



EFFECT OF THE APPLICATION OF BIOFERTILIZER GOATISH AS A BIOSTIMULANT ON GERMINATION *CANAVALIA ENSIFORMIS* L.

Shirley Santos Monteiro¹
Fillipe Silveira Marini²
Dualyson da Silva Santos³
Shênia Santos Monteiro⁴
Juliana Ferreira de Lima⁵
Leopoldo Oliveira de Lima⁶

ABSTRACT

Objective: This study aimed to evaluate the influence of different concentrations of goatish biofertilizer as an alternative biostimulant on the germination and vigor of pork bean seeds.

Theoretical framework: The availability of complementary nutrients via seeds promotes germination and vigor, since they are fundamental factors for the good development of production. Therefore, the use of alternative technologies as a biostimulant promote better formation and development of the plant.

Methodology: The research was carried out at the Seed Technology Laboratory of the Federal University of Paraíba. A completely randomized design was used, with treatments at different concentrations of goat biofertilizer, namely: 0% (control), 25%, 50%, 75% and 100%, where they were immersed for 10 minutes. The substrate used was Germiteste paper, where 30 jack bean seeds were distributed and stored at a temperature of 30 °C for 12 hours of light. The variables analyzed were: germination speed index, germination, primary root length, hypocotyl length, width and length of cotyledons and green and dry mass of the variables mentioned above.

Results and conclusion: The application of the concentration of 50 and 75% proved to be efficient in the seed germination process and germination speed index. The 25% concentration of goat biofertilizer provided better performance in the morphological characteristics of jack bean seeds.

Research implications: The main contributions of the study are in the sense of demonstrating a different methodology as an alternative biostimulant in the germination and vigor of seeds, which can contribute to researchers and family farmers in overcoming seed dormancy, as well as increasing plant growth and development.

Originality/value: This study proposes to evaluate the biofertilizer as a biostimulant in the germination and vigor of jack bean seeds as an alternative for taking advantage of the organic residue.

Keywords: Pork Beans, Leguminous, Physiological Quality of Seeds, Seeds.

¹ Universidade Federal da Paraíba, Centro de Ciências Agrárias, Cidade Universitária, Areia, Paraíba, Brasil, E-mail: shirley_pinto_monteiro@hotmail.com Orcid: <https://orcid.org/0000-0002-4977-8388>

² Universidade Federal da Paraíba, Centro de Ciências Exatas e da Natureza, Cidade Universitária, João Pessoa, Paraíba, Brasil. E-mail: fsmarini@yahoo.com.br Orcid: <https://orcid.org/0000-0002-4693-5050>

³ Universidade Federal da Paraíba, Centro de Ciências Humanas Sociais e Agrárias, Bananeiras, Paraíba, Brasil. E-mail: dualyson@hotmail.com Orcid: <https://orcid.org/0000-0002-3513-8064>

⁴ Universidade Federal de Campina Grande, Campina Grande, Paraíba, Brasil. E-mail: shenia-monteiro@hotmail.com Orcid: <https://orcid.org/0000-0002-7414-1151>

⁵ Universidade Federal da Paraíba, Centro de Ciências Humanas Sociais e Agrárias, Bananeiras, Paraíba, Brasil. E-mail: julianacavnufpb@hotmail.com Orcid: <https://orcid.org/0000-0002-3814-3969>

⁶ Universidade Federal da Paraíba, Centro de Ciências Humanas Sociais e Agrárias, Bananeiras, Paraíba, Brasil. E-mail: leoolima@ig.com.br Orcid: <https://orcid.org/0000-0001-8868-9102>



EFEITO DA APLICAÇÃO DE BIOFERTILIZANTE CAPRINO COMO BIOESTIMULANTE EM GERMINAÇÃO DE *CANAVALIA ENSIFORMIS* L.;

RESUMO

Objetivo: Este estudo teve como objetivo avaliar a influência de diferentes concentrações de biofertilizante caprino como bioestimulante alternativo na germinação e vigor de sementes de feijão de porco.

