACM/SVCFAEC** = T11 and T12: Virgin savanna soil with phosphate from Araxá and cattle manure
**CS/SLC** = T13 and T14: Soil from crops cultivated for 10 years
**CSCM/SLCEC** = T15 and T16: Soil from crops cultivated for 10 years with cattle manure

# Assessing the viability of using Penergetic® to increase availability of Potassium and Phosphorus in Savanna Soils

**André Luís Teixeira Fernandes** - Agricultural Engineer, PhD in Water and Soil Engineering.
**Roberto Santinato** - Agricultural Engineer, MAPA Procafé Researcher.
**R. O. Silva** Manager of the Experimental Field Izidoro Bronzi, Araguari, MG.
**Antônio Nascimento Teixeira** Master's in Soil Science, Agricultural Consultant

## INTRODUCTION

Communities of micro- and macroscopic organisms that inhabit the soil carry out activities essential to the survival of animal and vegetal communities. In the soil, the main activity of these organisms are: mineralization of organic material; humus production, energy and nutrient cycling; fixation of atmospheric nitrogen; production of complex compounds that cause soil aggregation; decomposition of xenobiotics and biological control of pests and diseases, providing the ideal conditions for a high biodiversity.

In coffee crops, Penergetic technology has been used to promote the balance and intensification of microbiological activities in the soil, in order to improve the supply of potassium and phosphorus, and in particular their percentage in non-labile forms in the soil.

## OBJECTIVES

This study aimed to: **1)** evaluate the effect of **Penergetic® K (soil) and Penergetic® P (plant)** application on the soil biological balance, mineral nutrition, growth, productivity and quality of the coffee tree grown under irrigation in savanna soil; and 2) evaluate whether it is possible to reduce P and K fertilization in coffee crops through utilization of Penergetic technology.

## METODOLOGY

The experiment is being performed at the Izidoro Bronzi Experimental Campus, with a partnership between the Universidade de Uberaba, Association of Coffee Farmers of Araguari (Associação dos Cafeicultores de Araguari—ACA) and Procafé Foundation. The 3.7 x 0.7 m coffee crop is of the cultivar Catuaí Vermelho IAC 15, 7 years of age, located at the Chaparral Farm by the Highway Rodovia Café, Km 09, in the town of Araguari (MG). The drip irrigation system with pressure-compensating emitters has an outflow of 2.3 liters/hour, 3.7 m spacing between rows and .7 m between sprinklers. Five treatments were applied as shown in Table 1.

Fertilization applications were performed in October, November, January, February and March (2 applications per month). **Penergetic® K** was applied in October and for **Penergetic® P** - 3 applications were performed along with pesticide spraying. The crop, phytosanitary and nutritional management were carried out as recommended by Santinato, Fernandes (2012).

penergetic® | ACA Associação dos Cafeicultores de Araguari | UNIUBE Educação e Responsabilidade Social | Fundação Procafé

**Table 1**. Description of treatments at Izidoro Bronzi Experimental Field

| TREATMENT | DESCRIPTION |
|---|---|
| T1 | Standard Control (conventional drip, no PK fertilizations, standard nitrogen fertilization) |
| T2 | Standard top-dressing via fertirrigation (100% recommended NPK) |
| T3 | Standard top-dressing via fertirrigation (100% recommended NPK)+ Penergetic® K and P. |
| T4 | Standard top-dressing via fertirrigation (75% recommended NPK) + Penergetic® K and P. |
| T5 | Standard top-dressing via fertirrigation (50% recommended NPK) + Penergetic® K and P. |

| TREATMENT | TREATMENT/PRODUCTIVITY (SACS/HA) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2009 2010 | 2010 2011 | 2011 2012 | 2012 2013 | 2013 2014 | AVERAGE | PR % |
| T 1 | 44,7 | 49,3 | 43,2 | 32,7 | 23,6 | 38,7 | 100% |
| T 2 | 38,6 | 50,1 | 47,1 | 38,2 | 42,8 | 43,4 | + 12 |
| T 3 | 48,4 | 57,1 | 33,2 | 54,6 | 50,7 | 48,8 | + 26 |
| T 4 | 52,5 | 49,8 | 55,1 | 48,7 | 50,1 | 51,3 | + 32 |
| T 5 | 40,7 | 75,6 | 41,9 | 54,4 | 53,5 | 53,2 | + 37 |

**Table 2**. Harvest of different treatments, in additional sacs per hectare, five harvests, Izidoro Bronzi Experimental Field, Araguari/MG

| Number of Nematodes | | Treatments | | | | |
|---|---|---|---|---|---|---|
| | | T 1 | T 2 | T 3 | T 4 | T 5 |
| ***Meloidogine* sp.** | Soil | 112 | 276 | 256 | 172 | 188 |
| | Root | 860 | 884 | 326 | 160 | 72 |
| ***Pratylenchus* sp.** | Soil | - | - | - | - | - |
| | Root | - | - | - | 04 | - |
| ***Rotylenchulus reniformis*** | Soil | - | 04 | - | - | 04 |
| | Root | - | - | - | - | - |

**Table 3.** Nematode count in soil and coffee plant roots. Laboratory of Nematology - EPAMIG - Analysis 81/2013

## CONCLUSION

It can be concluded that after 5 harvests, the utilization of Penergetic technology is viable for coffee tree nutrition, as it allows a reduction of fertilizer needed and an increase in productivity. The mean increase in productivity over the five harvests, when compared to standard nutritional management, was 10 additional sacs/ha/year, with a 50% reduction in the quantity of NPK recommended. With regard to biological markers, when compared to the control group and standard fertirrigation group, the Penergetic treatments promoted increases of 16 and 36 % in microbial biomass, greater colonization of mycorrhiza in coffee roots, with values of 10.6 and 22%, and greater number of mycorrhizal spores, with 10 and 19/50 mL in the soil, as well as lower incidence of nematodes in coffee plant roots.

**NEMATOLOGICAL ANALYSIS – CAFÉ/ACA –ARAGUARI-MG/2013**

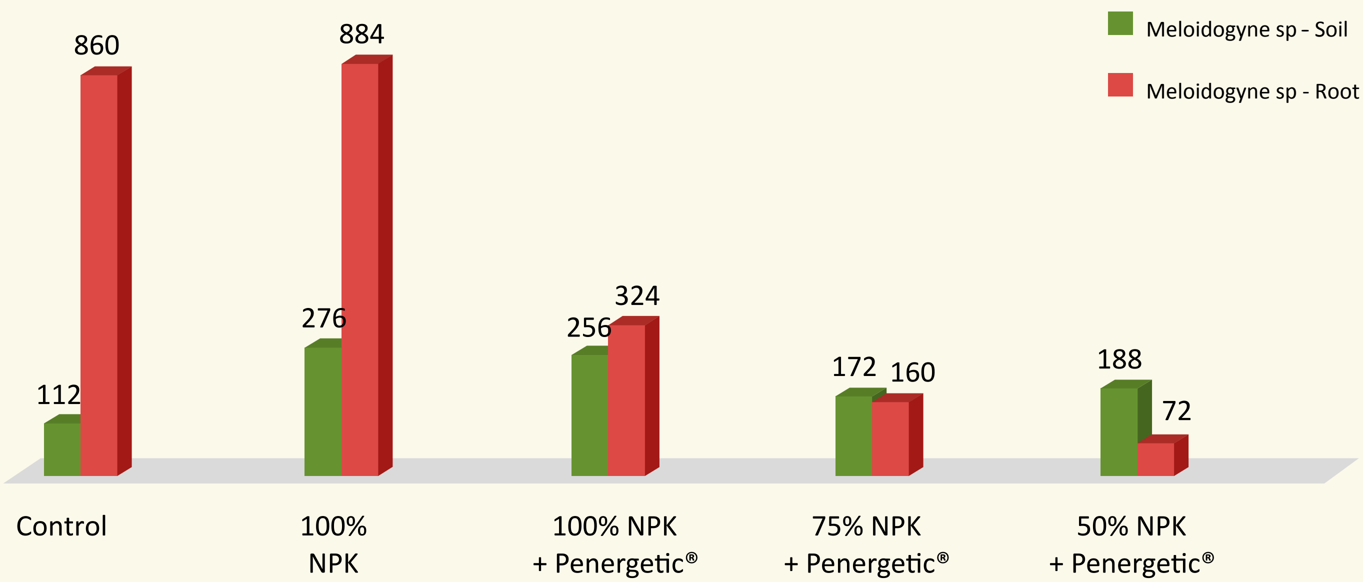


**Figure 1** – Nematode count in soil and root of coffee trees

**PRODUCTIVITY (SACS/HA)**

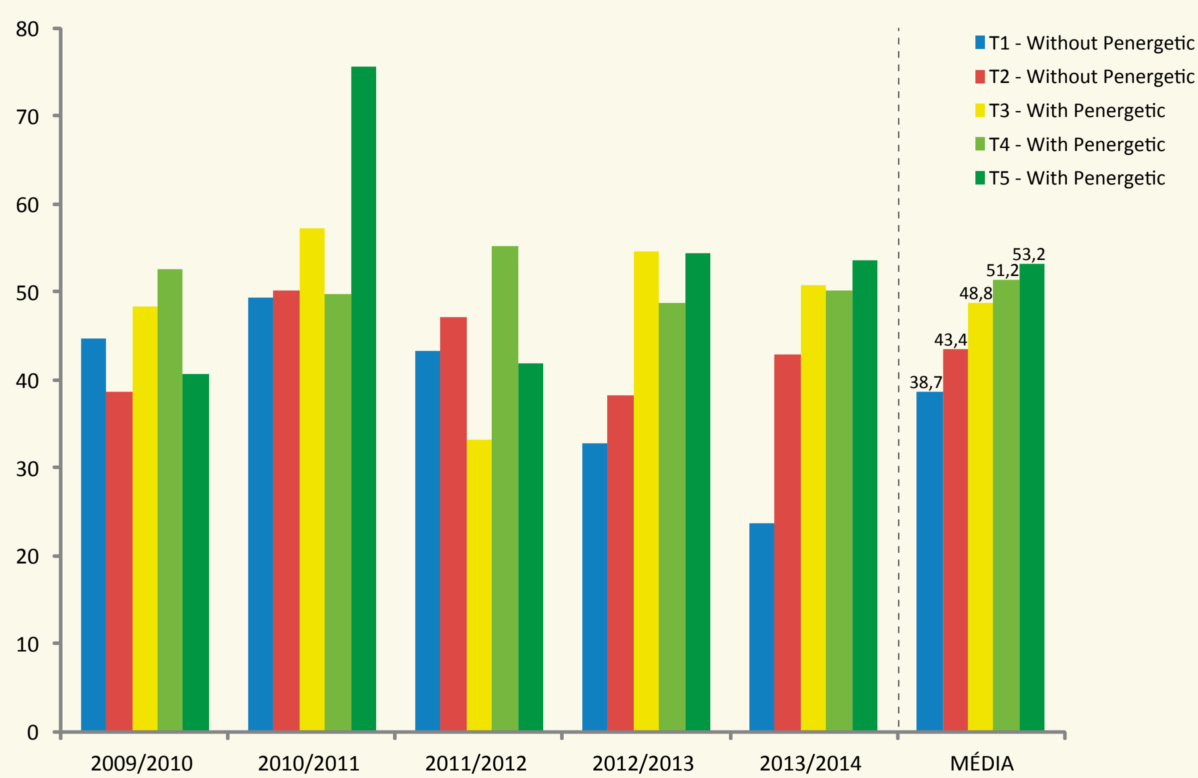


**Figure 2.** Productivity (sacs/ha), five harvests of coffee trees

# Effect of Penergetic® P and Penergetic® K in the stimulation of mycorrhization in soybean roots

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**Rodrigo Josemar Seminoti Jacques** PhD Soil Science, Professor Department of Soil Sciences/ UFSM.
**Edicarla Trentin -** Agricultural Engineer, Master's Student in Soil Sciences / UFSM.
**Gerusa Pauli Kist Steffen -** Agricultural Engineer, PhD in Soil Science, Researcher for Fepagro Florestas, Santa Maria/ RS.

Among the biological relationships established in the soil ecosystem, symbiosis between plants and heterotrophic microorganisms, leading to the establishment of mycorrhiza, is important due to the benefits it provides to the vegetal product. Mycorrhiza are considered to be the greatest ecological and economic expression of symbiosis between soil fungi and superior plant roots, whereby a mutualistic relationship between the plant root and the fungus provides the plant with a greater area for absorption of water and nutrients, such as phosphorus, nitrogen and potassium, and some non-fungistatic micronutrients due to the extension of its hyphae in the soil. The objective of this work was to evaluate the effect of Penergetic P and K on the mycorrhization rate of soybean plants under greenhouse conditions. Five-L pots were filled with 4 kg of soil, with the following treatments: **1)** control; **2)** control with Penergetic application; **3)** $P_2O_5$ and $K_2O$ applied at half the recommend dose; **4)** $P_2O_5$ and $K_2O$ at half the recommend dose, plus Penergetic; **5)** $P_2O_5$ and $K_2O$ at the recommended dose; **6)** $P_2O_5$ and $K_2O$ at the recommended dose, plus Penergetic. Penergetic K was applied to the soil seven days before the soybean was sown and Penergetic P was applied to the leaf at $V_3$ and $R_1$ phases. During crop blooming, mycorrhiza were identified and counted in the soil of each treatment, using the wet sieving and decanting method (GERDEMANN and NICHOLSON, 1963) and centrifugation in sucrose (JENKINS, 1964). The spores obtained were arranged on slides for microscopic identification of species based on morphological features (INVAM, 2001). During the grain filling phase, the percentage of mycorrhizal colonization was assessed, using the methodology proposed by Koske and Gemma (1989) for root whitening and evaluated using the intersect method proposed by Giovanetti and Mosse (1980). Greater numbers of spores and diversity of genera were observed in the treatments with Penergetic application, except in the treatment that utilized the recommended dose of $P_2O_5$ and $K_2O$, where the $P_2O_5$ content may have led to a reduction in the presence of spores in the soil. With regard to mycorrhization, Penergetic promoted increases of 29.41%, 27.86% and 7.84% in root colonization, when compared to control treatments, half of the dose and recommended dose of $P_2O_5$ and $K_2O$, respectively. The results allow us to conclude that Penergetic technology promoted increases in the number of mycorrhizal spores in the soil and in the percentage of root mycorrhization in soybean roots.

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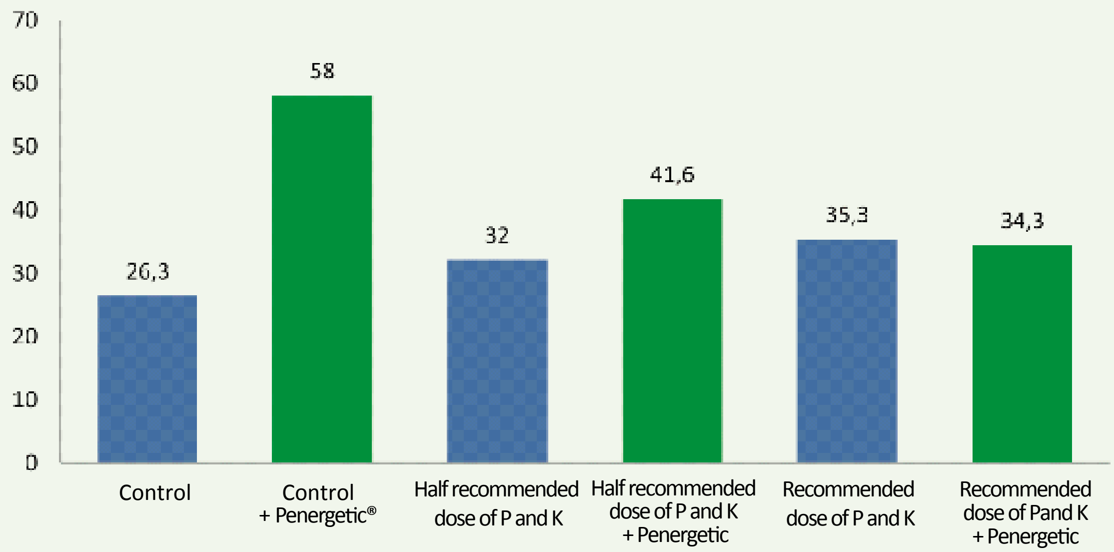
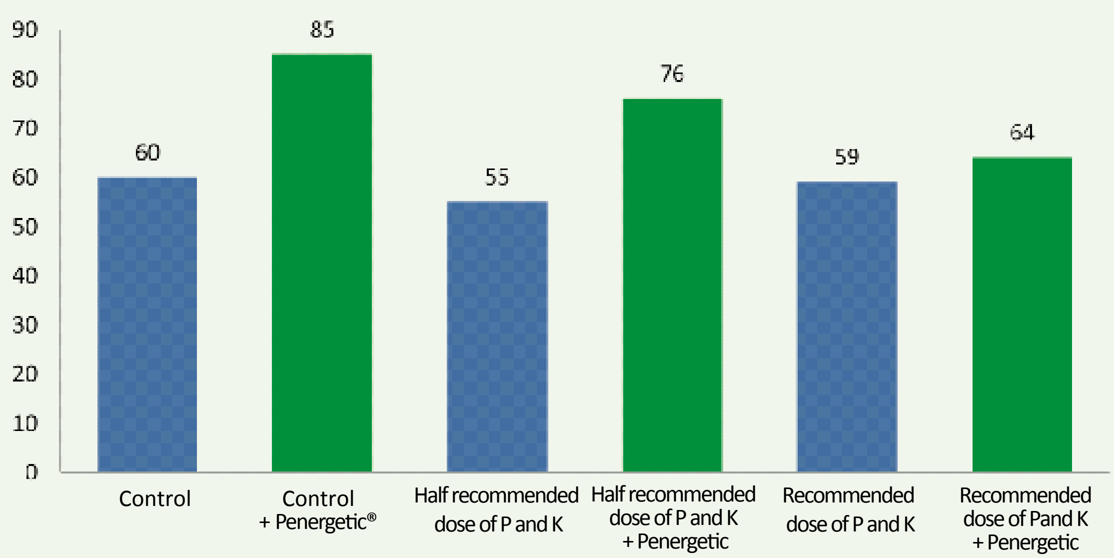
# Number of mycorrhizal spores in the soil and root mycorrhization in cultivar Fepagro 36RR soybean plants undergoing different treatments

Nº. of mycorrhizal spores per 100 grams of soil




Results at the **soybean blooming stage** - (CV 21.6%)

Nº. of mycorrhizal spores per 100 grams of soil




Results in **soybean grain filling** - (CV 18.66 %)

# Effect of Penergetic® P and Penergetic® K in the suppression of damage caused by nematodes in soybean crops

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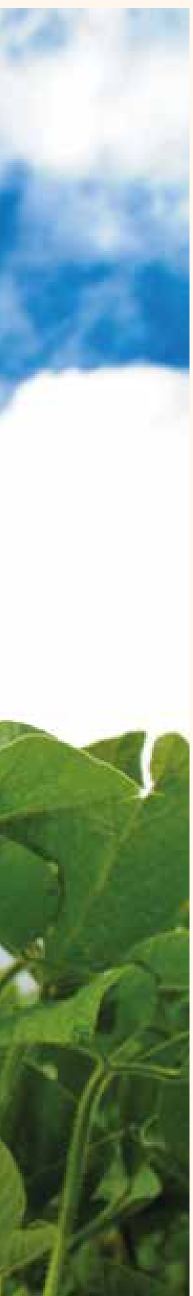
**Gerusa Pauli Kist Steffen** - Agricultural Engineer, PhD in Soil Science, Researcher for Fepagro Florestas, Santa Maria/ RS.
**Zaida Inês Antoniolli** - PhD in Mycorrhizal Molecular Aspects, Professor Department of Soil Sciences / UFSM.
**Rodrigo Josemar Seminoti Jacques** - PhD Soil Science, Professor Department of Soil Sciences/ UFSM.
**Edicarla Trentin** - Agricultural Engineer, Master's Student in Soil Sciences / UFSM.
**Juliane Schmitt** - Biologist, Master's student in Soil Sciences/UFSM.
**Andressa de Oliveira Silveira** - Post-doctorate in Soil Sciences, Department of Sanitary and Environmental Engineering/ UFSM

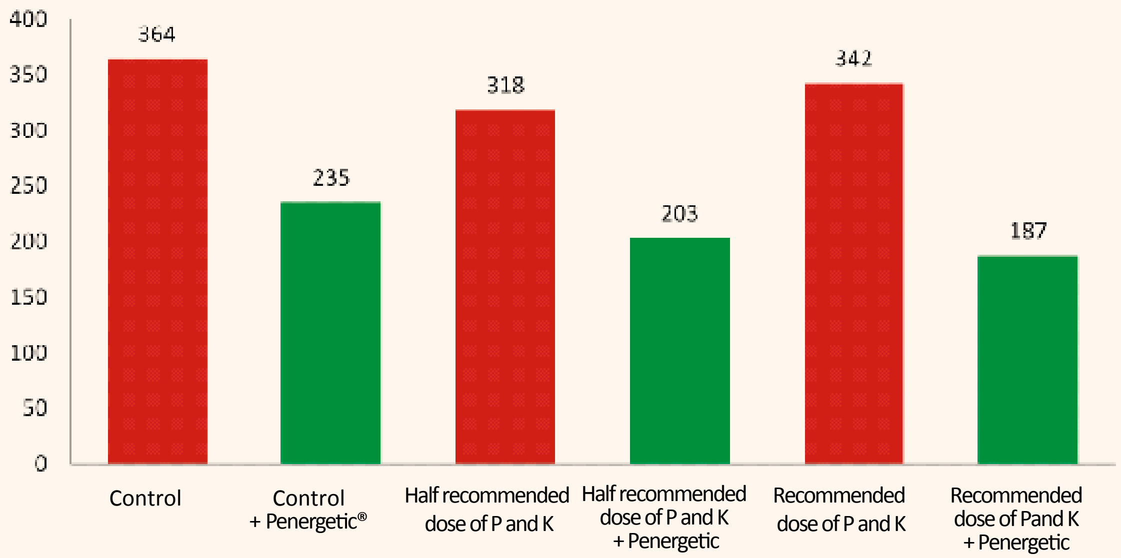
Their wide geographic distribution, easy dissemination and interaction with other phytopathogenic organisms place nematodes among the main pathogens responsible for crop damage. **Currently, the nematode species Pratylenchus brachyurus (Godfrey), which causes root lesions, is one of the main threats to soybean productivity in the Southeast and Central West regions of Brazil**. Because of the complexity involved in its control, management practices for phytonematodes should include stimulation of soil microbiota to promote competition between organisms in the rhizosphere.

Penergetic® P and K, composed of energized bentonite clay, aims to activate soil microbiota, optimizing interactions between edaphic organisms. This work aimed to evaluate the effects of Penergetic P and K application on soybean damage caused by P. brachyurus. In a greenhouse, 5-L plastic pots were sown with soybean cultivar Fepagro 36RR, inoculated with 1750 P. brachyurus eggs and juveniles. Nine treatments were evaluated: **1)** control without nematode inoculation; **2)** control with nematode inoculation but without Penergetic application; **3)** control with nematode inoculation and Penergetic application; **4)** recommended dose of $P_2O_5$ and $K_2O$ without nematode inoculation; **5)** recommended dose of $P_2O5$ and $K_2O$ with nematode inoculation but without Penergetic application; 6) recommended dose of $P_2O_5$ and $K_2O$ with nematode inoculation and with Penergetic® application; **7)** half the recommended dose of $P_2O_5$ and $K_2O$ without nematode inoculation; **8)** half the recommended dose of $P_2O_5$ and $K_2O$ with nematode inoculation but without Penergetic application; **9)** half the recommended dose of $P_2O_5$ and $K_2O$ with nematode inoculation and with Penergetic application. Penergetic K was applied to the soil 7 days before soybean sowing and Penergetic P was applied to the leaf at V3 and R1 phases. During the **crop cycle, the use of Penergetic reduced the typical symptoms of damage caused by P. brachyurus in soybean**. At the end of the crop cycle, the presence of phytonematode in the control treatment resulted in a 13% reduction in the number of beans and a 15% reduction in the grain weight per plant, regardless of Penergetic application. In the fertilization treatments (recommended dose or half dose), the utilization of Penergetic reduced the damage caused P. Brachyurus, demonstrating its efficiency as a tool in the management of phytonematodes in soybean crops.

# Number of phytonematodes penetrated into soybean plant roots, cultivar Fegagro 36RR, under different treatments

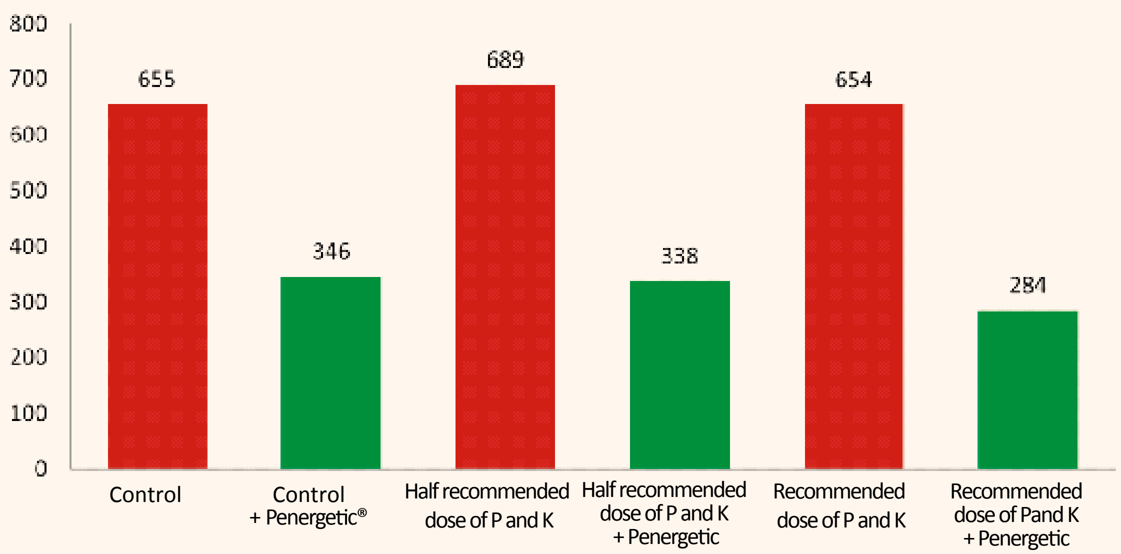


Number of phytonematodes per gram of root




Results for **soybean blooming** with inoculation of **Pratylenchus brachyurus**

Number of phytonematodes per gram of root




Results for **soybean grain-fill** with inoculation of **Pratylenchus brachyurus**

# Bioactivation effect of Penergetic® on microbial activity and soil quality

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**Zaida Inês Antoniolli** PhD in Mycorrhizal Molecular Aspects, Professor Department of Soil Sciences / UFSM.
**Rodrigo Josemar Seminoti Jacques** PhD Soil Science, Professor Department of Soil Sciences/ UFSM.
**Ricardo Bemfica Steffen** Agricultural Engineer, PhD in Soil Science, Post-doctorate in Soil Science/ UFSM.
**Gerusa Pauli Kist Steffen** - Agricultural Engineer, PhD in Soil Science, Researcher for Fepagro Florestas, Santa Maria/ RS.
**Antônio Carlos Bassaco** Master's student in Agrobiology, Technician at the Laboratory of Soil Biology/UFSM.

With the current growing demand for food and for a sustainable model of agriculture, the greatest challenge is meeting food production needs while at the same time preserving natural resources. Utilization of products that bio-stimulate the soil microbial population and vegetal photosynthetic activity aids in the reduction of production costs and environmental degradation and the increase in soil quality and crop productivity. The objective of this study was to evaluate soil quality by using biological indicators and determining microbial activity through basal respiration and activity of soil enzymes that are directly related to nutrient cycling. The experiment was carried out during the soybean crop cycle *(Glycine max L.)* at the Fepagro Center for Seed Research in Julio de Castilhos (Centro de Pesquisa em Sementes da Fepagro). Four treatments with three repetitions each were evaluated: **T1**: control; **T2**: only Penergetic; **T3**: Rolas recommended dose for K and P; **T4**: Rolas recommended dose for K and P + Penergetic. Soil sampling was performed at four different periods (12/03/2013; 01/13/2014; 03/07/2014 and 04/11/2014) at a depth of 10 cm. Samples were sifted in a 2mm sieve and stored at -4°C. Microbial basal respiration and enzymatic activities (ß–Glucosidase, acid phosphatase, urease) were determined as described in Dick et al. (1996) and FDA hydrolysis was performed in accordance with Adam & Duncan (2001). The best results for microbial respiration were found at the third collection, but there was no statistical difference between treatments with and without Penergetic and chemical fertilization, showing this to be a peak in the soil microorganism activity. FDA hydrolysis and ß-Glucosidase did not present statistical differences between treatments and collections, demonstrating their insensitivity in the detection of variations between different fertilization treatments utilized. However, **acid phosphatase showed increased activity in the treatment with Penergetic** in the second collection, although there was no difference when compared to the chemical fertilization treatments with and without Penergetic (Table 1).

**Table 1.** Enzymatic activity acid phosphatase (µg p-nitrophenol $g^{-1}$ dry soil $h^{-1}$) in samples collected before sowing and at 30, 90 and 120 days after soybean emergence.

| Treatments | Before sowing | 30 days | 90 days | 120 days |
|---|---|---|---|---|
| Control | $334,06^{ns}$ | 369,16 b | $406,76^{ns}$ | $423,36^{ns}$ |
| Penergetic | $415,40^{ns}$ | 468,06 a | $449,83^{ns}$ | $365,80^{ns}$ |
| Recommended dose of K and P | $413,80^{ns}$ | 429,03 ab | $457,36^{ns}$ | $373,30^{ns}$ |
| Recommended dose of K and P + Penergetic | $409,83^{ns}$ | 407,07 ab | $425,60^{ns}$ | $428,43^{ns}$ |
| CV% | 5,96 | 3,86 | 3,06 | 4,09 |

$^{Ns}$difference not significant

Urease presented greater activity in the treatment with Penergetic in the third collection, although with no difference from the chemical fertilization treatment (Table 2).

**Table 2**. Urease activity (μg $N\text{-}NH^4$ $g^{-1}$ dry soil $2h^{-1}$) in samples collected before sowing and at 30, 90 and 120 days after soybean emergence.

| Treatments | Before sowing | 30 days | 90 days | 120 days |
|---|---|---|---|---|
| Control | $57{,}35^{ns}$ | $75{,}54^{ns}$ | 100,86 b | $79{,}46^{ns}$ |
| Penergetic | $63{,}27^{ns}$ | $75{,}79^{ns}$ | 128,96 a | $70{,}90^{ns}$ |
| Recommended dose of K and P | $71{,}91^{ns}$ | $74{,}71^{ns}$ | 123,33 a | $87{,}40^{ns}$ |
| Recommended dose of K and P + Penergetic | $70{,}98^{ns}$ | $75{,}09^{ns}$ | 101,03 b | $78{,}90^{ns}$ |
| CV% | 5,96 | 3,12 | 3,06 | 10,41 |

$^{Ns}$difference not significant

Phosphatase and urease tended to be more sensitive to the effects of fertilization treatments in the soil. **Penergetic was shown to be an efficient tool for bioactivation of microbial activity.** However, more studies are needed to observe the behavior of the microbial population in the same soil as the present study and also in other crops.

# Biological activity and persistence of crop residues deposited on the surface of soil treated with Penergetic®

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**Edicarla Trentin** - Agricultural Engineer, Master's Student in Soil Sciences / UFSM.

**Zaida Inês Antoniolli** PhD in Mycorrhizal Molecular Aspects, Professor Department of Soil Sciences / UFSM.

**Rodrigo Josemar Seminoti Jacques** PhD Soil Science, Professor Department of Soil Sciences/ UFSM.

Feeding activity of the edaphic community and the decomposition rate of crop residues deposited on the soil are factors that directly interfere in the dynamics of nutrient cycling and crop management. This study aimed to: **1)** determine the persistence and size of different crop residues in a soybean crop that received Penergetic application during the crop cycle; and **2)** evaluate the effects of Penergetic application on feeding activity in the edaphic community. The assays were performed in Julio de Castilhos (RS) during growth of soybean cultivar Fepagro 36 undergoing different fertilization treatments and doses of Penergetic. The treatments applied to the crop were: **1)** control (without Penergetic application or mineral fertilization); **2)** Penergetic application as recommended by manufacturer; **3)** Phosphorus (P) and Potassium (K) application as recommended by the Manual of Fertilization and Calagem for the States of RS and SC (Manual de Adubação e Calagem para os Estados do RS e de SC); and **4)** Penergetic Application and Mineral fertilization (P and K). The litter-bag method was used to evaluate residue persistence. Wheat crop residues were cut manually with scissors and ryegrass residues were mechanically triturated in a triturator. Feeding activity alterations were evaluated using bait-laminas. After 21 days, slides were removed from the soil and evaluated for perforation, by scoring them as empty, partially empty or full holes. Differences in persistence and degradation rate were observed for both residues across the different treatments over the 120 days.

**Table 1.** Persistence in wheat and ryegrass straw residues at 30, 60, 90 and 120 days after soybean emergence using litter-bag method. Mean of 5 repetitions.

| Treatments | Persistence of Straw | | | |
|---|---|---|---|---|
| | Ryegrass straw | | | |
| | 30 | 60 | 90 | 120 |
| Control | 95,23 a[3] | 84,27 b | 69,34 ab | 72,08 a |
| Penergetic | 95.62 a | 86,02 a | 67,69 b | 66,75 c |
| Recommended dose of K and P | 94,43 ab | 84,58 b | 71,14 a | 70,16 b |
| Rec. dose of K and P + Penergetic | 92,91 b | 85,61 a | 71,00 a | 72,17 a |
| CV% | 26.14 | 24,54 | 18,21 | 17,45 |
| | Wheat Straw | | | |
| Control | 97.76[ns] | 87,58 a | 73,49 a | 74,15 a |
| Penergetic | 97,56[ns] | 84,58 b | 68,56 b | 69,74 b |
| Recommended dose of P | 97,15[ns] | 83,84 b | 70,30 b | 65,34 c |
| Rec. dose of K and P + Penergetic | 93,88[ns] | 84,56 b | 73,89 a | 69,96 b |
| CV% | 21,13 | 16,70 | 20,05 | 18,32 |

*[1]Ground straw. [2]Cut straw.*

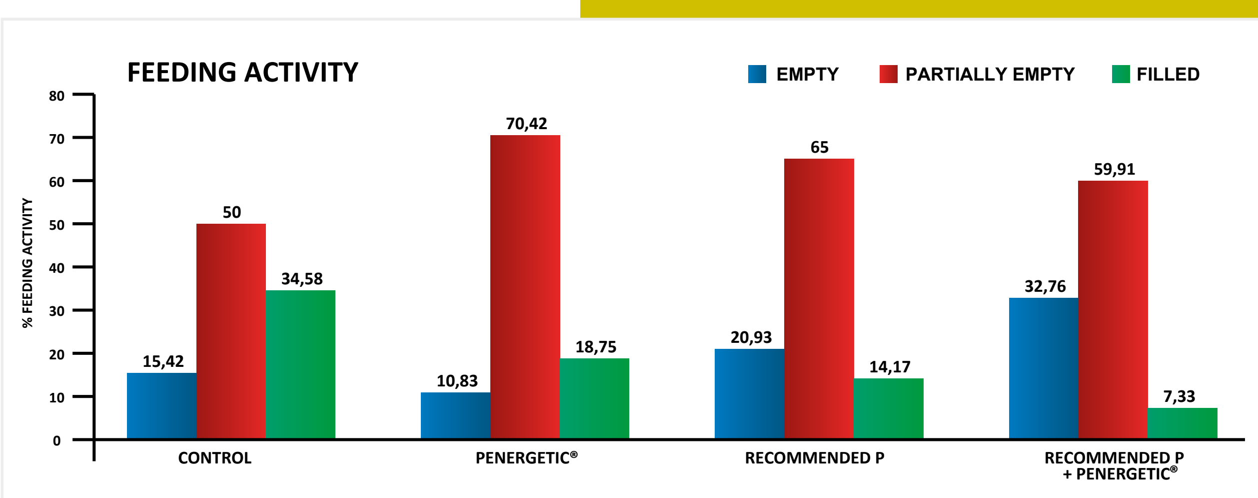
*[3]Means followed by the same letter in the column did not differ by Tukey's test at 10% probability.*

*[ns] difference not significant.*

A greater degradation rate was observed at 90 days. Residue size influenced residue persistence in the field. Triturated ryegrass straw persisted less, indicating a greater degradation rate. At 120 days, there was a greater degradation rate in the treatment with Penergetic alone (Treatment 2), while the greatest degradation in wheat residues occurred in Treatments 2 and 3. There were significant differences between treatments with regard to activity of organisms inhabiting the surface soil layer (0-8 cm; Figure 1).

The control plots presented a higher percentage of filled holes (34.58%), indicating less biological activity. **The plots treated with Penergetic alone presented the greatest percentage of partially empty holes (70.42%). The treatment with fertilizers (P and K) and Penergetic presented the greatest soil biological activity, shown by the smallest percentage of filled holes (7.33%) and the greatest percentage of empty holes (32.76%) in comparison to the other treatments. Penergetic in association with soil fertilization contributed to biological and microbiological activity, reducing surface residue persistence.**

**Figure 1.** Feeding activity of organisms in soybean crop soil, evaluated using bait-lamina method at 0-8cm depth. Mean of 30 repetitions.



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# Effect of Penergetic® P and Penergetic® K on mycorrhization and phytonematode penetration in wheat roots

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**Ricardo Bemfica Steffen** Agricultural Engineer, PhD in Soil Science, Post-doctorate in Soil Science/ UFSM.
**Gerusa Pauli Kist Steffen** - Agricultural Engineer, PhD in Soil Science, Researcher for Fepagro Florestas, Santa Maria/ RS.
**Edicarla Trentin** - Agricultural Engineer, Master's Student in Soil Sciences / UFSM.
**Juliane Schmitt** Biologist, Master's student in Soil Sciences/UFSM.
**Antônio Carlos Bassaco** Master's student in Agrobiology, Technician at the Laboratory of Soil Biology/UFSM.

## INTRODUCTION

Mycorrhiza are mutualistic associations between some fungi in the soil and a wide variety of plants. In addition to greater absorption of nutrients, mycorrhizal symbiosis provides plants with other benefits, such as: increased efficiency in nodulation and biological fixation of nitrogen; immobilization of heavy metals; optimization of water use; improvements in soil structure; and reduction of biotic and abiotic stresses.

## OBJECTIVE

The present work aimed to determine the effect of Penergetic technology, either in association with chemical fertilization or not, on mycorrhization and phytonematode penetration in wheat plant roots.

## METHODOLOGY

The experiment was performed in a greenhouse at the Soil Department of UFSM, Santa Maria, RS, using dystrophic red latosol collected from the municipality of Catuípe, RS. Four thousand grams of soil were conditioned in 5 L polyethylene pots. Penergetic was applied at doses and timepoints recommended by the manufacturer. Crop fertilization was performed in accordance with the Manual of Fertilization and Liming (Manual de Adubação e Calagem) and cultivar Quartzo wheat was sown on 07/23/2014, by placing 15 seeds into each pot. Ten days after emergence, pots were adjusted to 10 plants per pot. The experiment consisted of 6 treatments with 4 repetitions each, arranged in an entirely randomized fashion:

**T1** = Control

**T2** = Penergetic.

**T3** = Half recommended dose NPK

**T4** = Half recommended dose NPK + Penergetic..

**T5** = Recommended dose NPK, Manual of Fertilization

**T6** = Recommended dose NPK + Penergetic.

The treatments were carried out in the presence and absence of nematodes inoculated in the previous soybean crop. During crop blooming, the roots of 5 plants per repetition were collected to determine the percentage of mycorrhizal colonization and penetration. Means were compared by Tukey's test at 5% probability using SISVAR.