Referencial teórico: A disponibilidade de nutriente complementares via sementes propicia a germinação e vigor, pois são fatores fundamentais para o bom desenvolvimento da produção. Portanto, a utilização de tecnologias alternativa como bioestimulante promover uma melhor formação e desenvolvimento do vegetal.

Método: A pesquisa foi realizada no Laboratório de Tecnologia de Semente da Universidade Federal da Paraíba. Foi utilizado o delineamento inteiramente casualizado, sendo os tratamentos as diferentes concentrações de biofertilizante de caprino, a saber: 0% (controle), 25%, 50%, 75% e 100%, onde foram imersas por 10 minutos. O substrato usado foi o papel Germiteste, onde foram distribuídos, 30 sementes de feijão de porco, o qual foi enrolado e armazenado sob a temperatura de 30 °C por 12 horas de luz. As variáveis analisadas foram: índice de velocidade de germinação, germinação, comprimento da raiz primárias, comprimento do hipocótilo, largura e comprimento de cotilédones e massa verde e seca das variáveis citadas anteriormente.

Resultados e conclusão: A aplicação da concentração de 50 e 75% mostraram-se eficiente no processo de germinação da semente e índice de velocidade de germinação. A concentração de 25% de biofertilizante caprino proporcionou melhor rendimento nas características morfológicas das sementes de feijão de porco.

Implicações da pesquisa: As principais contribuições do estudo são no sentido de demonstrar metodologia diferente bioestimulante alternativos na germinação e vigor de sementes, podendo contribuir para pesquisadores e agricultores familiares na superação de dormências de sementes, assim como o aumento do crescimento e desenvolvimento planta.

Originalidade/valor: Este estudo se propôs a avaliar o biofertilizante como bioestimulante na germinação e vigor de sementes de feijão de porco como alternativa para o aproveitando do resíduo orgânico.

Palavras-chave: Feijão de Porco, Leguminosas, Qualidade Fisiológica de Sementes, Sementes.

RGSA adota a Licença de Atribuição CC BY do Creative Commons (<https://creativecommons.org/licenses/by/4.0/>).



1 INTRODUCTION

Pork beans (*Canavaliensiformis* L.) is a Fabaceae, a perennial plant grown annually, widely used as green manure, is a species that is favorable for cultivation in association with its morphological and physiological characteristics. It is a native species, but not endemic to Brazil, of natural occurrence and with wide distribution throughout the country occupying several phytogeographic domains and types of vegetation (Snak & Salinas, 2020). Seeds are important functions in the dissemination and survival guarantee of the species, besides providing relevant biological role (Marcos Filho, 2016), because it will give rise to individuals who at the end of the cycle will determine productivity.

It is understood that for plants to present their full vegetative and (re) productive potential is necessary to provide nutrients, whether present in the soil or through complementary fertilization, foliar or good quality seeds. We need to ensure that the crop has a favorable environment for germination and vigor, since these initial factors are determinant for good production (Aragão et al., 2001).



The germination process is carried out by enzymatic systems that control the seed metabolism and require appropriate conditions, that promote greater germination of seeds in a shorter period, taking into consideration the seed size and aspects of their morphology (Marcos Filho, 2016; Grzybowski, Vieira, Michelon & Panobianco, 2022).

In view of this, the use of alternative technology as a biostimulant can make possible a better formation and development of the root architecture, expressing the genetic potential of the seeds (Paula, Barbosa, Lima, Silva & Marini, 2013), besides being fundamental to improve the productivity of the plants. Consequently, this knowledge can be used to optimize valuable agro-economic characteristics, such as faster and more uniform seed germination (Sajeev, Bingbai & Bentsink, 2019).

The biostimulant applied via seeds is capable of originating more vigorous seedlings, with greater length, dry matter and percentage of emergence (Carvalho et al., 1994). The action of seed treatment with biostimulant can be evaluated by the physiological quality of the seeds. This can be evaluated by germination test and germination rate index.