## RESULTS

### *Mycorrhizal colonization*

**The mycorrhization percentage in wheat roots was affected by the addition of phosphorus to the soil and by the utilization of Penergetic**, although significant differences were not observed (Table 1).

**Table 1.** Percentage of mycorrhizal colonization in blooming wheat plant roots undergoing different treatments and grown in a greenhouse in the presence or absence of phytonematode *Pratylenchus brachyurus*.

| Treatments | Without | With |
|---|---|---|
| **T1 - Control** | 80,00 aA | 70,00 $^{ns}$B |
| **T2 - Penergetic®** | 73,75 abB | 86,25 $^{ns}$A |
| **T3 - Half Recommended NPK** | 62,50 abA | 61,25 $^{ns}$A |
| **T4 - Half Recommended NPK + Penergetic®** | 76,25 aA | 76,25 $^{ns}$A |
| **T5 - Recommended NPK** | 41,25 bB | 60,00 $^{ns}$A |
| **T6 - Recommended NPK + Penergetic®** | 55,00 abB | 66,25 $^{ns}$A |
| **CV%** | **12,27** | **9,52** |

*$^{ns}$ difference not significant*

*Means followed by the same lowercase letter in the same column and uppercase letter in the rows do not differ by Tukey's test at 5% probability.*

In contrast, the presence of nematodes in the soil did not affect mycorrhization in roots. Mean mycorrhizal colonization was 78%, 69% and 56%, respectively for the no-phosphorus, half dose and recommended dose treatments. In the comparison of treatment pairs, **Penergetic technology increased mean colonization percentage by 13%, except in the Control and Penergetic without nematode groups.**

*Phytonematode penetration*

Penergetic reduced penetration of the nematode Pratylenchus brachyurus in wheat roots, except in the Recommended dose of NPK treatment (Figure 1). **In the comparison between the Control and Penergetic treatments, there was a 54% reduction in nematode penetration and in comparison to the Half Recommended Dose of NPK treatment, there was a 43% reduction due to Penergetic application. Based on these results, it is possible that Penergetic results in greater activity of microorganisms in the rizosphere, which in turn creates a biological barrier, protecting the root from pathogenic attack.**

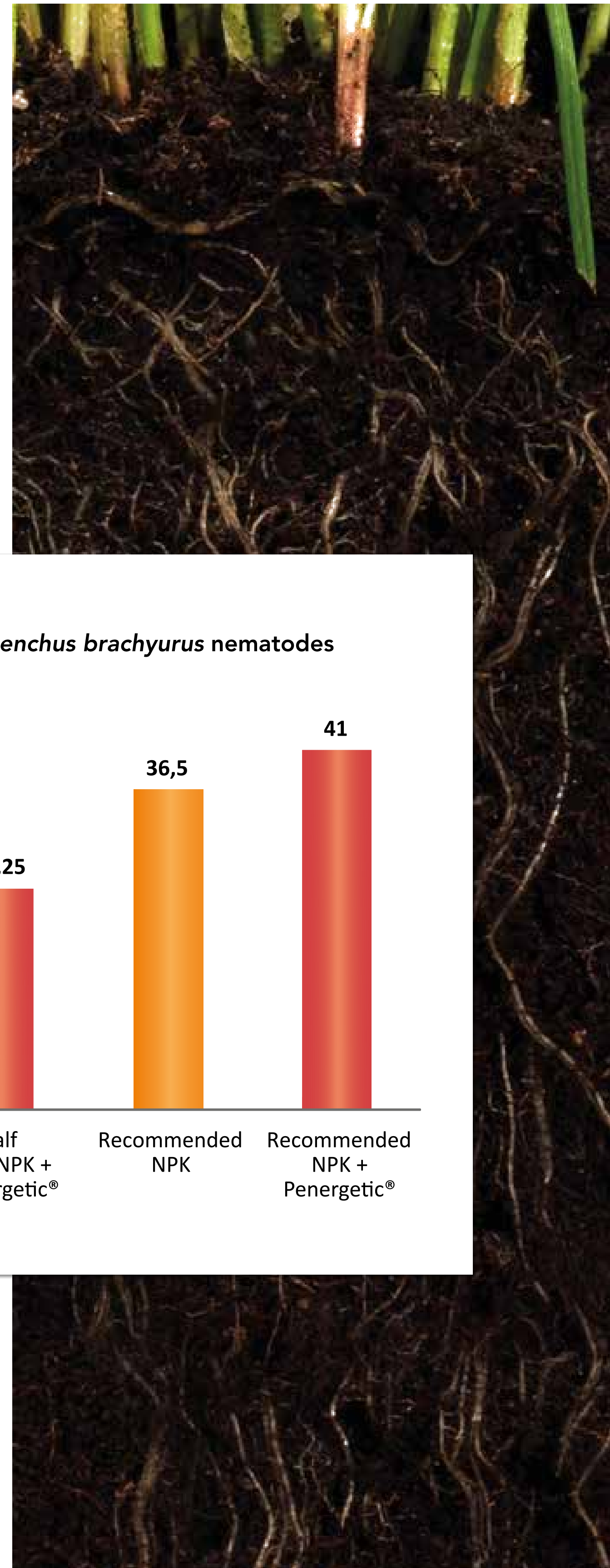
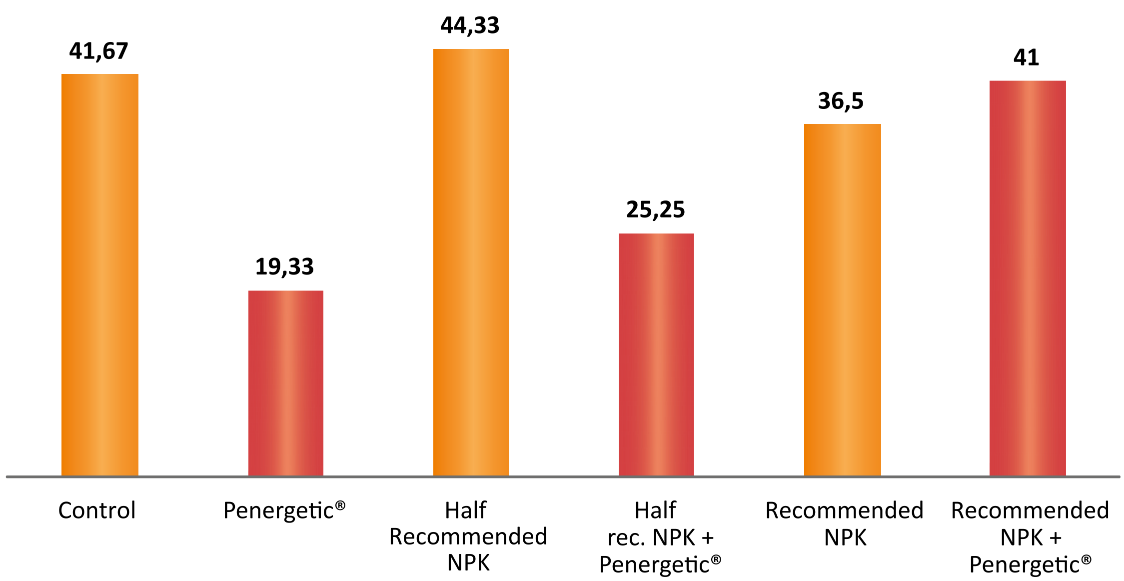


**Figure 1 - Penetration by number of *Pratylenchus brachyurus* nematodes**




## CONCLUSIONS

**Penergetic application increased mycorrhizal colonization in wheat plants by 13%,** even when the soil was fertilized with the recommended or half of the recommended dose of phosphorus, although the differences were not significant. For most of the treatments, **Penergetic reduced the penetration of *Pratylenchus brachyurus* nematodes in wheat roots by 50%.** The results indicate that use of Penergetic P and K may stimulate mycorrhization and reduce phytonematode penetration in wheat roots.

# Effect of Penergetic® P and Penergetic® K on soil microorganism activity in wheat crop

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## INTRODUCTION

Conventional agriculture is characterized by the adoption of large quantities of chemical inputs, with no concern for their environmental impacts. When used inappropriately and continuously, fertilizers and pesticides impact not only the pedosphere, but the planet's entire ecosystem. Much effort has been given toward innovations to substitute expensive and degrading inputs with more efficient, less expensive and less aggressive ones. Among these, Penergetic is recommended to increase photosynthetic efficiency (Penergetic P) and optimize decomposition of organic matter by activating soil microorganisms (Penergetic K). In order to evaluate this input in crops it is important to use microbiological markers, since Penergetic aims to activate microorganisms.

## OBJECTIVE

The present study aimed to determine the effect of Penergetic application, associated to chemical fertilization or not, on soil microorganism activity in a wheat crop, using the following microbiological markers: basal respiration; C content; N and P in the microbial mass; and enzymatic activity of ß-glucosidase, acid phosphatase and urease.

## METHODOLOGY

Wheat cultivation, Quartzo cultivar (medium-cycle), was carried out in the period between June 2014 and November 2014 at the Fepagro Center for Seed Research (Centro de Pesquisa em Sementes da Fundação Estadual de Pesquisa Agropecuária—FEPAGRO), in Julio de Castilhos/RS, under the direction of Dr. Madalena Boeni. Official recommendations from the Technical Information for Wheat and Triticale (Informações Técnicas para Trigo e Triticale) were followed: 170Kg seeds / ha, in a direct sowing system in dystrophic red latosol with 7 x 50 m plot, randomly arranged in three blocks with six treatments:

**T1** = Control;

**T2** = Penergetic;

**T3** = Recommended NPK according to the Fertilization Manual;

**T4** = Recommended NPK according to the Fertilization Manual + Penergetic;

**T5** = 30Kg $P_2O_5$;

**T6** = 30Kg $P_2O_5$ + Penergetic

The recommended fertilization treatments, selected in accordance with the soil fertility analysis and accounting for a mean wheat productivity of 4 t / ha, consisted of 60 Kg / ha $P_2O_5$; and 40 Kg / ha $K_2O$. All treatments received 20 Kg / ha N at sowing and 80 Kg / ha N in the topping in the form of urea: 60% of the dose at stages V3 - V4, early tillering (07/18/2014); and 40% at V7, early elongation (08/07/2014).
During the experiment, 4 soil samples were collected for microbiological analyses: at approximately 30 (07/22/2014), 60 (08/29/2014), 90 (09/25/2014) and 120 (10/23/2014) days after sowing. All results were submitted to analysis of variance (ANOVA), using Sisvar software, and means were compared using Tukey's test at 5% probability ($P<0.05$).

## RESULTS

### *Basal soil respiration*

Soil basal respiration is proportional to aerobic microorganism activity in the soil, which for the most part, degrades the organic matter, utilizing $O_2$ as the final electron acceptor, releasing $CO_2$. It is therefore assumed that the greater the production of $CO_2$ in the soil, the greater the microorganism activity. **The greatest respiration rate of microorganisms in the soil occurred at 60 days after sowing, at which time Penergetic stimulated soil microbial activity, as can be seen in the comparison between the control and Penergetic treatments.** This tendency was observed until the end of the experiment, although without significant differences. **The greatest C-$CO_2$ production occurred in the Penergetic treatment at 60 days**. At 90 and 120 days after sowing, all of the Penergetic treatments presented higher levels of basal respiration than their treatment pairs without Penergetic, however, without significant differences, **demonstrating the tendency of this technology to stimulate soil microbial activity**.

*Soil microbial biomass*

Microbial biomass is an indicator of C, N and P stores, which are rapidly cycled in the soil. **C content in soil microbial biomass was higher at 60 days as well as in the treatment with 30 kg $P_2O_5$ + Penergetic at all collection points.** There was a small, though not significant, increase in the C-content in the Penergetic treatment when compared to the Control at 30 and 60 days. The Recommended NPK treatments were not significantly different at any of the timepoints evaluated. **Conversely, the 30kg $P_2O_5$ + Penergetic treatment presented increased C content at all time points and significant increases at 30 and 90 days.** N content in the microbial biomass showed the same tendency as C, where the 30kg $P_2O_5$ + Penergetic treatment resulted in higher N content than the other treatments at all timepoints. **Despite the lack of significant differences in most of the comparisons, Penergetic application resulted in increased P content in soil microbial biomass.**

*Soil enzymatic activity*

The greater the activity of a-glucosidase, the greater the degradation of soil residues by microorganisms. The highest ß–glucosidase activity was also found at 60 days. Phosphatases catalyze the hydrolysis of organic phosphorus to inorganic phosphorus ($PO_4^{-2}$), making it available to plants. Quantification of its activity may provide an index of the mineralization of phosphorus in soils. **At 30 days after sowing, all treatments with Penergetic presented significantly increased phosphatase activity in comparison to treatments without Penergetic** (Table 1).

**Table 1.** Acid phosphatase activity (µg p-nitrophenol $g^{-1}$ dry soil $h^{-1}$) in samples collected at 30, 60, 90 and 120 days after wheat was sown.

| Treatments | 30 days | 60 days | 90 days | 120 days |
|---|---|---|---|---|
| **Control** | 595,91 b | 618,04 $^{ns}$ | 635,02 $^{ns}$ | 574,50 ab |
| **Penergetic®** | 637,76 a | 678,23 $^{ns}$ | 678,60 $^{ns}$ | 643,77 a |
| **Recommended NPK** | 566,32 c | 707,17 $^{ns}$ | 593,09 $^{ns}$ | 547,89 b |
| **Rec. NPK + Penergetic®** | 624,75 ab | 693,64 $^{ns}$ | 666,77 $^{ns}$ | 546,48 b |
| **30 kg de $P_2O_5$** | 545,24 c | 609,26 $^{ns}$ | 616,24 $^{ns}$ | 543,48 b |
| **30 kg de $P_2O_5$ + Penergetic®** | 643,39 a | 634,79 $^{ns}$ | 552,84 $^{ns}$ | 631,65 ab |
| **CV %** | 1,72 | 8,48 | 9,30 | 5,59 |

ns not significant

Urease enzymes act upon the N cycle, contributing to the release of inorganic N for plant absorption. **At 60 and 90 days, there was higher urease activity in all Penergetic treatments when compared to those without Penergetic, although without significant differences. At 120 days, however, Penergetic caused significant increases in urease activity in all three Penergetic treatments when compared to their treatment pairs without Penergetic** (Table 2).

**Table 2.** Urease activity (µg N-$NH_4$ $g^{-1}$ dry soil $2h^{-1}$) in samples collected at 30, 60 90 and 120 days after wheat was sown.

| Treatments | 30 days | 60 days | 90 days | 120 days |
|---|---|---|---|---|
| **Control** | 101,52 a | 99,83 $^{ns}$ | 95,78 $^{ns}$ | 33,56 cd |
| **Penergetic®** | 86,49 b | 102,17 $^{ns}$ | 99,48 $^{ns}$ | 41,67 b |
| **Recommended NPK** | 103,04 a | 98,66 $^{ns}$ | 83,47 $^{ns}$ | 31,12 d |
| **Rec. NPK + Penergetic®** | 96,35 ab | 110,53 $^{ns}$ | 84,58 $^{ns}$ | 44,93 b |
| **30 kg of $P_2O_5$** | 107,22 a | 105,63 $^{ns}$ | 101,15 $^{ns}$ | 38,25 bc |
| **30 kg of $P_2O_5$ + Penergetic®** | 107,52 a | 110,26 $^{ns}$ | 103,89 $^{ns}$ | 53,50 a |
| **CV %** | **4,82** | **9,58** | **8,41** | **5,89** |

ns not significant

## CONCLUSION

Utilization of Penergetic, either associated with mineral fertilization or not, stimulated phosphatase activity 30 day after wheat was sown. Soil basal respiration was stimulated by Penergetic without mineral fertilization 60 days after wheat was sown. Urease activity was stimulated by Penergetic 120 days after sowing, either in association with mineral fertilization or not. **For all of the microbiological markers evaluated, the great majority of comparisons between treatments with and without Penergetic application showed that Penergetic stimulated soil microorganisms.** In many cases, there were not significant differences either due to small numerical differences or to a high coefficient of variation (CV%), which is characteristic of microbiological analyses of samples collected in field experiments where the natural heterogeneity of the soil is evident.

# Effect of Penergetic® P and Penergetic® K on production components of wheat grown in the presence or absence of nematodes

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## INTRODUCTION

Wheat is the second most produced cereal in the world, following corn, with a production of 712.7 million tons in the 2013/2014 harvest. The wheat crop has a high potential for expansion, considering the enormous national market for its commercialization. Penergetic is a product recommended for optimizing the decomposition of soil organic matter by activation of microorganisms (Penergetic K) and for increasing the photosynthetic efficiency in plants (Penergetic P), making it capable of providing improved wheat productivity due to increased plant nutrition and decreased susceptibility to phytopathogens.

## OBJECTIVE

To evaluate the effect of Penergetic technology on production components of wheat cultivated in the presence and absence of Pratylenchus spp phytonematodes, which cause root lesions.

## METHODOLOGY

The experiment was carried out in a greenhouse at the Soil Department at

UFSM, Santa Maria/RS. Distrophic Red Latosol, which was used in an experiment with Penergetic in a soybean crop in the 2013/2014 harvest, was collected from Catuípi, RS. Penergetic was applied at doses and timepoints recommended by the manufacturer. Fertilization was performed according to the Manual for Fertilization and Liming (Manual de Adubação e Calagem). Wheat cultivar Quartzo was sown on 07/23/2014, placing 15 seeds per pot and after ten days, adjusting to 10 plants per pot. The experiment consisted of six treatments with four repetitions each, arranged in an entirely randomized fashion.

**T1** = Control

**T2** = Penergetic

**T3** = Half recommended dose NPK

**T4** = Half recommended dose NPK + Penergetic

**T5** = Recommended dose NPK, Manual of Fertilization

**T6** = Recommended dose NPK + Penergetic

The inoculum consisted of pure populations of Pratylenchus brachyurus obtained from species-specific isolation, performed at the Agrolab/GO. Five plants were collected at two different stages, blooming and maturation, to evaluate production components: stem diameter, plant height (from the stem to the ear, without aristas), dry phytomass of the aerial part, number of grains and dry mass of grains. The data were analyzed using analysis of variance and means were compared using Tukey's test at 5% probability with SISVAR software.

## RESULTS

During blooming, Penergetic showed a tendency to reduce stem diameter in plants grown in the absence of nematodes, with a significant difference between the Control and Penergetic treatments. In the presence of nematodes, Penergetic led to an increase in stem in all of the comparisons between treatments with and without Penergetic, with a significant difference between the Control and Penergetic treatments. The utilization of Penergetic tended to increase aerial part phytomass of wheat plants in blooming, both in the presence and absence of phytonematodes. It is noteworthy that Penergetic was able to impede the effects of nematodes in the reduction of aerial phytomass, although without presenting statistical differences, since significant reductions in phytomass were only observed in the treatments without Penergetic. In all comparison between treatments with and without Penergetic, there was a tendency toward increased number and mass of grains in plants grown with Penergetic application, both in the presence or absence of nematodes. In the grain mass, for all treatments without Penergetic, except for the Half recommended NPK treatment, the presence of nematodes significantly reduced the number and mass of grains per plant. However, in the presence of Penergetic there were no significant differences between plants grown with and without nematodes, demonstrating the protective effect of Penergetic in the reduction of harmful effects of phytonematodes in wheat plants.

## CONCLUSIONS

Utilization of Penergetic technology, in association with mineral fertilization or not, tended to increase plant height and phytomass in wheat plants during blooming and in the number and mass of grains, both in the presence and absence of phytonematodes, however without significant differences. Phytonematodes caused significant reductions in height, phytomass, number and mass of grains only in wheat plants grown without Penergetic application; Penergetic minimized the harmful effects of Pratylenchus nematodes on production components of wheat.

# Effect of Penergetic® Technology on decomposition rate in ryegrass (*Lolium multiflorum* Lam.) crop residues

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**Rosana Matos de Morais** Biologist, PhD in Plant Science - UFSM
**Cléber Witt Saldanha** Forest Engineer, PhD in Physiology

## INTRODUCTION

Organisms and microorganisms in the soil are the main agents of biochemical activity in agricultural systems and are directly involved in all biological processes that provide cycling and make nutrients from organic residues available to plants (González et al., 2001). Therefore, practices that provide biostimulation of these agents benefit nutrient cycling and crop productivity. This work aimed to determine the effect of using Penergetic technology, associated to different levels of fertilization, on the decomposition rate of ryegrass crop residues in a wheat crop.

## MATERIAL AND METHODS

The decomposition rate of ryegrass crop residues was determined during the growth a Quartzo cultivar wheat crop using the decomposition bag (Thomas & Asakawa, 1993) or litter bag methodology (Rezende et al., 1999; Amado et al., 2002). The assay was performed at Fepagro Sementes in Júlio de Castilhos (RS). Six field treatments and one natural control treatment were evaluated: **T1** = control without fertilizer; **T2** = control + Penergetic; **T3** = phosphorus and potassium as recommended by CQFS-RS/SC; **T4** = phosphorus and potassium as recommended by CQFS-RS/SC + Penergetic.; **T5** = 30 Kg $P_2O_5$; **T6** = 30 Kg $P_2O_5$ + Penergetic.; **T7** = natural forest; 250g / ha Penergetic K and P were applied to the wheat. The litter bags were made of voile fabric (20x10 cm) and filled with approximately 25g of ryegrass crop residues. These residues were collected from the field, dried at room temperature and triturated in a silage mill and then distributed randomly on the soil of the experimental plots. During the period of 110 days, five litter bags were removed from each treatment and three bags were removed from the natural forest at timepoints of 0, 30, 60, 90 and 110 days. To evaluate mass loss, the material was externally washed to remove particles of soil and impurities and then dried in an oven with forced aeration at 65° C until reaching constant weight. The bags were then weighed on an analytical balance to determine progressive mass loss of the residues.

## RESULTS AND DISCUSSION

Persistence of the ryegrass crop residues decreased over the course of the 110-day evaluation period, with the highest decomposition rate occurring at 60 days, at which time there was a greater mass loss of residues. Higher rates of persistence of straw in the field indicate a lower decomposition rate (Table 1).

**Table 1. Mean ryegrass crop residue Persistence at 30, 60, 90 and 110 days after wheat emergence (Quartzo cultivar), using litter bag method.**

| Treatments | Straw persistence | | | |
|---|---|---|---|---|
| | 30 | 60 | 90 | **110** |
| **Control** | 93,63 a | 69,29 ab | 68,86 ab | **68,97 a** |
| **Control + Penergetic®** | 77,04 c | 73,09 ab | 68,67 ab | **63,60 a** |
| **Recommended CQUFS-RS/SC fertilization** | 87,01 b | 66,69 b | 67,54 ab | **64,21 a** |
| **Recommended CQUFS-RS/SC fertilization + Penergetic®** | 86,44 b | 72,43 ab | 74,53 a | **70,08 a** |
| **30 kg $P_2O_5$** | 86,53 b | 71,56 ab | 70,84 ab | **65,60 a** |
| **30 kg $P_2O_5$ + Penergetic®** | 85,33 b | 75,59 a | 67,00 ab | **66,21 a** |
| **Natural forest** | 82,86 b | 72,47 ab | 66,00 b | **63,00 a** |
| **CV (%)** | **3,60** | **6,49** | **6,44** | **9,83** |

*[1]Means followed by the same letter in the columns do not differ by Tukey's test at 10% probability*

During the first 30 days of evaluation, the highest persistence was observed in the control treatment, demonstrating a lower decomposition rate. **The Control + Penergetic treatment presented significantly lower persistence when compared to all of the other groups.** After 90 days, there was no effect on residue persistence in the crop residues from the crop or the natural forest (Table 1).

The straw decomposition coefficient expresses the number of grams of degraded residue daily for each gram of straw in the litter bag. At 30 days, the decomposition coefficient data (Table 2) corroborate the persistence, where the Control + Penergetic presented the highest decomposition rate and the Control treatment presented the lowest rate (Table 2).

**Table 2.** Mean ryegrass crop residue decomposition coefficient at 30, 60, 90 and 110 days after wheat emergence (Quartzo cultivar), using litter bag method.

| Treatments | K (g day$^{-1}$) | | | |
|---|---|---|---|---|
| | 30 | 60 | 90 | **110** |
| **Control** | 0,053 c | 0,251 ab | 0,267 a | **0,273 a** |
| **Control + Penergetic®** | 0,190 a | 0,230 ab | 0,271 a | **0,309 a** |
| **Recommended CQUFS-RS/SC fertilization** | 0,113 b | 0,291 a | 0,284 a | **0,310 a** |
| **Recommended CQUFS-RS/SC fertilization + Penergetic®** | 0,117 b | 0,238 ab | 0,224 a | **0,257 a** |
| **30 kg $P_2O_5$** | 0,114 b | 0,243 ab | 0,254 a | **0,295 a** |
| **30 kg $P_2O_5$ + Penergetic®** | 0,124 b | 0,206 b | 0,280 a | **0,286 a** |
| **Natural forest** | 0,145 b | 0,224 ab | 0,288 a | **0,315 a** |
| **CV (%)** | **21,19** | **16,98** | **15,47** | **20,61** |

*[1]Means followed by the same letter in the columns do not differ by Tukey's test at 10% probability*

At the same time point (30 days), the remaining treatments, recommended CQUFS-RS/SC fertilization with and without Penergetic, 30 kg $P_2O_5$ with and without Penergetic and natural forest, did not present significant differences (Table 2).

Measuring accumulated decomposition over time is an additional method for evaluating the effect of Penergetic and phosphate and potassium fertilizer on the decomposition of crop residues. Table 3 shows the mean amount in grams of decomposed straw for each treatment at the different timepoints, given the initial amount in each experimental unit.

**Table 3.** Mean accumulated ryegrass crop residue decomposition at 30, 60, 90 and 110 days after wheat emergence (Quartzo cultivar), using litter bag method.

| Treatments | Decomposition (g) | | | |
|---|---|---|---|---|
| | 30 | 60 | 90 | **110** |
| **Control** | 1,59 c | 7,52 ab | 8,01 a | **8,20 a** |
| **Control + Penergetic** | 5,69 a | 6,90 ab | 8,13 a | **9,27 a** |
| **Rec. CQUFS-RS/SC fertilization** | 3,38 b | 8,72 a | 8,51 a | **9,29 a** |
| **Rec. CQUFS-RS/SC fertilization + Penergetic** | 3,50 b | 7,15 ab | 6,71 a | **7,71 a** |
| **30 kg $P_2O_5$** | 3,42 b | 7,30 ab | 7,63 a | **8,84 a** |
| **30 kg $P_2O_5$ + Penergetic®** | 3,73 b | 6,18 b | 8,40 a | **8,58 a** |
| **Natural forest** | 4,34 ab | 6,73 ab | 8,63 a | **9,46 a** |
| **CV (%)** | **21,13** | **17,37** | **16,58** | **20,54** |

[1]*Means followed by the same letter in the columns do not differ by Tukey's test at 10% probability.*

At 30 days, the application of Penergetic to the soil increased the decomposition rate in surface ryegrass crop residues. Although it was numerically higher, the mean accumulated decomposition rate of the Control + Penergetic treatment was not significantly different from that found in the natural forest, which was utilized as a natural control treatment to gauge the biological and edaphoclimatic conditions in an environment with little anthropic interference, where we expected to find the highest residue decomposition rates (Table 3).

The Control treatment presented the lowest accumulated decomposition at 30 days, showing lower biological activity of organisms and microorganisms involved in vegetal decomposition on the soil surface. Conversely, the treatments with mineral fertilization, either with or without Penergetic, presented intermediate mean accumulated decomposition: significantly lower than the Control + Penergetic and significantly higher than the Control treatment (Table 3).

These results suggest that there was an isolated effect of Penergetic on surface biological activity of the agricultural system, directly affecting nutrient cycling, which may positively impact soil quality. Although it was less significant, it was also possible to observe a positive effect of the addition of mineral fertilizers (phosphorus and potassium), both in isolation and in combination with Penergetic, on the activity of biota and microbiota involved in the decomposition of surface residues, when compared to the Control treatment (Table 3).

As was observed for the decomposition coefficient, there were no significant differences between the treatments in relation to accumulated decomposition of ryegrass residues at 90 days (Table 3).

## CONCLUSION

Application of Penergetic to a wheat crop raised the decomposition rate of ryegrass crop residues on the soil, decreasing the persistence of surface straw in the first 30 days.

# Feeding activity of soil microorganisms and fauna in crops using different management practices

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## ABSTRACT

Soil biological activity is a key to maintaining production sustainability in agriculture. This work aimed to evaluate the effects of mineral fertilization (phosphatase and potassium) and Penergetic technology on soil bioactivation in crops by evaluating food consumption of fauna and edaphic microorganisms. The assays were carried out in soybean (summer) and wheat (winter) crops treated with different methods of fertilization, with or without addition of Penergetic. The 4 treatments evaluated were: **T1** = Control without fertilizers; **T2** = Control + Penergetic; **T3** = Phosphorus and Potassium fertilization; **T4** = Phosphorus and Potassium fertilization + Penergetic. Penergetic K (Kompost) and P (Pflanzen) were applied to both crops at 250g / ha. The bait-lamina method was used to evaluate feeding consumption in experimental plots. The laminas remained in the soil for 21 days and were evaluated for percentage of empty, partially empty and full holes at two soil layers:0-8 and 8-16 cm deep, receiving scores for feeding activity pattern. Principal components analysis (PCA) was carried out as well as scores for feeding activity, crop productivity and basal respiration. Penergetic in combination with phosphate and potassium fertilization promoted a significant increase in feeding activity of fauna and microorganisms present in the 0-8 cm deep layer of soil in a soybean crop.

*Key words: Soil biology, bioactivation, feeding consumption.*

## INTRODUCTION

Organisms and microorganisms living in the soil interfere directly and indirectly in the biogeochemical cycles of elements and in plant nutrition. Although nutrient mineralization depends on the action of microorganisms, soil fauna also play an important role in this process by regulating the microbial population (Trogello et al., 2008; Socorrás & Izquierdo, 2014). In addition, the diverse groups that make up the soil fauna perform important systemic services, such as initial fragmentation of debris, stimulation, digestion and dissemination of microorganisms and selective predation of fungi and bacteria, all of which interfere directly in the decomposition of organic matter and alter nutrient availability (Cragg & Bardgett, 2001).

Soil fauna influences nutrient cycling processes either directly, by physically modifying plant litter and soil environment, or indirectly, through interactions with the microbial community. Its direct effects on biogeochemical cycling occur through fragmentation of vegetal debris and its incorporation into the soil, increasing availability of nutritional resources for microorganisms and mediating the transference of solutes and particulates deep within the soil profile (Decaëns et al., 2003; Trogello et al., 2008). They also affect biogeochemical cycling by rearranging soil particles, altering the pore size distribution and consequently the infiltration patterns and gas emissions (Beare et al., 1995).

Due to modifications caused by soil use, especially from agriculture, the fauna and microorganisms are affected to differing degrees by agricultural impacts (Alvarez et al., 2001), both from modification of soil properties and from the direct action of these practices on organisms.

Feeding consumption of soil biota is an indicator of decomposition rate (Reinecke et al., 2008) and the functional integrity of ecosystems (Filzek et al., 2004). The bait-lamina method, originally developed by von Tërne (1990) to measure feeding activity of in situ soil organisms, is able to detect alterations in the feeding consumption patterns of soil fauna in environments under different management practices, be they deleterious or beneficial.

Penergetic technology has been used in agriculture to bioactivate microorganisms and fauna in the soil system. Its effect is due to the addition of energized particles, which are introduced into agricultural systems via pulverization on soil and plants. Upon coming into contact with the soil, the energy from the technology acts beneficially in the agricultural system, interfering in the biological activity of soil biota and microbiota, as well as in nutrient availability. The energization process used in Penergetic technology is derived from the theories of Michael Faraday, in 1846, and James Clerk Maxwell in 1864, both physicists working on material energization (Pauli, 1927;

Dirac, 1928; Noack, 1985). In the 1960's, it was reported that some genera of bacteria exhibited the surprising behavior of persistently migrating North, even when the orientation of the sample on a slide was altered by rotating the plate of the microscope (Bellini, 1963). Since then, research has been carried out to understand the mechanism involved in this behavior. Bellini (2009) described the electromagnetic movement, demonstrating that the movement of protons and electrons occurs differently and, together with the force of gravity, this movement generates a direction of frequency, which orients the movement of certain microorganisms.

Currently, there are many works in the literature demonstrating the effect of utilizing electromagnetic energy on microbial activity (Siannah et al., 2003; Siannah et al., 2012), feeding activity orientation of edaphic organisms (Esquivel et al., 2004; Hsu et al., 2007; Wajnberg et al., 2010) and crop productivity (Pieturszewski, 1993; Barbosa-Cánovas et al., 1998; Hajnorouzia et al., 2001; Novitsky et al., 2001; Zapata et al., 2002; Souza-Torres et al., 2006; Pekarskas et al., 2011; Ladino et al., 2012; Padrino et al.; 2013). The present study thus aimed to evaluate the effects of mineral fertilization (phosphorus and potassium) and Penergetic technology on bioactivation of the soil in crops, by measuring feeding consumption of fauna and edaphic microfauna.

## MATERIAL AND METHODS

Assays were carried out in soybean (January) and wheat (October) crops under different treatments of fertilization and Penergetic application in harvest year 2014, in the municipality of Júlio de Castilhos, RS, Brasil. The treatments evaluated were: **T1** Control; **T2** Control + Penergetic; **T3** CQFS-RS/SC recommended phosphorus and potassium; and **T4** = CQFS-RS/SC recommended phosphorus and potassium + Penergetic. Penergetic was applied at 250g / ha: Penergetic P (applied to aerial part) and Penergetic K (applied to the soil). Based on initial phosphorus and potassium contents in the soil, 50 Kg $P_2O_5$ and 80 Kg $K_2O$ / ha were added to the **T3** and **T4** treatment plots.

The slides used for the assays were constructed in accordance to description of the bait-laminas sold by the German company Terra Protecta (1999). The holes were filled with substrate composed of a homogenous mixture of cellulose, wheat flour and activated carbon (70:27:3). In each experimental plot, 30 laminas were inserted vertically into slots in the soil with a metallic lamina in between crop rows in two groups of 15 laminas, with approximately 5 meters distance in between each. The laminas remained in the soil for 21 days, at which time they were removed and stored in individual paper bags for posterior laboratory processing. The results were expressed as percentage of empty, partially empty and filled holes at each soil layer. For the 0-8 cm layer, the first eight holes were assessed and for the 8-16 cm layer, the 9th to 16th holes were evaluated. In addition, empty holes were given a score of 3, partially empty a score of 2, and filled a score of 1. Based on these scores for consumption pattern for each of the laminas, a mean consumption rate per treatment was calculated. The higher the score received, the greater the feeding activity of organisms and microorganisms in the experimental plot. The results were analyzed using analysis of variance, with the aid of Sisvar software (Ferreira, 2000). Means were compared by Tukey's test at 5% probability ($P<0.05$).

## RESULTS

There was a higher percentage of filled holes in the laminas deposited in the Control treatment, in comparison to all of the other treatments, for both depths evaluated in the soybean crop (Figures 1 and 2). Persistence of substrate not reached by fauna and microorganisms in the soil indicates less biological activity in the soil, allowing a comparison of consumption patterns in the different field treatments.

For empty holes in the soybean crop, at the 0-8 cm layer, there were significant differences among the treatments, with the highest mean percentage (32.1%) observed in the Penergetic with phosphate and potassium fertilization treatment, which significantly differed from the Control treatment (Figure 1). **Penergetic addition, in combination with mineral fertilizers or not, increased activity of the edaphic community in the soil, promoting greater feeding activity at the 0-16 cm layers in the soybean crop (Figures 1 and 2).**

In all treatments evaluated in the soybean crop, mean percentage of partially empty holes was higher than 50% for the 0-8 cm layer and the Penergetic alone treatment presented 70.4% partially consumed holes, significantly differing from the Control treatment (Figure 1).

In the wheat crop, there were no significant differences between the treatments for the 0-8 cm layer or 8-16 cm layer (Figures 1 and 2).

Feeding activity at the 0-8 soil layer

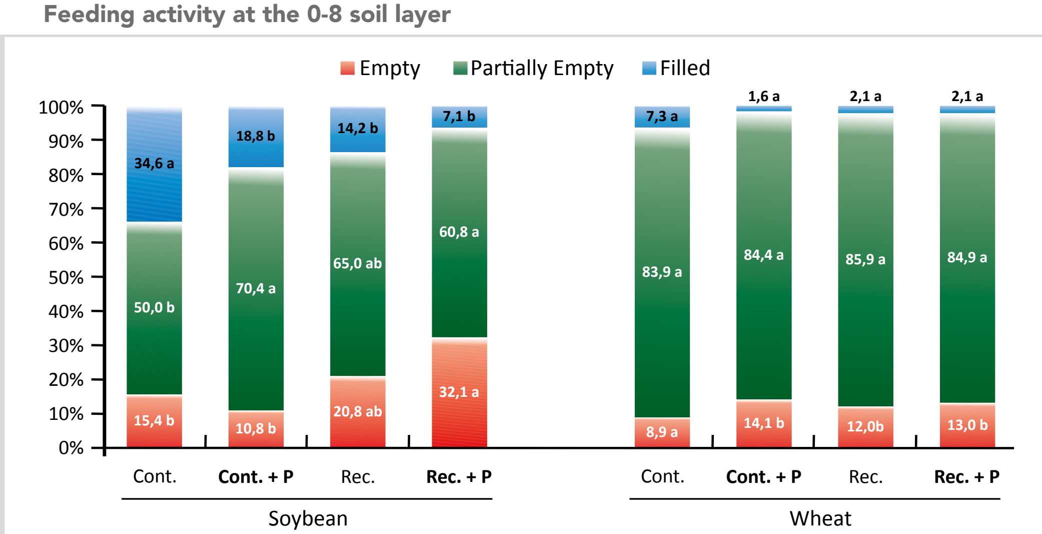


**Figure 1.** Percentage of empty, partially empty and filled holes at the 0-8 cm soil layer, indicating feeding activity in soybean and wheat crops under different treatments. Mean of 30 repetitions. Means followed by the same letter in each category of consumption do not differ by Tukey's test at 5% probability.

In the consumption pattern scores, the bioactivation effect of mineral fertilization in combination with Penergetic technology on the activity of biota and microbiota is even more evident. For both soil layer depths in the soybean crop, the control laminas scored significantly lower, indicating less biological activity in comparison to the other treatments (Figures 3 and 4).

In the soybean crop, at the 0-8 cm soil layer, where there is a greater diversity and abundance of fauna and microfauna, the combination of mineral fertilization and Penergetic application significantly increased soil biological activity.