One practice that has been growing in non-conventional agriculture is the use of liquid biofertilizers, which contains organisms and nutrients (micro- and macronutrients) that improve plant health, leaving the most resistant to pest and disease attacks (Stuchi, 2015). Liquid biofertilizers are products that contain bioactive principles or organic agents, free of agro-toxic substances and bio-regulators, able to act, directly or indirectly, on all or part of the cultivated plants, increasing their productivity, without taking into account their hormonal or stimulant value (Brazil, 2004; Morzelle, Peters, Angelini, Castro & Mendes, 2017).

Biofertilizers act as growth promoters (nutritional balance) and as elicitors in the induction of systemic resistance in the plant. In addition, they help to protect the plant against phytopathogenic organisms, by antibiotics (Bettiol, Tratch & Galvão, 1998) and against phytophagous insects, by repellent, phagoterrent action (feeding inhibitors) or by affecting their development and reproduction (Medeiros, Wanderley & Wanderley, 2003). In addition, the production of biofertilizer has contributed to the optimization of the use of organic waste generated in family-based establishments in agroecological transition (Timm, Gomes & Morselli, 2004), and may be an alternative in seed germination.

In view of the above, the present study aimed to evaluate the influence of different concentrations of the goat biofertilizer as an alternative biostimulant on germination and rate of germination of pork bean seeds (*Canavaliensiformis L.*).

2 THEORETICAL FRAME

The seed is life, as well as food base, multiplication, survival, is the basic element of agriculture as a social strategy. In agriculture, the possession of seeds represents autonomy, freedom, popular power, independence and self-sufficiency (Gutiérrez, 2003). Family farmers have played a key role beyond agriculture (Monteiro, Marini, Santos, Pereira & Vasconcellos, 2019). In this sense, the use of creole varieties is a conditioning factor for the management of healthy and sustainable agro-ecosystems, since this strategy makes possible the use of locally adapted genotypes, which are capable of converting abiotic resources available in agro-ecosystems into biomass of economic interest (Petersen, Silveira, Dias, Curado & Santos, 2013).

In this way, seeds play a fundamental role in agriculture, being a source of food (grain), as well as means of propagation of plant species (Du et al., 2020). It should take into consideration some main factors that guarantee its quality, such as high vigor, ability to generate healthy and resistant offspring, high percentage of germination and being free of pathogens and varietal mixtures (Ramos, 2021).



Sprouting and sprouting rate are two of the main links in seed quality that can influence crop yield directly or indirectly. Direct effects are relevant to the distinct ability of seedlings to incorporate dry matter, due to the difference in the level of vigor of the seeds (Lazaretti, 2020).

The physiological quality of the seeds is extremely important for agriculture, besides being related to several aspects, such as initial growth, performance, plant uniformity and grain yield (Cantarelli, Shuch, Rufino, Tavares & Vieira, 2015).

2.1 General Aspects of Pork Beans

Pork beans (*Canavaliensiformis*) is a Fabaceae widely distributed in tropical countries (Lopes, 2012). In Brazil, there are 17 species, with the Cerrado and Atlantic Forest being the domains with the greatest diversity of the genus (Queiroz & Snak, 2016). It is an annual or biannual, herbaceous, erect plant reaching up to 1.2 m in height. They have alternating, trifoliolate leaves with large, oval elliptical leaflets, dark green in color, with prominent ribs. The pods are flattened, broad and long and have around 4 to 18 seeds. These seeds are ellipsoids 1.2 cm long, white or pink (Barreto, 2018).

Pork beans are widely used as green fertilizer because they grow rapidly and adapt to various soil and climate conditions (Ambrosano et al., 2018). Besides the remarkable rusticity that favors the complete covering of the soil. Highlighting the potential for restoration of degraded areas, and for many other purposes (Coneglian, Ribeiro, Melo, Pereira & Doreram Junior, 2016). Present potential for use in phytoremediation programs, since it accumulates high levels of metals in the root and in the aerial part, produces a large quantity of dry matter, establishes symbiosis with mycorrhizal fungi and nitrogen fixing bacteria (Silva, Andrade & De-Campos, 2018; Santana, Ferreira, Tarouco, Schardong, Antonioli, Antonioli, Nicoloso & Jacques, 2019).