Correction of phosphorus and potassium levels, as well as Penergtic application alone or in combination with fertilization increased feeding activity of fauna and microfauna in

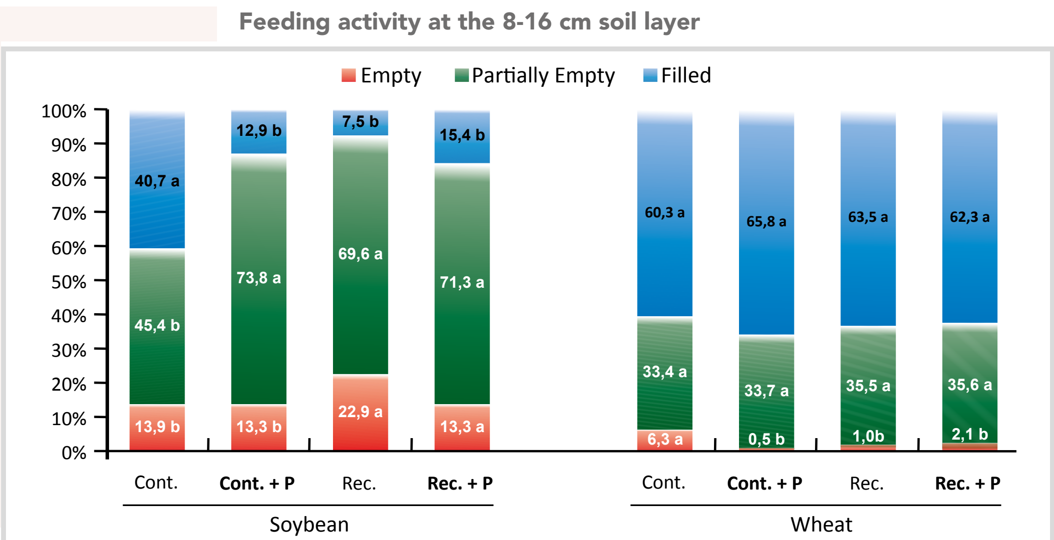


**Figure 2.** Percentage of empty holes, partially empty and filled in 8 - 16 cm soil layer, indicating the feeding activity of soybean and wheat crops under different treatments. Average of 30 repetitions. Medium with the same letter on each degree of consumption in the holes of the bait laminas do not differ by 5% probability.

the soybean crop. In the 0-8 cm layer, the combined use of fertilization and Penergetic stimulated soil biological activity, with the highest percentage of empty holes (32.1%) and the lowest percentage of filled holes (7.1%) (Figure 3).

According to Silva Filho et al. (2002), there are between 104 and 107 g$^{-1}$ of populations of solubilizing microorganisms in the soil, varying with the location and evaluation method, and to the order of 106 g$^{-1}$ of soil in the rizosphere of a variety of legumes. It is known that there is interaction between microorganisms and between microorganisms and the environment, however most of the available information is related to use of biochemical signals between microorganisms. Recent results have shown that in addition to biochemical signals, fungi and bacteria can "communicate" with the environment through electromagnetic signals (Cifra et al., 2011; Dotta et al., 2011; Dotta & Rouleau, 2014).

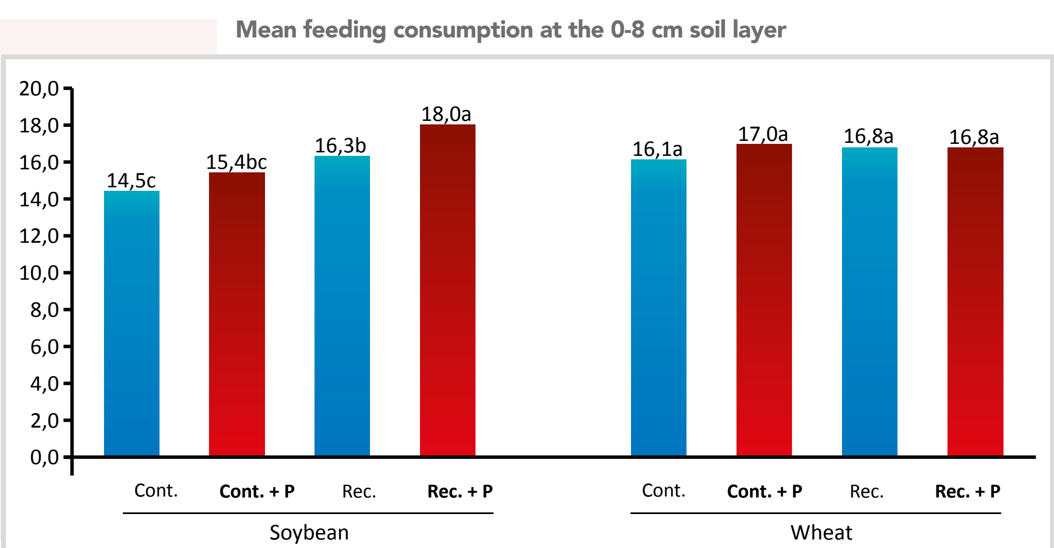


**Figure 3**. Mean feeding consumption rate at the 0 – 8 cm soil layer, based on consumption pattern scores for the bait laminas from soybean and wheat crops. Scores: 1) filled hole; 2) partially empty; and 3) empty. Mean of 30 repetitions.

Mean feeding consumption at the 8-16 cm soil layer

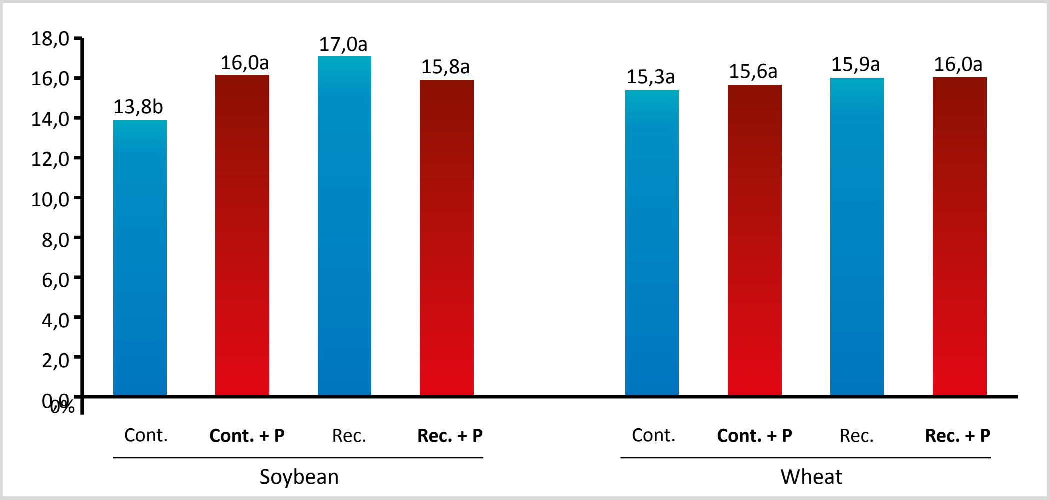


**Figure 4**. Mean feeding consumption rate at the 8-16 cm soil layer, based on consumption pattern scores for the bait laminas from soybean and wheat crops. Scores: 1) filled hole; 2) partially empty; and 3) empty. Mean of 30 repetitions.

The absence of a significant effect observed for the fertilization and Penergetic treatment in the wheat crop (Figures 1-4) may be related to the climatic conditions in the region where the study was carried out, characterized by temperatures below 10° C in the winter (Lima et al., 2013), which may have inhibited soil biological activity.

It is important to underline the fact that there is a demand for new models of agriculture capable of producing quality foods with reduced application of chemical inputs, aiming at reduced production costs and environmental protection. The issue of dependence and excessive use of mineral fertilizers has been discussed for decades, along with the search for alternatives that can guarantee agricultural sustainability (Costa, 2002). Mineral fertilization costs have increased steadily and phosphate reserves are being consumed at an accelerated pace, jeopardizing this practice in the near future.

Proposals for new technologies are imperative, aiming to improve the quality of agricultural systems, to benefit crop productivity and the survival of organisms and microbiota present in these systems. Biostimulation of the life present in the soil contributes to agricultural sustainability and directly affects cycling of organic matter, contributing to the reduction of external nutrients needed in crops.

## CONCLUSION

Fauna and microorganism feeding activity at 0-8 and 8-16 cm layers was intensified by use of Penergetic, in isolation or in combination with phosphate and potassium fertilization in the soybean crop. In the winter crop, soil feeding activity was similar.

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# Effect of soil bioactivation on suppression of damage caused by *Pratylenchus brachyurus* in soybean

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Brazil is the largest exporter and second largest producer of soybeans in the world. Currently, production in Brazil is led by the states of Mato Grosso, Paraná, Rio Grande do Sul and Goiás, which produce 82.0% of the country's soybean supply. According to the Brazilian Ministry of Agriculture, soybean production in 2020/2021 is estimated at 86.5 million tons (MAPA, 2011). Approximately 25 pathogens are of economic importance to this crop and the impact of phytonematodes has been of growing importance to the productive system in Brazil, possible preventing soybean growth in some areas (GRIGOLLI; ASMUS, 2014).

Currently, the control of phytopathogens is based on use of inputs that can guarantee productivity and reduce the damage caused by these organisms in roots. However, this practice could lead to environmental contamination (I). Thus, there has been increased pressure to reduce the use of chemical products in agriculture. According to Sediyama et al. (2014), there is a current retrogression in pest control programs, with increased intensity and dosage of pest-control products in crops, leading to undesirable consequences from an economic and environmental standpoint. With the selection of individuals resistant to pesticides, increasingly aggressive inputs have been used with increasingly undesirable consequences. In soybean crops, new pests arise at each harvest and their control has been increasingly inefficient.

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Among phytopathogens responsible for damage in soybean crops, phytonematodes of the Pratylenchus spp. genera, which cause root lesions, are of special importance, due to their high capacity to adapt to diverse agrosystems and the speed and ease with which they disseminate in crops. It is essential that new pest-control alternatives be evaluated for their efficiency to control these phytoparasites. The aim of this work was to evaluate the effect of Penergetic® P and K on the penetration of phytonematodes in soybean roots.

The penetration of *Pratylenchus brachyurus* was evaluated in soybean cultivar Nidera 5909. The plants were grown in 3L plastic pots with soil in a greenhouse.

The treatments evaluated were: **1)** Contol; **2)** Penegetic® application without fertilizer; **3)** Phosphorus (P) and Potassium (K) as recommended by CQFS-RS/SC (2004); and **4)** Penergetic application in combination with Phosphorus (P) and Potassium (K) as recommended by CQFS-RS/SC (2004). Penergetic was applied according to technical recommendations: Penergetic K (250 g $^{ha-1}$) was applied to the soil before sowing and Penergetic P (250 g ha-1) was applied to aerial part at stage V3 (125 g $^{ha-1}$) and 15 days after the first application (125 g $^{ha-1}$).

The inoculum was composed of pure populations, obtained from species-specific isolation. Inoculum preparation was performed by trituration of roots according to Hussey and Barker (1973) and modified by Boneti and Ferraz (1981). 5 mL of a solution containing 1750 juveniles of P. brachyurus, which was distributed in 3 holes of approximately 2 cm in depth, located around each plant. After 30 days, during the period of blooming, the number of phytonematodes in the roots was counted using the root staining method of Byrd et al. (1983). The roots were then placed on two glass slides under a microscope at 40X increase for counting. The data were analyzed using analysis of variance and Tukey's test with SISVAR software (FERREIRA, 2000).

Use of Penergetic® P and K decreased the number of phytonematodes penetrated in the roots of soybean, both at 30 days after emergence and during blooming. Since the plants were grown in a greenhouse, protected from biotic and abiotic stresses, the results demonstrate a susceptibility of soybean to the attack of these phytonematodes as well as the efficiency of the different products used to control these organisms. This decrease is related to two factors: a) a smaller number of phytonematodes penetrated in the root system; and b) reduced multiplication of these organisms in the soil, demonstrating a delaying effect on the nematode cycle within the root and smaller source of inoculum in the soil.

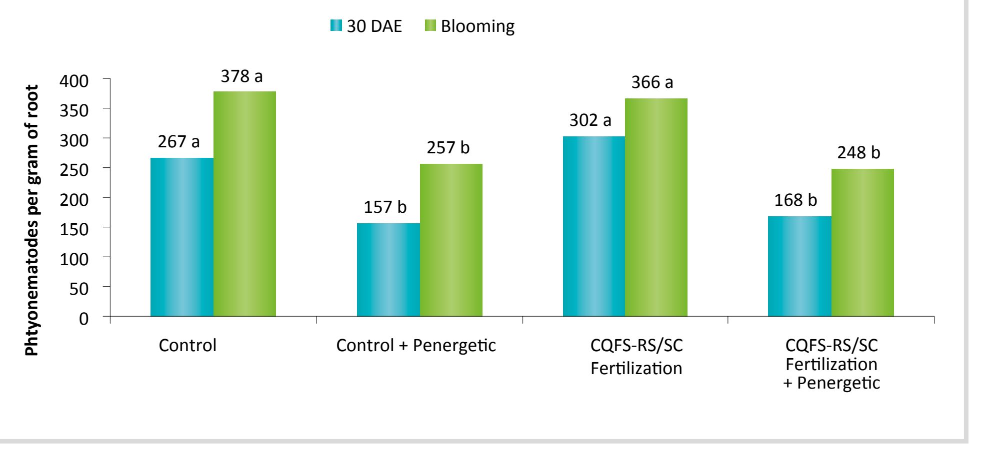
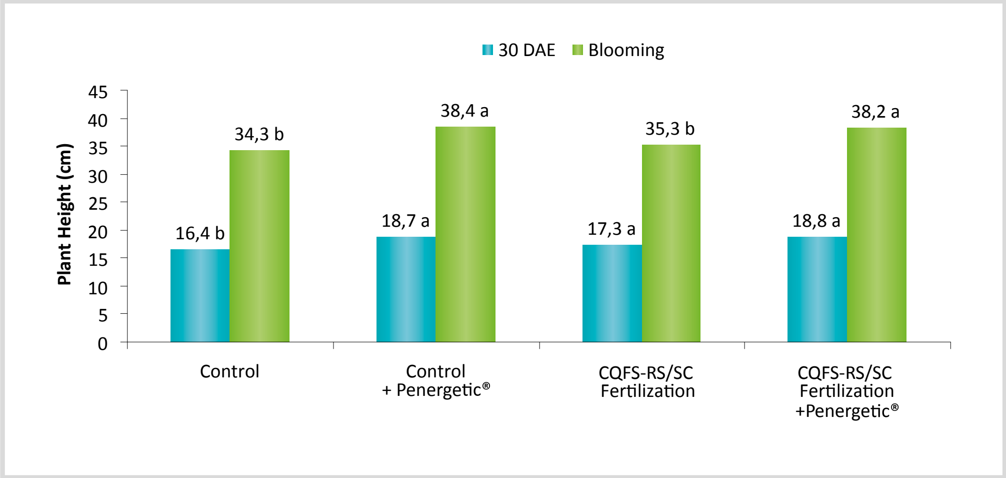



**Figure 1.** Number of Pratylenchus brachyurus nematodes penetrated in the roots of soybean at 30 days after emergence (DAE) and during blooming.

In terms of damage caused to the root system, after stages V4-5, at which point the cycle of phytonematodes is established within the root and the amount of neoplastic deformations, necrosis and root failure begin to correspond directly to the degree of parasitism and to the probable damage caused by the phytonematodes, the root damage in soybean was significantly lower in the plants treated with Penergetic ®.

**Figure 2.** The height of the soybean plants maintained in soil inoculated with *Pratylenchus brachyurus* phytonematoide at 30 days after emergence (DAE) and in the flowering stage (blooming).




Given the reduced effectiveness of available chemical nematicides, management of infested areas should be carried out by integrating a number of techniques, such as the use of crops and cultivars that are not hosts, the use of antagonistic plants and the use of technologies capable of limiting the damage caused by the attack of these organisms. **The results of this work demonstrate the efficiency of Penergetic technology as an auxiliary tool in the control of phytonematodes in the field, due to its effects in reducing the intensity of phytoparasitic infection in the root system of a soybean crop.**

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# Effects of Penergetic® technology on seed germination and chlorophyll content in soybean plants

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Brazil is currently the second largest producer of soybean in the world. The increased productive capacity in soybean production in Brazil is linked to scientific advances and availability of technologies in the production sector. Over the last 40 years, the worldwide soybean production increased by over 500%. In addition, lifestyle changes in countries such as China and the increasing demand for raw material to produce biodiesel suggest the continued growth in worldwide production. Vencato et al. (2010) estimate that soybean production in Brazil will increase by 40% by 2020, surpassing the U.S. in production and becoming the largest producer of this oil seed. However, in order to achieve this projection, it is urgent to provide technologies that can sustain this production level. According to the U.S. Department of Agriculture, Brazil exports and produces 26.5 and 31.3% of the worldwide supply of soybean, respectively.

According to Freitas (2011), increased soybean production has always been associated with scientific advances and availability of technologies. Included among these advances are mechanization, the creation of highly productive cultivars adapted to diverse regions and the development of technologies for crop management and pest management, since pests and diseases are responsible for a significant portion of the annual losses.

In this context, the adoption of innovative products that reduce the use of economically and environmentally costly inputs may be a viable strategy for achieving more sustainable productive systems without reducing crop productivity. Penergetic is noteworthy among these products as it utilizes electromagnetic energy to optimize photosynthetic efficiency in plants (Penergetic P). Pekarskas et al. (2011), evaluating the effect of Penergetic application in winter crops, reported increased wheat productivity and quality. Jankauskiene and Surviliene (2009), evaluating effect of different products on germination in garden crops, reported that Penergetic P increased seed vigor in tomato, radish, cucumber and beet. The same authors, evaluating Penergetic P powder on beet seedlings, reported greater absorption of active photosynthetic radiation, higher electron transmission rate and increased dry matter accumulation.

According to Motta et al. (2000), guaranteeing better crop performance depends essentially on seed quality, characterized by germination and vigor, which is determined by capacity of a seed lot to establish normal seedlings in field conditions.

Relative chlorophyll content is the parameter most evaluated to assess leaf nitrogen levels (N) in order to predict the level of fertilization needed. Chlorophyll content is important because it determines the photosynthetic potential of a plant through its control of the amount of solar radiation a leaf absorbs (HATFIELD et al., 2008).

The present work aimed to evaluate the effect of Penergetic P on soybean seed germination and photosynthetic process at the vegetative phase.

For the germination test, cultivar Nidera 5909 soybean seeds were treated with 0, 2, 2.5 and 3 grams Penergetic P per Kg of seed, with four repetitions of 25 seeds each. Germitest paper, in roll form, was moistened with distilled water at a proportion of 2 ½ the weight of the paper and the material was maintained at 25 °C. Germination was counted on the fifth day after assay installation.

Chlorophyll content was evaluated under field conditions, using cultivar Nidera 5909 and two treatments: Control and Penergetic P at a dose of 250 g / ha. Chlorophyll content was evaluated before application (Stage V3) and at stages V4, V6 and R1, in 12 plants per treatment.

The data for germination and chlorophyll content were analyzed using analysis of variance and Tukey's test at 5% probability.

Use of Penergetic P as a soybean seed treatment significantly increased germination and root growth (Figure 1), with concentrations of 2.5 and 3 grams per Kg seed, providing significantly higher germination in comparison to the other treatments. The longest root length was found at the dose of 3 grams of Penergetic, while 2 grams and 2.5 grams were superior to the Control treatment.

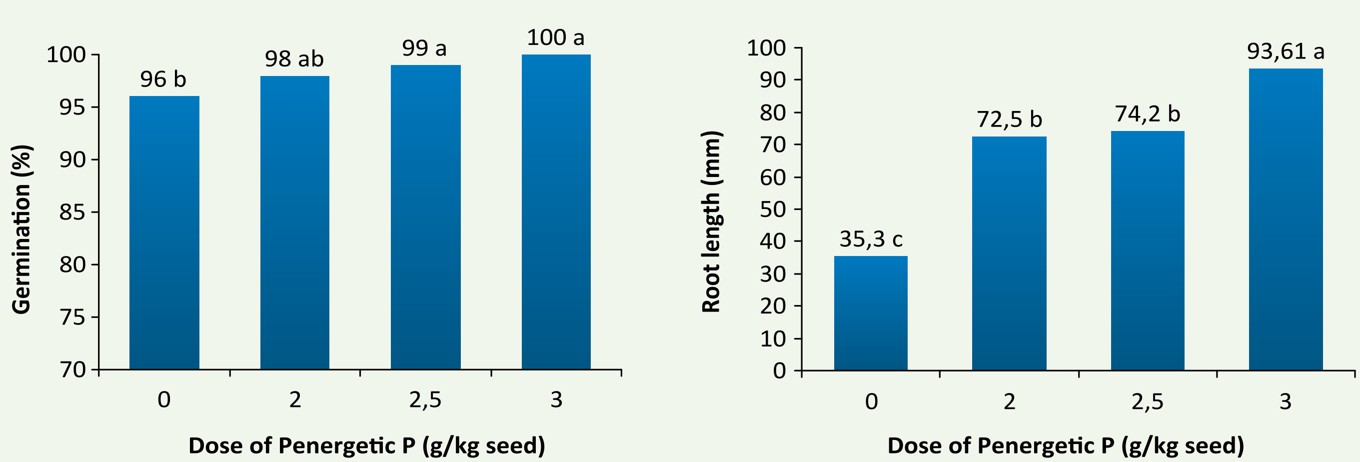


**Figure 1.** Germination percentage and root length in soybean at different doses of Penergetic P via seed treatment.

Penergetic P increased chlorophyll content, determined by chlorophyll meter, from application of the product until the R1 stage, presenting a quadratic response for this variable (Figure 2). This data is important due to the positive correlation between chlorophyll content and N content in the plant. N is an inductor of metabolic processes, with effects on absorption of macro and micronutrients and on allocation of matter and energy by plants (SILVA et al., 2011).