Pig bean seeds, numb due to the hardness of the integument, which makes it difficult to enter water and start the germination process, which interferes with the establishment of the crop and the determination of its physiological quality (Ponce, Pellizzaro, Inácio Neto, Lima, & Takahashi, 2017), and treatments that provide suitable conditions for germination are necessary.

Products applied to seeds such as fertilizers and biostimulants can directly affect the physiological quality of seeds. Causing impact on germination capacity and development of normal seedlings. Thus, it is important to evaluate the effect of these products, such as biofertilizer on seed quality (Frezato et al., 2021), and can be observed by germination testing.

The use of biostimulants for seed treatment has the potential to move traditional agriculture based on the use of agrochemicals towards more sustainable agriculture, as these systems can promote plant establishment as well as provide protection against biotic and abiotic stresses, resulting in improvements in food productivity and quality (Pereira, Oliveira, Fraceto & Santaella, 2021).

2.2 Biostimulant in Seed Germination

Well-nourished plants produce larger and more numerous seeds, accumulate a higher content of organic matter, and are related to physiological development and adequate metabolism. Thus, maintaining an adequate supply of nutrients to crops is an important way of managing them in order to obtain good yields (Amaro, Costa, Porto, Araújo, & Fernandes, 2020).

Biostimulators are considered a promising tool for agriculture, with high productivity, quality and environmental conservation (Colla & Bathhael, 2020). When used in the germination phase improves the performance of the seedlings, accelerating the emergency speed and enhancing the potential of the seeds of several species (Aragão, Dantas & Alves,



2003). In addition, it has the ability to improve germination and seedling establishment, increase root system, improve nutrient mobilization, growth, productivity and tolerance to both biotic and abiotic stresses (Sharma, Fleming, Selby, Rao & Martin, 2014).

The seeds are in constant exchange of moisture with the environment, so the water has a great influence on their physiological quality (Lima et al., 2018). In this way, the combination of treatments that protect and promote the good development of seeds, has been widely applied (France Neto, Henning, Krzyzanowski, Henning, & Lorini, 2015). These treatments are characterized by low cost, low impact on the environment and significant results in production. The use of liquid biofertilizers, when applied to seeds, can bring benefits that reflect during the vegetative and reproductive phases of plants (Martín, UnêdaTrevisoli, Môro, & Vieira, 2016).

The use of alternative products such as biofertilizers has been growing throughout the agricultural environment, with the main role being to use these inputs that are less aggressive to the environment and that make possible the development of sustainable agriculture. The use of biofertilizer generates savings on imported inputs and also promotes improvements in environmental sanitation (Monteiro & Monteiro, 2020). For, they are prepared from the anaerobic or aerobic digestion of organic and mineral material, aiming at the supply of nutrients, their composition varies according to the material and method used in their making (Medeiros, Freitas, Veras, Anjos, Borges, Cavalcante Neto, Nunes & Ferreira, 2008).

Biofertilizer are natural products that can favor plant growth, because they have in their composition humic substances resulting from the decomposition of organic waste, favoring the absorption of nutrients, stimulating plant growth, which are associated with the formation of the root system (Monteiro & Monteiro, 2020).

Research with biofertilizer in Fabaceae showed positive results, as demonstrated by Monteiro, Monteiro, Santos, Lima, & Costa (2021), where they evaluated the effect of the concentration of biofertilizer as a biostimulant in the germination of *Canavaliensiformis*, saw an increase in the percentage of germination with application of biofertilizer the fruit residue base, demonstrating

The biofertilizer is highlighted by nutrients, where there is a great diversity of available microorganisms that, when applied to plants, stimulates natural processes to increase the absorption of nutrients, in ways accessible to farmers (Bomfim, 2017). This biofertilizer is development from by-products, paving the way for recycling and waste reduction, generating benefits for farmers, consumers and the environment (Xu & Geelen, 2018). Among the important characteristics related to seed quality that can be affected, the germination rate stands out (Ramos, 2021).

3 MATERIAL AND METHODS

The experiment was conducted at the Seed Technology Laboratory of the Center for Human, Social and Agrarian Sciences, at the Federal University of Paraíba, Campus III, Bananeiras, PB.

Pig bean seeds, from the germplasm bank of the Seed Technology Laboratory and goat biofertilizer collected from the Caprinoculture Sector of the Center for Social and Agrarian Humanities, whose composition is based on 75% non-distilled water (volume) and 25% goat dung, which was produced by means of aerobic fermentation in containers with a capacity of 50 L, were used.

The experimental design was entirely casualized design, being treatments with different levels of goat biofertilizer, namely: 0% (control), 25%, 50%, 75% and 100%, for 10 minutes immersion in these concentrations, being carried out four repetitions of 50 seeds each.

The substrate used was Germitest paper previously sterilized and moistened once with distilled water at 2.5 times its dry weight, placing two leaves under it and one on the seeds. Germitest paper with the seeds was wrapped and placed inside 0.033 mm thick transparent



polyethylene plastic bags. The bags were closed, arranged in an upright position. They were then kept in a germination camera at 30°C and a 12-hour photoperiod.

The number of sprouted seeds was in daily contact for 9 days, using root emission as the sprouting criterion. The seeds were considered germinated when the tip of the root projected ≥ 2 mm out of the operculum opening.

The viability of the seeds was evaluated by calculating the germination rate index (IVG) by Equation 1, described by Maguire (1962) and the germination rate at 7 and 10 days after the installation of the experiment.

$$IVG = G_1/N_1 + G_2/N_2 + \dots + G_n/N_n \text{ Equation 1}$$

Where: IVG = germination rate index; G = germinated seeds, computed at first, second, and last count; N = number of days from sowing at first, second, and last count.

The variables analyzed were: rate of germination (IVG), final germination (%), primary root length (cm), length of the hypocotyl (cm), width and length of cotyledons (cm) and green and dry mass (g) of the above mentioned variables, according to the rules of the Seed Analysis Rules. Normal seedlings were considered those with well developed and healthy essential structures, without signs of lesions or deformities. The seedlings were separated into root, hypocotyl and cotyledons of each repetition, and measured with the aid of a graduated ruler (cm). To obtain green and dry mass, they were weighed in precision scales and submitted to an oven for the circulation of forced air at 65°C for 72 hours.

Data were submitted to the variance analysis by the F-test ($p < 0.05$), and in case of significance, polynomial regression analysis was performed to unfold the effects of goat biofertilizer concentrations. For these analyzes, the statistical software ASSISTAT version 7.7 (Silva & Azevedo, 2009) was used.

4 RESULTS AND DISCUSSIONS

The pig bean seed obtained the highest germination percentage in the concentrations of 50 and 75% under immersion in the goat bio-fertilizer, the other concentrations brought about a reduction in the germination of the seeds (Figure 1), but were above the minimum value stipulated for the marketing of pig bean seeds, which is 70% (Mapa, 2013), demonstrating that the seeds were suitable for their use. By demonstrating that the pork bean was able to produce seedlings with germination in these concentrations. Emphasizing Du Fradin's report (2015), which showed that the application of biostimulant in seeds improves germination uniformity and increases nutritional efficiency, crop quality characteristics, abiotic stress tolerance.

Our findings showed that immersion in the 50% solution in goat biofertilizer tends to promote normal seedlings, which is due to the presence of humic substances in its composition. Therefore, the success of the crop is dependent on the establishment of field seedlings, showing direct relationship in the germinative process of the seeds (Silva et al., 2020).