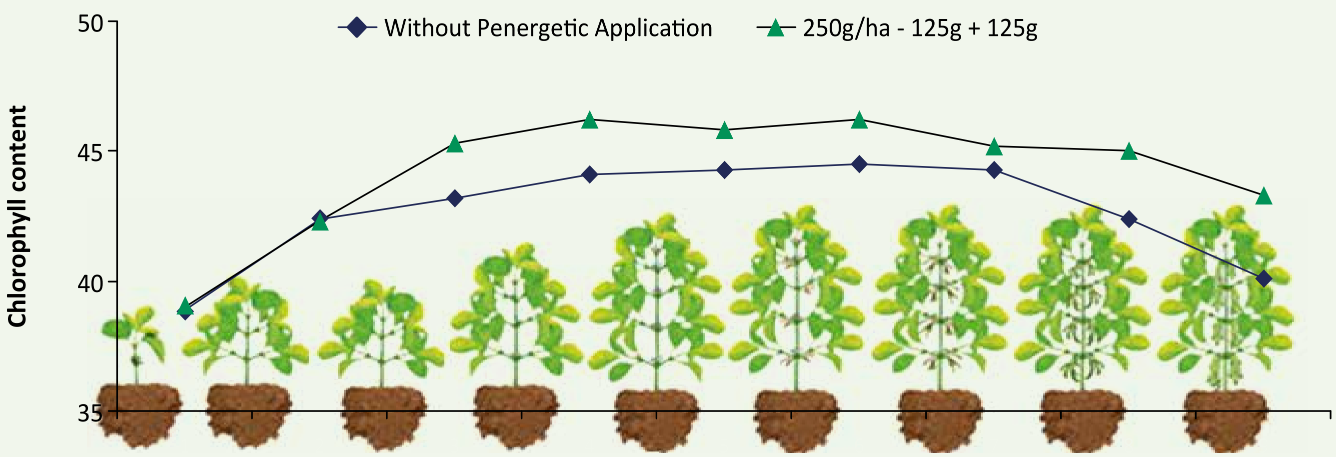


**Figure 2.** Falker chlorophyll content measured in soybean plants under different treatments.

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# Evaluation of Penergetic® P and Penergetic® K in temperate climate fruit trees

**Alessandra Vendrameto Martins** - Eng. Agrônoma.

**INTRODUCTION**

The productivity and fruit quality of an orchard result from the interaction of several factors, especially the genetic potential and the environment (management of the soil and nutrients and water balance). The maximum production and optimum fruit quality are achieved when the nutritional status of the plant is ideal. In many agricultural situations this condition is fulfilled by the annual supply of fertilizers and soil acidity correction. The nutritional aspect is particularly important for the fruit, due to the influence mineral elements have on their quality. Fruit trees are highly responsive to the addition of fertilizers. In many cases fertilization, and consequently the nutritional condition of crops, may affect not only productivity, but the size and weight of the fruit, color, appearance, taste, aroma, postharvest storage, resistance to pests and diseases, among others. The bioactivation or biological activation in plants is a positive interference that provides support to help them reach their productive potential, enabling plants to fully convert sunlight, water and nutrients into grains, fruit, fibers, cellulose, etc., facilitating their association with the soil and its microorganisms. This will result in a healthier and more robust and vigorous plant.

**OBJECTIVE**

The objective of this study is to evaluate the performance of products Penergetic® K and Penergetic® P in the bioactivation of the soil and cv Kampai peach plants.

**METHODOLOGY**

The experiment is being conducted on the property of Mr. Alberto Nascimento in the district of Campos de Holambra, municipality of Paranapanema, Sao Paulo state, in a 4 year-old Peach cv Kampai farm. Two treatments were applied, and the fertilizer is composed of 100kg / ha of potassium nitrate, 100kg / ha of urea and 150 kg / ha of KCl divided into two applications. The treatments:

Control: Standard local production treatment.

Treatment 1: 600 g/ha Penergetic® K and 600 g/ha Penergetic® P.

Penergetic® K was applied in a single dose on 6/26/2014, and applications of the Penergetic® P was applied in three separate applications: 06/18/2014; 07/02/2014 and 07/20/2014. The following evaluations were carried out: fruit shelf life and firmness (lbs), Brix (soluble solids) chemical analysis of the fruits and productivity.

**RESULTS**

The first soil analysis prior to conducting the experiment was carried out on 06/04/2014. At the end of the experiment, a new analysis to measure the total P level before and after the application of Penergetic® will be performed. For the evaluation shelf life, the fruits were visually observed (Figures 1 and 2) and firmness was evaluated with the help of a penetrometer. In addition, brix and fruit size were evaluated. Evaluations were made on the day of harvest and 3, 5, 7 and 10 days after harvest. For chemical analysis of the fruits, 15 fruits from each treatment were collected and sent to the laboratory. The analysis of the treated area showed levels of elements, such as potassium, calcium, manganese, among others, to be higher than those of the Control. For the evaluation of crop productivity, the fruits of three plants were counted and the mean of the three plants for each treatment was obtained. Afterwards, approximately 30 fruits from each treatment were collected and weighed in order to obtain mean yield per plant. The results were: 238 fruits per plant in the control, and 306 fruits per plant from the Treatment with Penergetic® K and Penergetic® P, a mean production increase of 68 fruits per plant with Penergetic® application. The mean weight in grams per fruit also presented differences: 85 grams in the control, and 88 grams in the Penergetic® treatment, even when the treated area showed a higher number of fruits per plant, its average weight was also higher. Production performance parameters in the Penergetic® treatment increased by 33% when compared to the control.

**CONCLUSIONS**

In conclusion, plants treated with Penergetic presented larger fruits and significantly higher productivity than those of the Control, with a 33% increase in mean weight per fruit when compared to the Control.

**FIGURE 1.** SHELF LIFE OF PEACHES FROM THE 1ST HARVEST



**FIGURE 2.** SHELF LIFE OF PEACHES FROM THE 2ND HARVEST

# The use of **soil and plant bioactivator with and without mineral fertilizer** in soybean and its relationship to nutritional bioavailability and production components

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Soybean (Glycine max L.) is of great importance to Brazilian agricultural activity, ranking second place among the main products worldwide, both in area and production value. The soils in which soybeans are grown usually have a high phosphoros fixation capacity (Q), which makes use of primary fertilizer efficient (Motomiya et al., 2004). Since the rate of absorption and transport of inorganic phosphorus (Pi) by roots is greater than its diffusion rate in the ground, a depletion zone is formed, resulting in depletion of P in the rhizosphere. In this way, the plant develops mechanisms to capture this element beyond that area, through associations or mutualistic symbioses among fungi and roots, which are denominated mycorrhiza (MOREIRA & Siqueira, 2002). The so-called modern soil management techniques have been greatly decreasing the diversity and number of mycorrhiza in the field, resulting in declines in resilience and stability of agro-ecosystems (JEFFRIES et al., 2003). In this respect, manufacturers of commercial products have been promoting the survival of these organisms, which target the stabilization of mycorrhiza in the soil and the decreased use of phosphate fertilizers, which are currently called plant and soil bioactivators.

Considering the importance of the fertilization of soybean for productivity gains and the complexity of the application and availability of P in the soil-plant system in tillage, this study aims to evaluate the use of a soil and commercial plant bioactivator in the presence and in the absence of fertilizer in the base as well as the nutritional bioavailability and production yield of soybean components. The experiment was conducted under field conditions in no tillage system in straw in the city of Palotina, Paraná state, during the period October 2014 to February 2015. The soil was classified as Oxisol type 3 and the chemical and particle size analysis are presented in Table 01. Four treatments were implanted, taking into account need for P in soybean crops (EMBRAPA SOY, 2010) and Penergetic application as a commericial bioactivator, as follow:

**T1** (+F+BI): 100% of phosphorus + 100% of bioactivator;
**T2** (+F-BI): 100% of phosphorus + 0% of bioactivator;
**T3** (-F+BI): 0% of phosphorus + 100% of bioactivator;
**T4** (-F-BI): 0% of phosphorus + 0% of bioactivator.

Glyphosate-resistant Cultivar TMG 7363® was used, placing 14 seeds per meter and applying the formulated fertilizer 07-36-10 ($N_2$, $P_2O_5$, $K_2O$) at 400 kg / ha. Each treatment area was 36 $m^2$. Penergetic® K was applied before sowing at a dose of 300 g / ha and Penergetic® P was applied twice: at 28 days after emergence (DAE), in V5 growth stage (150 g / ha.), and at 39 DAE, in R1 (150 g / ha.). After 86 DAE we performed leaf collection for analysis of leaf tissue: 25 leaves from the middle third of the plant in the R5.3 growth stage. The following macronutrients were determined: Phosphorus (P), nitrogen (N), potassium (K), calcium (Ca), Magnesium (Mg) and Sulfur (S) and the micronutrients Copper (Cu), Zinc (Zn), Manganese (Mn), Boron (B) and Iron (Fe).

At 115 DAE harvest took place, in which yield components were determined: number of pods per plant (NPP); number of grains per pod (NGP) and 100 grain-weight (M100); correcting grain moisture to 13%. The experimental design was completely randomized (DIC), with four treatments and three replications. The data were submitted to F test (Fisher) with analysis of variance (ANOVA), at 1% and 5% significance level, and means were compared by Tukey's test at 5% probability.

The results of the ANOVA for the macronutrients of the leaf tissue revealed a significant effect for P and N at 5% probability ($0.01 \leq p < 0.05$) and for the element K at 1% probability ($p < 0.01$ ). For other elements there were no significant differences (Table 02). Considering the development stage in which the leaves were collected (R5.3), several elements are transferred to the grains, having reduced their levels in leaf tissue (HALL, 1998). For P, it was observed that the highest average was expressed by **T3** treatment (-F + BI), which suggests that the full use of bioactivator without basic fertilization favored the increase of the element, although it was not statistically different from **T2** (+ F-BI) and **T4** (-F-BI), or from **T1** (+ F + BI), which presented the lowest mean.

In the absence of P in the base fertilization, the commercial bioactivator managed to maintain the mean level of this nutrient, although this was due to the fact that the soil was able to provide P satisfactorily, from the availability that was already in the field, as determined by soil analysis (Table 01). Soybeans have potential to provide high yields even under low or no phosphorus fertilization, especially when there is a residual effect from previous fertilizations, as long as the availability of P in soil is above levels considered to be critical (LANTAMANN et al., 1996), which event occurred in this experiment.

Yet when plants absorb P at rates that exceed the growth demand, some processes act in order to prevent the accumulation of toxic concentrations of P (Shachtman et al., 1998). Considering these facts, **the treatment T1 (+ F + BI), which presented the lowest mean, could be linked to this regulation of P in the plan**t.

ANOVA revealed that there were no statistical differences by the F test ($p \geq 0.05$) for leaf tissue micronutrients. This may be explained when we observe the levels of micronutrients found in the soil, as as can be seen in Table 01: all the elements are within the ideal parameters, enabling their delivery to the plant during its cycle (EMBRAPA SOJA, 2010).

Analysis of yield components (Table 3) revealed that the NPP and M100 variables presented significant differences by the F test at 5% probability ($0.01 \leq p < 0.05$) whereas for the variable NGP there were no significant differences by the test F ($p \geq 0.05$). In the evaluation of M100, it was noted that the treatments T2 (+ F-BI) and T3 (-F + BI) presented superior means when compared to the others, but were not statistically different from T1 (+ F + BI). The T4 treatment (-F-BI) presented the lowest mean, but did not differ from T1 (+ F + BI). This leads us to conclude that the use of both mineral P and the use of bioactivator, individually, were able to raise the grain mass.

Is worth mentioning that the initial P level in the soil was 24.60 mg dm-3 (Table 1), a high content according to Embrapa Soja (2010). Therefore, it is concluded that for leaf P the use of the commercial bioactivator was similar to that of mineral fertilizer. For micronutrients, there were no significant results. Yield components indicated that the bioactivator provided results equivalent to mineral fertilization, although these data refer to a single harvest. However, there should also be similar evaluations with other cultivars and fertility conditions, mainly in soil with limited P in order to complement the results found in this experiment.

**Table 1**. Soil Analysis Results

| pH | P | $K^+$ | $Ca^{2+}$ | $Mg^{2+}$ | $Al^{3+}$ | $H^+ + Al^{3+}$ | SB | CTC |
|---|---|---|---|---|---|---|---|---|
| $H_2O$ | mg $dm^{-3}$ | ---------------------------------- $cmol_c$ $dm^{-3}$ ---------------------------------- | | | | | | |
| 5,65 | 24,6 | 0,6 | 6,61 | 1,11 | 0 | 3,83 | 8,32 | 12,15 |
| **V** | **Fe** | **Cu** | **Zn** | **Mn** | **$S(SO_4)^{-2}$** | **Clay** | **Silt** | **Sand** |
| % | ----------------------mg $dm^{-3}$------------------- | | | | | ---------------- % -------------- | | |
| 68,51 | 69,94 | 10,98 | 7,24 | 324,17 | 19,05 | 7,68 | 23,44 | 68,88 |

P, $K^+$, $S(SO_4)^{-2}$ = Mehlich-I. $Al^{+3}$, $Ca^{+2}$ e $Mg^{+2}$ = KCl 1 N.

**Table 2.** Result of macronutrients in plant tissue

| Treatments | P * | N * | K ** | Ca ns | Mg ns | S ns |
|---|---|---|---|---|---|---|
| | ---------------------------------------- g $Kg^{-1}$ ---------------------------------------- | | | | | |
| T1(+F+BI) | 3,76 b | 31,26 b | 18,33 a | 17,48 a | 1,53 a | 4,48 a |
| T2(+F-BI) | 4,13 ab | 31,56 b | 16,96 b | 16,68 a | 1,28 a | 4,94 a |
| T3(-F+BI) | 4,39 a | 31,92 b | 18,33 a | 16,28 a | 1,40 a | 4,72 a |
| T4(-F-BI) | 4,00 ab | 37,24 a | 15,98 b | 16,29 a | 1,62 a | 4,82 a |
| Mean | 4,07 | 32,99 | 17,4 | 16,68 | 1,46 | 4,74 |
| CV (%) | 5,28 | 5,89 | 2,41 | 3,81 | 9,11 | 8,77 |

The averages followed by the same letter in the same column do not differ statistically. Tukey's test was applied at 5% probability; ns - not significant;
** - Significant at 1% probability by F test (Fischer);
* - Significant at 5% probability by F test; CV - Coefficient of variation.

**Table 3.** Results of production components analysis

| Treatments | NPP* | NGL ns | M100* (g) |
|---|---|---|---|
| T1(+F+BI) | 47,27 a | 2,32 a | 11,32 ab |
| T2(+F-BI) | 38,30 ab | 2,50 a | 11,52 a |
| T3(-F+BI) | 47,17 a | 2,54 a | 11,62 a |
| T4(-F-BI) | 34,15 b | 2,25 a | 09,94 b |
| Mean | 41,72 | 2,4 | 11,09 |
| CV (%) | 14,51 | 8,02 | 6,6 |

NPP - number of pods per plant; NGP - number of grains per pod and M100 - mass of 100 grains.
The means followed by the same letter in the same column do not differ statistically.
Tukey's test was applied at 5% probability; ns - not significant;
* - Significant at 5% probability by F test (Fischer). CV - Coefficient of variation.

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penergetic

# Phosphate fertilizer adjustment using Penergetic® technology in soybeans

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**Carlos Ernesto Machado** Agricultural Engineer
**Jéssica Guimarães Santana dos Reis** Agricultural Engineer

Currently, world agricultural production founded upon the use of high amounts of inputs related to fertilization of crops and control of pests and diseases, resulting in increased environmental pollution and rising costs of production. In Brazil, a country with great competitiveness in international agribusiness, this situation is no different.

In the search for alternative sustainable agriculture, Oliveira et al. (2014) reported that many of the advances made by Brazilian agribusiness are due to the widespread use of fertilizers and pesticides, which are necessarily imported in large quantities in order to keep up with the demand of Brazilian agriculture. Also, according to the researcher, the safety and sustainability of Brazilian agribusiness are threatened by the availability and susceptibility of these inputs to the prices of the international market. In addition, there is growing pressure to achieve higher productivity in a more sustainable way to provide the growing population with food and energy.

Reports published by FAO and UNESCO cite countries such as Brazil as potential exporters of food in the coming years, due to the country's soil and climatic conditions and area. However, we must ask ourselves at what cost? Currently 53% of the phosphorus and 93% potassium used in Brazilian agriculture, in various crops, are mainly imported from countries like Russia and China, in the case of phosphates and Russia and Canada in the case of potash fertilizers. According to projections, the dependence on imports of these fertilizers will increase significantly by 2025.

Research carried out in China (the largest producer and consumer of phosphate fertilizer) showed that only excess fertilizers used by Chinese farmers in recent years would supply all the demand for phosphate fertilizers in Western Europe and half the demand of African countries (Sattari et al. , 2015). MacDonald et al. (2010) determined that the phosphorus surplus in world agriculture exceeds 13 kg per hectare per year. Bouwman et al. (2010) in a review on nutrient losses and demand for mineral fertilizers in agriculture, demonstrated that between the years 1950-2000, the phosphorus surplus added to soils was 11 million tons. The same study indicates that by the year 2050 if the global agriculture does not adopt mitigation measures, the surplus will increase by approximately 54%.

In 2013, during the 7th International match Workshop, held in Sweden, research areas were defined aiming to: **1)** optimize the management of phosphorus in the world modifications; **2)** determine soil phosphorus transport routes for surface and subsurface waters; **3)** intensify the monitoring, modeling and communication regarding phosphorus used in agriculture; **4)** determine the importance of organic farming systems to match management; **5)** identify appropriate measures to reduce phosphorus losses and **6)** implement mitigation strategies to reduce losses and the use of phosphorus. In this sense, the adoption of alternative and innovative products that result in reducing the use of high economic and environmentally costly inputs, represents a viable strategy for producers that are seeking to adopt more sustainable production systems without reducing crop yields. In this sense, this study aimed to evaluate the possibility of adjusting phosphorus fertilization, using Penergetic® technology in soybeans.

The tests consisted of side by side plantations/crops in 28 properties in the South of Brazil, 18 properties in the Southeast and 11 properties in the Midwest region in the agricultural year 2013/2014, in addition to 100 properties in the South of Brazil, 17 properties in the Southeast, 9 properties in the Midwest region in the agricultural year 2014/2015. The treatments were: **1)** local producer's standard (standard NPK) and **2)** use of Penergetic® technology with adjustment of phosphate fertilizer based on analysis of the fertility of the evaluated soil in each property, according to the NPK formulations for each region. Potassium fertilization was standardized in the areas and in treatments, being used in coverage in the form of potassium chloride. Penergetic® K (250 g ha-1) was applied to the soil during desiccation in pre-sowing and Penergetic® P (250 g $ha^{-1}$) was applied to the leaf in two stages, 125 g in the V3 stage and 125 g 15 days after the first application.

The control of pests, diseases and weeds was performed according to the technical indications for the crop, being identical in side by side plots. During the


harvest, all areas were monitored by the producer and the work team, determining the productivity of the 58 crops through measurements per area. The results were analyzed by analysis of variance (ANOVA) using Sisvar software. The means of each treatment were compared by Tukey's test at 5% probability ($P < 0.05$).

The use of Penergetic® technology significantly reduced phosphorus fertilization in all groups, maintaining productivity at levels higher than observed in the "Local Producer Standard" groups. According Veneklaas et al. (2012), the reduction in availability of phosphorus for crops can directly result in impaired productivity. However, according to the author, limiting productivity only occurs if technologies that enhance efficiency in the use of fixed nutrients in the soil are not used.

Owen et al. (2015) in studies on the use of effective microorganisms demonstrated the importance of microbial diversity in crop yields. This work points out the current trend of increased use of inputs stemmed from "green" technologies, increasing the mineralization of essential nutrients in crops, especially of phosphorus (P), and increasing its availability to plants. McDaniel et al. (2014), in a meta-analysis of 122 studies published in recent years on the effects of agriculture on soil microflora, concluded that the lack of crop rotation and monoculture are selecting microorganisms adapted to certain plants and, therefore, determining the microbiological reactions occurring in these soils and the intensity of these reactions, increasing imbalances with harmful effects on agricultural sustainability.

At the crop level, phosphorus efficiency is linked to the efficiency of microorganisms to make nutrients available. According to the authors, the phosphorus input in the production system in adjusted dosages is a key measure in mitigating the recurring excesses in Brazilian and world agriculture.

According to Gatiboni et al. (2008), organic forms of phosphorus (Po) are phosphate ions bound to organic compounds, their lability being directly related to the susceptibility of the decomposing organic radical to which the phosphate is attached. According to the authors, this storage form of phosphorus in the soil is highly susceptible to microbial attack and makes up the "pool" of labile soil phosphorus. According to the author, in soil fertilized with phosphorus in mineral form, the organic phosphorus contribution to plant nutrition is only 6%. However, to the extent that the soil no longer receives phosphorus fertilization, this contribution is replaced by values close to 45%. According to Stevenson (1994), the organic phosphorus can contribute to up to 80% of total soil phosphorus, being extremely relevant in tropical soils, working actively in the availability of this nutrient to plants. Thus, the biological processes regulate the dynamics and distribution of labile forms of phosphorus in the soil. Social, economic and environmental benefits practiced in a sustainable agriculture represent the most viable path for the trends of productive growth with social, economic and environmental responsibility.

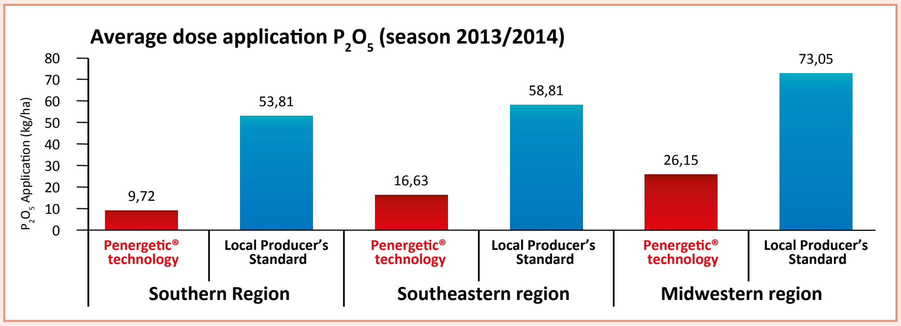


**Figure 1**. Average dose application $P_2O_5$ in the South, Southeast and Midwest in trials side by side between Penergetic® technology and local producer's standard fertilization. (Harvest 2013/2014).

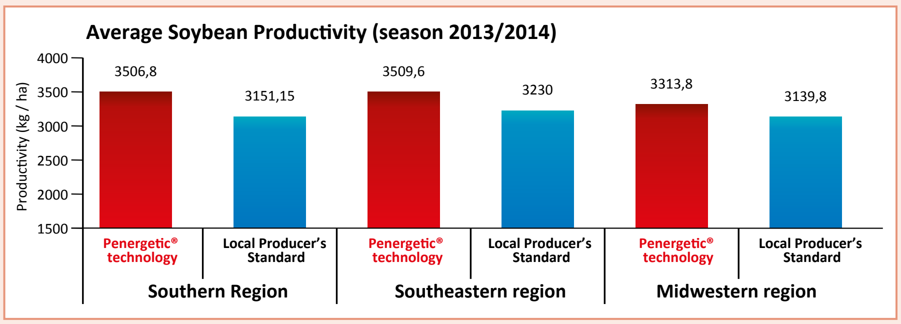


**Figure 2.** Average productivity of soybeans in the South, Southeast and Midwest in trials side by side with Penergetic® technology and local producer's standard fertilization. (Harvest 2013/2014).

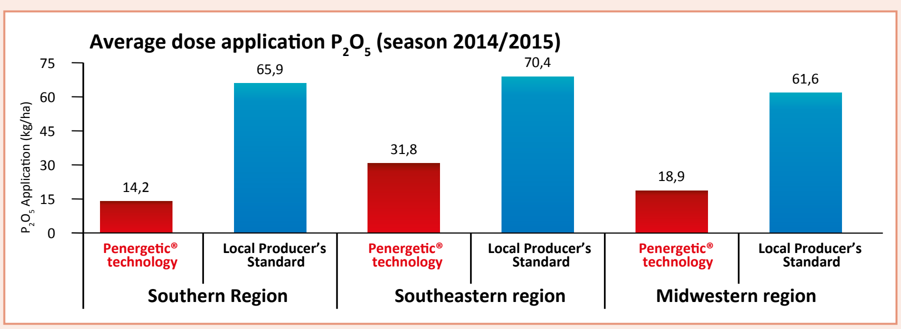


**Figure 3.** Average dose application of $P_2O_5$ in the South, Southeast and Midwest in trials side by side between Penergetic® technology and local producer's standard fertilization (Harvest 2014/2015).

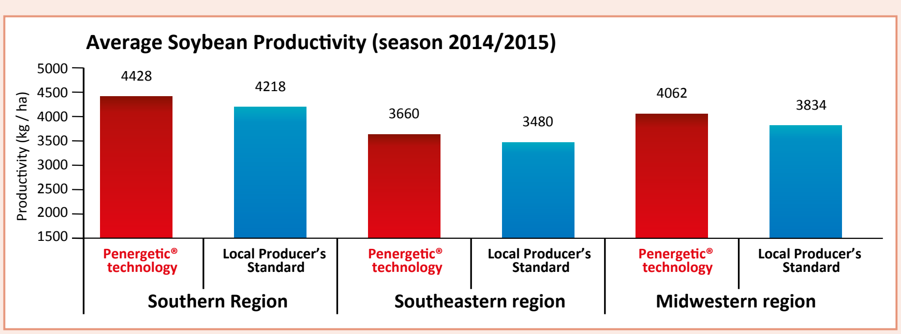


**Figure 4.** Average productivity of soybeans in the South, Southeast and Midwest in trials side by side with Penergetic® technology and local producer's standard fertilization (Harvest 2014/2015).

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# Effect of Penergetic® P and Penergetic® K on soybean production

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## INTRODUCTION

Crops' need for phosphorus is generally lower than that for potassium (K) and nitrogen (N), however, the amount applied is typically higher (Vieira, 2006). This is due to the high P fixation rate in tropical soils, mainly caused by precipitation with Fe and Al, reaction with hydrated oxides of these metals and reaction with silicate clays. Because of this, phosphorus utilization in crops varies from 5% to 25% (Malavolta, 1980). In this sense, there may be elevated levels of phosphorus in the soil without increased availability to plants. Thus, the development of technologies that provide greater availability of phosphorus for plants could provide a reduction in the amount of phosphate fertilizers applied to the soil, causing economic and environmental gains, since these fertilizers are produced from non-renewable mineral reserves (Pelá et al., 2009).

The Penergetic® technology consists of the application of Penergetic® K and P products, using bentonite clay and / or calcium carbonate as vehicles, which are subjected to the application of electric and magnetic fields (Brito et al., 2012). These products, according to the manufacturer, are used as a soil bioactivator (Penergetic® K, applied to the soil), which increases and balances the microbiological activity in the soil, and a plant bioactivator (Penergetic® P), which provides more energy to the photosynthetic process and facilitates beneficial plant-microbe interactions (Penergetic®, 2013). There are already promising results from the use of these products in wheat (Pekarskas, 2012;. Kadziuliene et al, 2005), vegetables (Jankauskiene et al., 2009), common bean (Brito et al, 2012.) and potato (Jakiene et al., 2008).

## OBJECTIVE

This study aimed to evaluate the effects of Penergetic® K and Penergetic® P in soybean production, as well as to validate the recommendations of phosphorus and potassium fertilization in the field.

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## METHODOLOGY

Field experiments were conducted in the following four municipalities of Unaí, Minas Gerais; Silvânia-GO; Jataí-GO and Fortaleza do Tabocão-TO. The chemical and physical characteristics of the soils in the experimental areas are described in Tables 1, 2, 3 and 4.

**Table 1.**

Soil analysis of the experimental area of Jataí-GO, 2014/2015

| | pH | M.O. | | Ca | Mg | Al | H+Al | V | M |
|---|---|---|---|---|---|---|---|---|---|
| (cm) | (water) | g/dm³ | mmolc/dm³ | | | | | % | |
| 0-10 | | 46 | | 3,7 | 0,7 | | | 63 | |
| K | P | B | Cu | Fe | Mn | Zn | Clay | Silt | Sand |
| mg/dm³ | mg/dm³ | mg/dm³ | | | | | g/kg | | |
| 210 | 11 | 0,28 | 7 | 26,8 | 33,1 | | 370 | 90 | 540 |

Extraction Methods: P-Mehlich (for Phosphorus), hot water Boron extraction, DTPA extractant for plant available Fe, Zn, Cu, Mn – hot water

**Table 2.**

Soil analysis of the experimental area of Silvânia GO, 2014/2015.

| | pH | M.O. | | Ca | Mg | Al | H+Al | V | M |
|---|---|---|---|---|---|---|---|---|---|
| (cm) | (water) | g/dm³ | mmolc/dm³ | | | | | % | |
| 0-10 | 5,6 | 30 | | 3,1 | 1,3 | | | 63 | |
| K | P | B | Cu | Fe | Mn | Zn | Clay | Silt | Sand |
| mg/dm³ | mg/dm³ | mg/dm³ | | | | | g/kg | | |
| 170 | 8,8 | 0,19 | 2,9 | 41 | 21,5 | | 370 | 90 | 540 |

Extraction Methods: P-Mehlich (for Phosphorus), hot water Boron extraction, DTPA extractant for plant available Fe, Zn, Cu, Mn – hot water

**Table 3.**

Soil analysis of the experimental area of Unaí, Minas Gerais, 2014; 2015.

| | pH | M.O. | | Ca | Mg | Al | H+Al | V | m |
|---|---|---|---|---|---|---|---|---|---|
| (cm) | (water) | g/dm³ | mmolc/dm³ | | | | | % | |
| 0-10 | 5,4 | 26 | | 3,2 | 1,1 | | | 59 | |
| K | P | B | Cu | Fe | Mn | Zn | Clay | Silt | Sand |
| mg/dm³ | mg/dm³ | mg/dm³ | | | | | g/kg | | |
| 162 | 8,9 | 0,3 | 3,8 | 45 | 26,3 | 2,4 | 360 | 100 | 540 |

Extraction Methods: P-Mehlich (for Phosphorus), hot water Boron extraction, DTPA extractant for plant available Fe, Zn, Cu, Mn – hot water

**Table 4.**

Soil analysis of the experimental area of Fortress of Tabocão-TO, 2014/2015.

| | pH | M.O. | | Ca | Mg | Al | H+Al | V | M |
|---|---|---|---|---|---|---|---|---|---|
| (cm) | (water) | g/dm³ | mmolc/dm³ | | | | | % | |
| 0-10 | 4,5 | 56 | | 2,5 | 0,8 | | | 47 | |
| K | P | B | Cu | Fe | Mn | Zn | Clay | Silt | Sand |
| mg/dm³ | mg/dm³ | mg/dm³ | | | | | g/kg | | |
| 90 | 8,4 | 0,32 | 2,2 | 37 | 25,1 | 2 | 400 | 100 | 500 |

Extraction Methods: P-Mehlich (for Phosphorus), hot water Boron extraction, DTPA extractant for plant available Fe, Zn, Cu, Mn – hot water

The experimental design used in all trials consisted of randomized blocks with ten repetitions, with 30 M  40 M. The treatments were formed by a 3x2 factorial, with three doses of fertilizer (No fertilizer; Recommended Use Penergetic® and fertilization standard) and two treatments (No Penergetic® and with Penergetic®). Penergetic® K was applied at a dose of 250 g / ha applied at the time of planting and Penergetic® P was applied at a dose of 250 g / ha performed 20 days after germination. The treatments were designated as:

**T1** - No fertilizer;

**T2** - No fertilizer + Penergetic® Technology;

**T3** - Penergetic Recommended Fertilization;

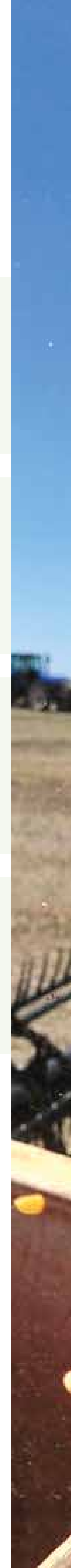
**T4** - Penergetic Recommended Fertilization + Penergetic Technology.;

**T5** - Standard farm fertilization;

**T6** - Standard farm fertilization + Penergetic® Technology.

The table on the right describes the seeding of data in each region:

| | |
|---|---|
| **Fortaleza do Tabocão -TO**<br>Sowing: Oct / 2014<br>Cultivar: 8667<br>Density: 13 seeds / linear m | **Silvânia-GO**<br>Sowing: Nov / 2014<br>Cultivar: Nidera 7227<br>Density: 20 seeds / linear m |
| **Unaí-MG**<br>Sowing: Oct / 2014<br>Cultivar: 8667<br>Density: 13 seeds / linear m | **Jataí-GO**<br>Sowing: Nov / 2014<br>Cultivar: Nidera 5904<br>Density: 16 seeds / linear m |



In the four experiments, we used 50 cm spacing between rows and broadcast application of 150 kg / ha KCl was performed before planting. The evaluations were: Number of grains / m², 100-grain mass (g) and final yield (corrected to 13% moisture). Data were subjected to analysis of variance and Tukey's test (5%).

**RESULTS**

Based on the analysis of Table 5 and Figure 1, it is possible to observe that in Jataí-GO there was a significant treatment effect on the 100-grain mass, grains / m² and in the final soybean yield. **It was observed that in treatments where no fertilizer was used, there was a significant increase in the productivity of soybeans with the use of Penergetic® technology, ranging from 5 to 8%.**

Analyzing Table 6, it is possible to see that there was an increase in the number of grains / m² when applying Penergetic®, however this increase was not significant. The 100-grain mass presented an increase of 3 to 5% with the application of Penergetic® (Table 7).

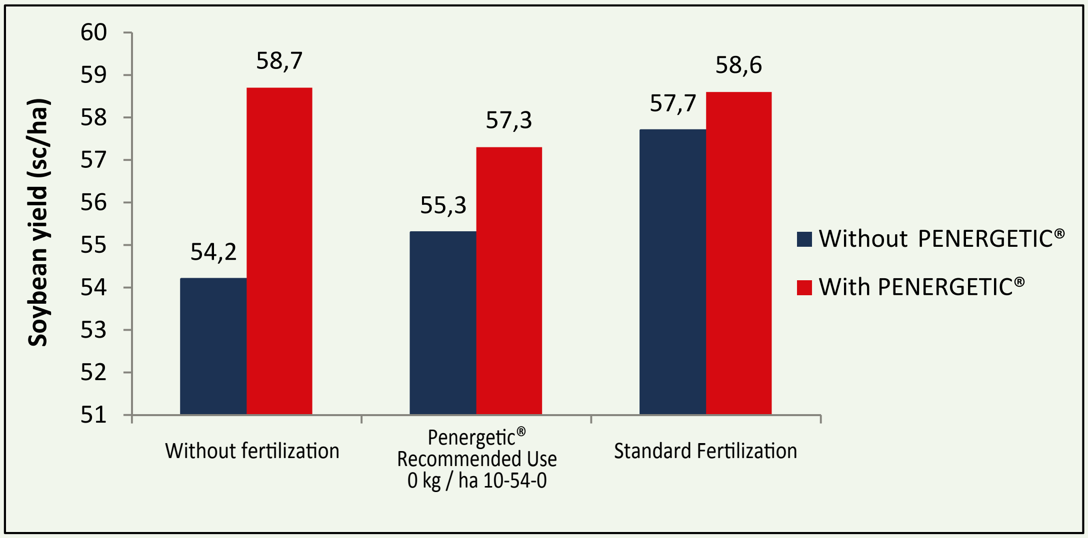
For the standard fertilization treatment (complete fertilizer), Penergetic® technology did not promote a significant increase in vegetable yield.

**In this experiment we found that it was possible to eliminate basic fertilization with the application of Penergetic® technology, likely because the activation effect on soil microbiota provides greater release of nutrients to the plant.**

Table 5. Soybean yield in the treatments. Jataí-GO, 2014/2015.

| Repetitions | Without Fertilization | | Penergetic® Recommended Use 0 kg / ha 10-54-0 | | Standard Fertilization | |
|---|---|---|---|---|---|---|
| | W/O PEN | W/ PEN | W/O PEN | W/ PEN | W/O PEN | W/ PEN |
| 1 | 53,4 | 66,6 | 56,5 | 56,6 | 57,3 | 55,2 |
| 2 | 53 | 59,2 | 55,9 | 59,3 | 54,6 | 56,3 |
| 3 | 55,7 | 60 | 56,7 | 55,8 | 60 | 59 |
| 4 | 54,7 | 64,6 | 54,7 | 57,4 | 55,1 | 58,4 |
| 5 | 53,4 | 55,6 | 54 | 55,5 | 57,5 | 57,6 |
| 6 | 55,7 | 53,5 | 54 | 58,9 | 57,9 | 59,1 |
| 7 | 55,5 | 58,6 | 55,2 | 58,3 | 56,2 | 60,1 |
| 8 | 53,9 | 53,2 | 56,6 | 57,7 | 57,3 | 57 |
| 9 | 53,5 | 58 | 55 | 55,4 | 60 | 63,2 |
| 10 | 53,4 | 58,7 | 55 | 58,7 | 57,7 | 60 |
| **Mean** | **54,2 b** | **58,7 a** | **55,3 ab** | **57,3 ab** | **57,7 ab** | **58,6 a** |
| % | 100 | 108 | 102 | 105 | 106 | 108 |
| **C.V: 4,9%** | | | | | | |

**Graph 1**. Mean soybean yield in the treatments. Jataí-GO, 2014/2015




*Means followed by the same letter do not differ by Tukey test at 5% probability

**Table 6.** Number of grains / m2 of the soybean in treatments. Jataí-GO, 2014/2015.

| Repetitions | Without Fertilization | | Penergetic® Recommended Use 0 kg / ha 10-54-0 | | Standard Fertilization | |
|---|---|---|---|---|---|---|
| | W/O PEN | W/ PEN | W/O PEN | W/ PEN | W/O PEN | W/ PEN |
| 1 | 1982 | 2452 | 2125 | 2114 | 2219 | 1950 |
| 2 | 2056 | 2064 | 2103 | 2052 | 2214 | 2077 |
| 3 | 2120 | 2267 | 2104 | 2081 | 2076 | 2169 |
| 4 | 2001 | 2382 | 2092 | 2138 | 2391 | 2194 |
| 5 | 2116 | 2023 | 2089 | 2130 | 2038 | 2095 |
| 6 | 2132 | 2015 | 2164 | 2234 | 2218 | 2169 |
| 7 | 2137 | 2150 | 2113 | 2277 | 2189 | 2157 |
| 8 | 2087 | 2085 | 2131 | 2043 | 2175 | 2070 |
| 9 | 2137 | 2157 | 1966 | 2101 | 2208 | 2259 |
| 10 | 1965 | 2145 | 2181 | 2188 | 2348 | 2146 |
| **Mean** | **2073 b** | **2173 ab** | **2106 ab** | **2135 ab** | **2207 a** | **2128 ab** |
| % | 100 | 104 | 101 | 102 | 106 | 102 |
| **C.V: 4,7%** | | | | | | |

*Means followed by the same letter do not differ by Tukey test at 5% probability

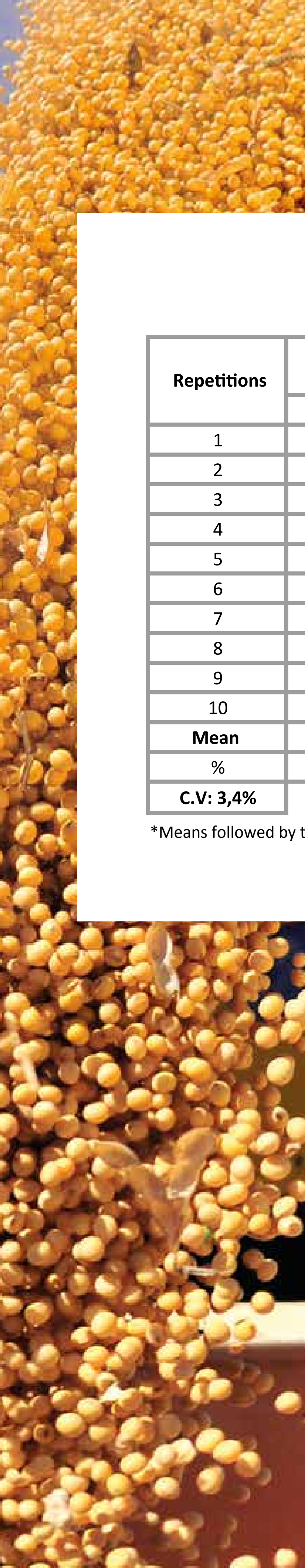


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**Table 7. 100-grain mass (g) of soybean** in the treatments. Jataí-GO, 2014/2015.

| Repetitions | Without Fertilization | | Penergetic® Recommended Use 0 kg /ha 10-54-0 | | Standard Fertilzation 250kg /ha 10-54-0 | |
|---|---|---|---|---|---|---|
| | S/ PEN | C/ PEN | S/ PEN | C/ PEN | S/ PEN | C/ PEN |
| 1 | 16,2 | 16,3 | 16 | 16,1 | 16,4 | 17 |
| 2 | 15,5 | 17,2 | 16 | 17,4 | 15,5 | 16,3 |
| 3 | 15,8 | 15,9 | 16,2 | 16,1 | 15,8 | 16,3 |
| 4 | 16,2 | 16,3 | 15,7 | 16,1 | 15 | 16 |
| 5 | 15,1 | 16,5 | 15,5 | 15,6 | 16,2 | 16,5 |
| 6 | 15,7 | 15,9 | 15 | 15,8 | 15,6 | 16,4 |
| 7 | 15,6 | 16,4 | 15,7 | 15,4 | 15,9 | 16,7 |
| 8 | 15,5 | 15,3 | 15,9 | 16,9 | 15,5 | 16,5 |
| 9 | 15 | 16,1 | 16,8 | 15,8 | 15,6 | 16,8 |
| 10 | 16,3 | 16,4 | 15,1 | 16,1 | 15,3 | 16,8 |
| **Mean** | **15,6 b** | **16,2 ab** | **15,7 b** | **16,1 ab** | **15,6 b** | **16,5 a** |
| % | 100 | 103 | 100 | 103 | 100 | 105 |
| **C.V: 3,4%** | | | | | | |

*Means followed by the same letter do not differ by Tukey test at 5% probability

In Silvânia-GO, as can be seen in Table 8 and Figure 2, the application of Penergetic® K and Penergetic® P in the treatment without fertilization and the treatment with fertilization as recommended by Penergetic®, generated an increase of 8-9% in soybean yield, reaching the same level of productivity provided by treatment with standard farming fertilization.

In the no-fertilization treatment, the use of Penergetic® technology provided an increase in the 100-grain mass (Table 9) and the number of grains / m², where all three treatments using Penergetic (without fertilization, Penergetic® Recommended Use and standard fertilizer) presented better results (Table 10).

In Jataí-GO, it was also possible to eliminate base fertilization using Penergetic® technology.

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**Table 8. Soybean yield** (sc / ha) by treatment. Silvânia-GO, 2014/2015.

| Repetitions | Without fertilization | | Penergetic® Recommended Use 100 kg 5-37-00 | | Standard Fertilization 300 kg 5-37-00 | |
|---|---|---|---|---|---|---|
| | W/O PEN | W/ PEN | W/O PEN | W/ PEN | W/O PEN | W/ PEN |
| 1 | 56,8 | 63 | 59,2 | 59,8 | 63,9 | 62,9 |
| 2 | 52,5 | 60,7 | 57,3 | 59,5 | 65,3 | 63,3 |
| 3 | 58,5 | 59,5 | 60,2 | 66,3 | 63,1 | 65,6 |
| 4 | 59,3 | 63,2 | 56,4 | 60,4 | 62,6 | 59,3 |
| 5 | 58,9 | 66,7 | 56,2 | 60,6 | 57,3 | 65,5 |
| 6 | 56 | 59,5 | 58,8 | 59,2 | 63,9 | 62,1 |
| 7 | 58,1 | 61,1 | 54,1 | 60,8 | 61,8 | 61,4 |
| 8 | 54,6 | 64,4 | 59 | 63 | 68,1 | 62,2 |
| 9 | 54,5 | 56,4 | 58,4 | 58,8 | 64 | 67,1 |
| 10 | 55,9 | 60,1 | 59 | 62,6 | 67,9 | 62,6 |
| **Mean** | **56,5c** | **61,4 ab** | **57,8 bc** | **61,1 ab** | **63,7 a** | **63,2 ab** |
| % | **100** | **109** | **102** | **108** | **113** | **112** |
| **C.V: 4,3%** | | | | | | |

*Means followed by the same letter do not differ by Tukey test at 5% probability

**Graph 2. Average soybean** yield in the treatments. Silvânia-GO, 2014/2015.

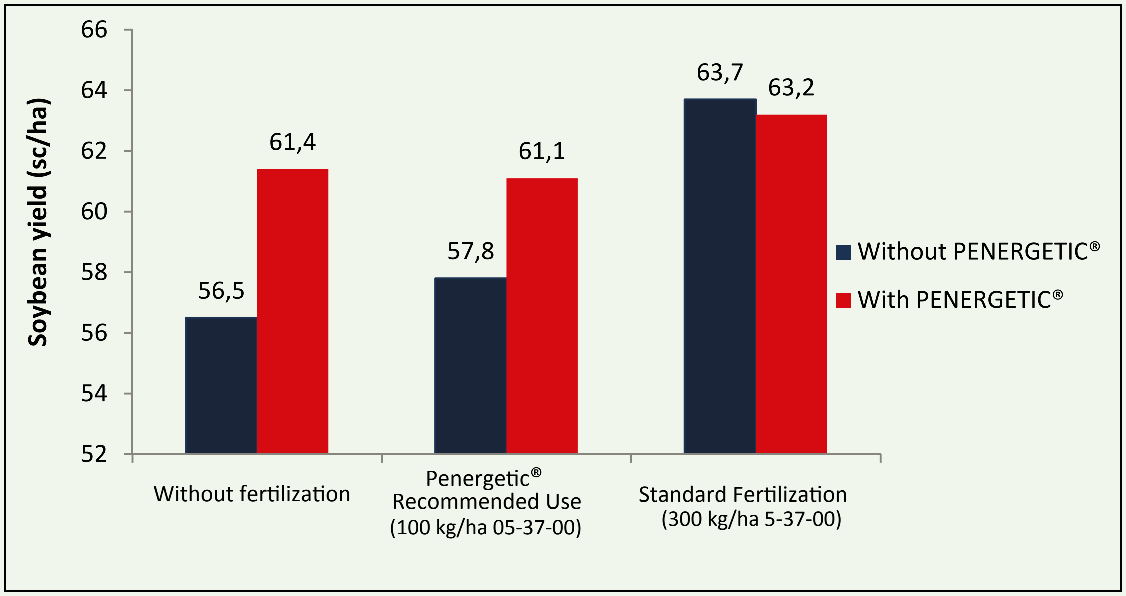


**Table 9. 100-grain mass of soybean** in the treatments. Silvânia-GO, 2014/2015.

| Repetitions | Without Fertilization | | Penergetic® Recommended Use 100 kg 5-37-00 | | Standard Fertilization 300 kg 5-37-00 | |
|---|---|---|---|---|---|---|
| | W/O PEN | W/ PEN | W/O PEN | W/ PEN | W/O PEN | W/ PEN |
| 1 | 17,9 | 18,7 | 18,6 | 17,4 | 19,2 | 18 |
| 2 | 17,7 | 18,6 | 18,6 | 18,3 | 19,6 | 18,1 |
| 3 | 18,3 | 18,4 | 18,6 | 18,1 | 19,3 | 18,7 |
| 4 | 19,1 | 18,4 | 17,6 | 18,4 | 18,4 | 18,3 |
| 5 | 17,7 | 18,4 | 18,4 | 17,4 | 17,9 | 18,5 |
| 6 | 18,2 | 17,8 | 17,9 | 17,5 | 18,5 | 18,7 |
| 7 | 17,6 | 18,8 | 19,6 | 17,8 | 18,3 | 18,8 |
| 8 | 17,6 | 18,5 | 18,6 | 17,5 | 18,9 | 18,8 |
| 9 | 17,6 | 18,7 | 18,4 | 18,5 | 19,6 | 18,8 |
| 10 | 17,1 | 18,5 | 18,5 | 17,9 | 18,5 | 19 |
| **Mean** | **17,8b** | **18,4 ab** | **18,4 ab** | **17,8 b** | **18,8 a** | **18,5 a** |
| % | 100 | 103 | 103 | 100 | 105 | 104 |
| **C.V: 4,4%** | | | | | | |

*Means followed by the same letter do not differ by Tukey test at 5% probability

**Table 10. Number of grains / m2 of soybean** in the treatments. Silvânia-GO, 2014/2015

| Repetitions | Without fertilization | | Penergetic® Recommended Use 100 kg 5-37-00 | | Standard Fertilization 300 kg 5-37-00 | |
|---|---|---|---|---|---|---|
| | W/O PEN | W/ PEN | W/O PEN | W/ PEN | W/O PEN | W/ PEN |
| 1 | 1906 | 2015 | 1906 | 1998 | 2002 | 2099 |
| 2 | 1777 | 1956 | 1847 | 1946 | 1995 | 2105 |
| 3 | 1921 | 1945 | 1941 | 2195 | 1961 | 2111 |
| 4 | 1863 | 2063 | 1925 | 1971 | 2043 | 1950 |
| 5 | 1993 | 2177 | 1828 | 1951 | 1918 | 2129 |
| 6 | 1844 | 2002 | 1971 | 2031 | 2077 | 1995 |
| 7 | 1978 | 1947 | 1654 | 2046 | 2026 | 1959 |
| 8 | 1861 | 2088 | 1908 | 2162 | 2166 | 1989 |
| 9 | 1860 | 1808 | 1903 | 1907 | 1954 | 2143 |
| 10 | 1966 | 1954 | 1919 | 1994 | 2208 | 1972 |
| **Mean** | **1897b** | **1996 ab** | **1880 b** | **2020 a** | **2035 a** | **2045 a** |
| % | 100 | 105 | 99 | 106 | 107 | 108 |
| **C.V: 2,5%** | | | | | | |

*Means followed by the same letter do not differ by Tukey test at 5% probability

In the experiment performed in Unaí, Minas Gerais, as shown in Table 11 and Figure 3, the application of Penergetic® promoted a 7% increase in soybean yield in the treatment without fertilization, which was not statistically different from the result for standard fertilization.

The best result for soybean yield was obtained in the treatment where the fertilizer was adjusted according to Penergetic® recommendations for use and a combination of Penergetic® K and Penergetic® P was used (Table 11 - Chart 3).

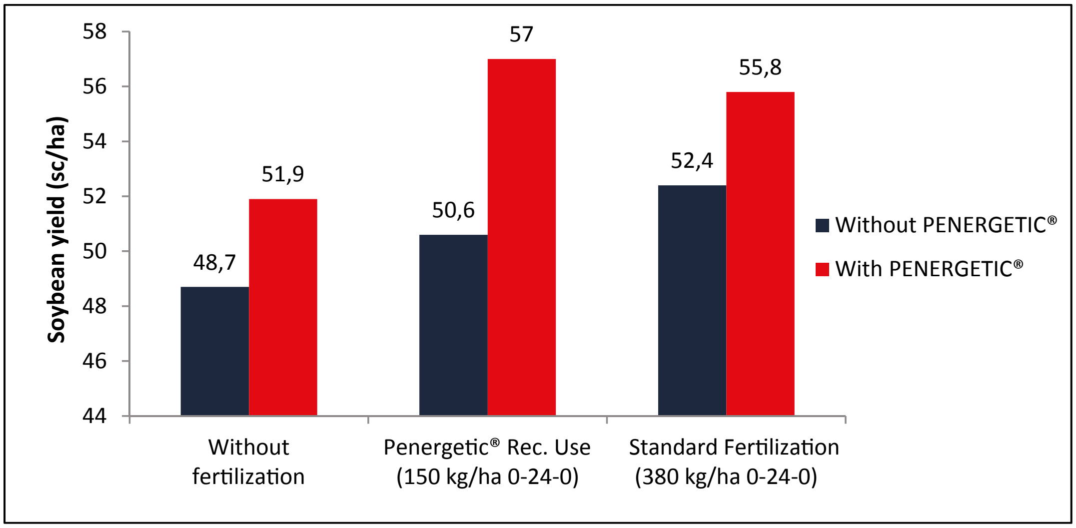
**Table 11.**

Soybean yield (sc / ha) by treatment. Unaí-MG, 2014/2015

| Repetitions | Without Fertilization | | Penergetic® Recom.Use 100 kg 5-37-00 | | Standard Fertilization 300 kg 5-37-00 | |
|---|---|---|---|---|---|---|
| | W/O PEN | W/ PEN | W/O PEN | W/ PEN | W/O PEN | W/ PEN |
| 1 | 50,2 | 54,5 | 53 | 58,3 | 55,2 | 54,8 |
| 2 | 45,7 | 51,5 | 48,4 | 60,8 | 49,1 | 54,5 |
| 3 | 45,1 | 54,8 | 47,7 | 58 | 51,8 | 58,3 |
| 4 | 50,4 | 49,6 | 51,7 | 53,2 | 51,7 | 63 |
| 5 | 49,3 | 48,6 | 47,3 | 55,2 | 49,3 | 51,2 |
| 6 | 51,4 | 51,6 | 54,4 | 55,1 | 47,4 | 56,5 |
| 7 | 47,5 | 54,3 | 51,1 | 58,3 | 55,7 | 51,3 |
| 8 | 46,7 | 51,4 | 52 | 62 | 59,7 | 55,9 |
| 9 | 51,2 | 52,4 | 50,7 | 54 | 54,4 | 56,2 |
| 10 | 49,5 | 51 | 49,7 | 55,8 | 50,2 | 57,3 |
| **Mean** | **48,7 d** | **51,9 cd** | **50,6 cd** | **57,0 a** | **52,4 bc** | **55,8 ab** |
| % | 100 | 107 | 104 | 117 | 108 | 115 |
| **C.V: 5,3%** | | | | | | |

*Means followed by the same letter do not differ by Tukey test at 5% probability

**Graph 3.** Average soybean yield in the treatments. Unaí-MG, 2014/2015



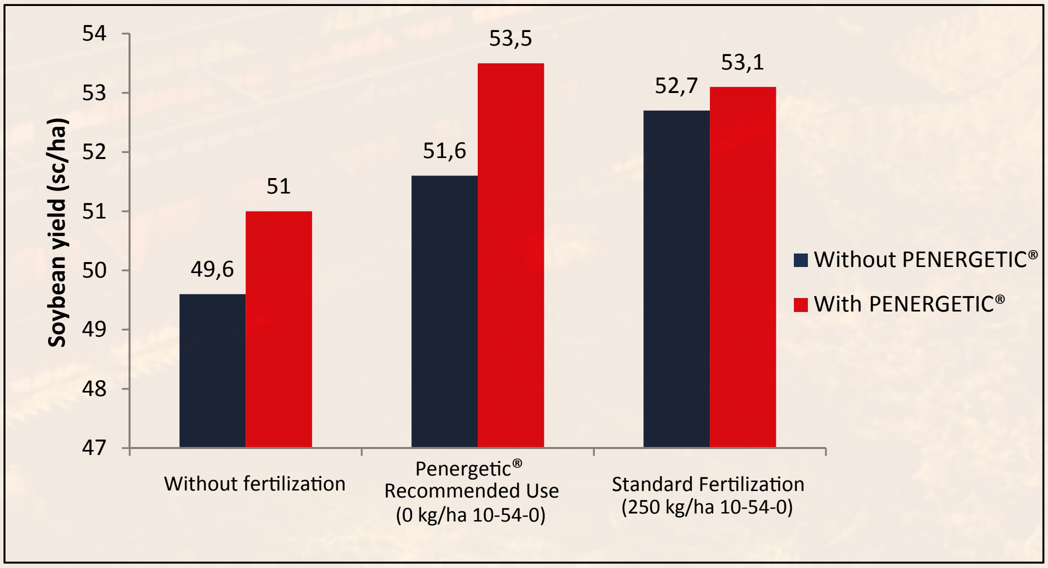

In the municipality of Fortaleza do Tabocão, in Tocantins state, as shown in Table 12 and Chart 4, the application of Penergetic® promoted a 3% increase in soybean yield in the treatment without fertilization. This result did not differ statistically from the treatment with standard fertilization used by the farm.

The highest yield was achieved with the fertilizer adjusted according to Penergetic recommendations and application of Penergetic® technology, yielding 53.5 SC / ha (Table 12 - Chart 4).

**Table 12.** Soybean yield (sc / ha) by treatment. Unaí- MG, 2014/2015

| Repetitions | Without Fertilization | | Penergetic® Recom.Use 0 kg /ha 10-54-0 | | Standard Fertilization 250kg /ha 10-54-0 | |
|---|---|---|---|---|---|---|
| | W/O PEN | W/ PEN | W/O PEN | W/ PEN | W/O PEN | W/ PEN |
| 1 | 45,6 | 47,8 | 52,3 | 54,6 | 54,3 | 54,7 |
| 2 | 47,4 | 48,8 | 53,2 | 53,4 | 50,6 | 57,4 |
| 3 | 51,4 | 52,6 | 50,4 | 56,4 | 53,1 | 52,4 |
| 4 | 50,6 | 50,7 | 51,3 | 48,7 | 48,5 | 53,6 |
| 5 | 47,6 | 53,7 | 49,7 | 49,9 | 53,2 | 54,8 |
| 6 | 48,7 | 49,1 | 48,7 | 53,5 | 54,9 | 55,9 |
| 7 | 51 | 53,6 | 52,4 | 54,3 | 56,4 | 52,4 |
| 8 | 52,6 | 48,6 | 55,3 | 50,9 | 50,3 | 50,4 |
| 9 | 49,9 | 53,4 | 51,4 | 55,3 | 52,4 | 48,9 |
| 10 | 51,2 | 51,5 | 50,8 | 58,3 | 53,6 | 50,3 |
| **Mean** | **49,6 b** | **51,0 ab** | **51,6 ab** | **53,5 a** | **52,7 a** | **53,1 a** |
| % | 100 | 103 | 104 | 108 | 106 | 107 |
| **C.V: 4,5%** | | | | | | |

*Means followed by the same letter do not differ by Tukey test at 5% probability




**Graph 4.** Average soybean yield in the treatments. Fortaleza do Tabocão, Tocantins, 2014/2015.

## CONCLUSIONS

The use of Penergetic® technology promoted increases of between 6 and 8% in soybean yields in the mean of the four experiments.

This increase in productivity is directly related to the increase in the number of grains / m², as well as the increase of the grain mass, also observed with the use of Penergetic® K and Penergetic® P.

In all the sites studied, the use of Penergetic® technology combined with an adjustment in the base fertilization, promoted a reduction in the use of fertilizers, without significant losses in soybean production, in comparison to productivity levels obtained with standard farm fertilizing.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