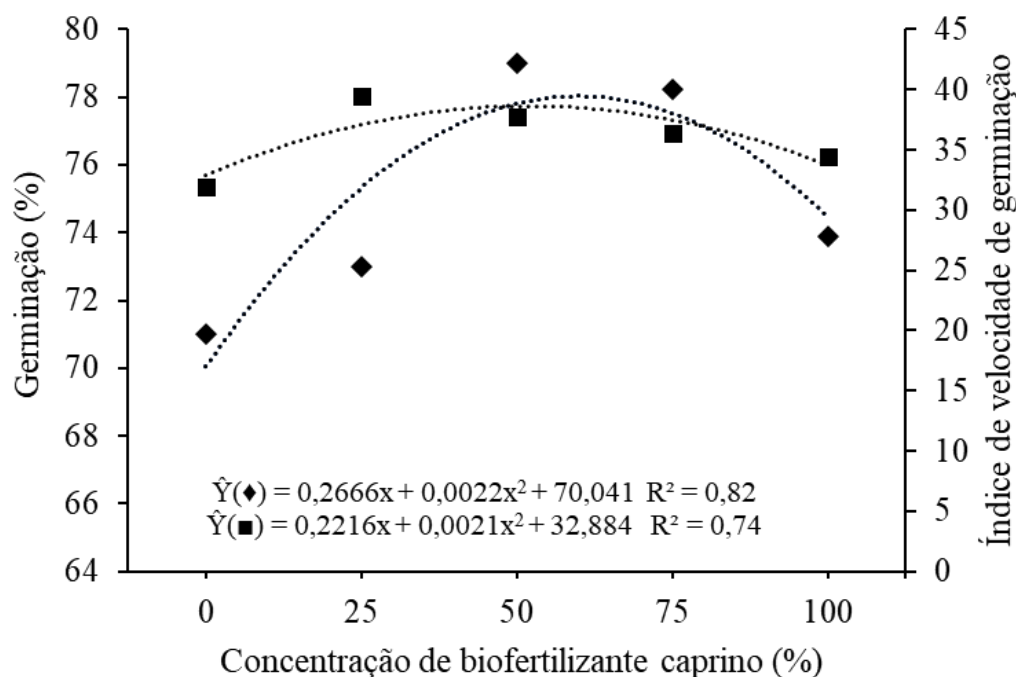


Figure 1. Germination (♦) and sprouting rate index (■) in soaked pork bean seeds at different concentrations of goat biofertilizer.

When analyzing the germination rate index, it was found that as the concentration of goat biofertilizer increased, the increase of this rate occurred. However, from the concentration of 75%, a decrease in this index is observed for pork bean seeds immersed in the goat biofertilizer (Figure 1). Where the highest indices indicate that seeds germinated more quickly and uniformly, thus being considered more vigorous (Donato et al., 2015), reflecting directly on a suitable seedling establishment (Silva et al., 2020).

From a nutritional point of view, goat biofertilizer presents, in addition to the large amount of organic matter normally present, nutrients available in higher concentrations, such as: Ca, Fe, K, Mg, Mn, P and S, which can influence the formation of the embryo of the cotyledons and the efficacy on vigor and physiological quality (Teixeira, Borém, Araújo, & Andrade, 2005). Calcium, for example, is a constituent element of plant structure with important physiological functions in metabolism, which neutralizes organic acids and activates some enzymes, such as phosphatase, favoring the germinative power of seeds (Embrapa, 2006).

The larger seeds have a larger amount of reserve tissue (Carvalho & Nakagawa, 2000) which contributed to a higher germination and germination rate index. It is known that high physiological quality (maximum germination and vigor) is a necessary condition to promote an adequate establishment of seedlings (Silva et al., 2020). Therefore, more vigorous seeds have greater potential to present high performance even under adverse environmental conditions (Marcos Filho, 2015). A strategy that emphasizes the environmental context can help promote an environment conducive to agricultural development (Rajkamal, Velmurugan & Suryakumar, 2022).

The primary root and hypocotyl presented significant difference under immersion in the goat biofertilizer (Figure 2). Positive responses were obtained with the use of the goat biofertilizer at concentrations of 25 and 50%, leading to an increase in the primary and hypocotyl root of the pork bean seedlings. The liquid biofertilizer is absorbed more easily by the plant root, as it penetrates directly, the same is observed with application via seed (Maghanaki, Ghobadiana, Najafia, & Galogah, 2013). Consequently, there is a greater growth of the roots, providing greater resistance of the plants to biotic and abiotic stresses (Dario, Barbieri & Martin, 2014).

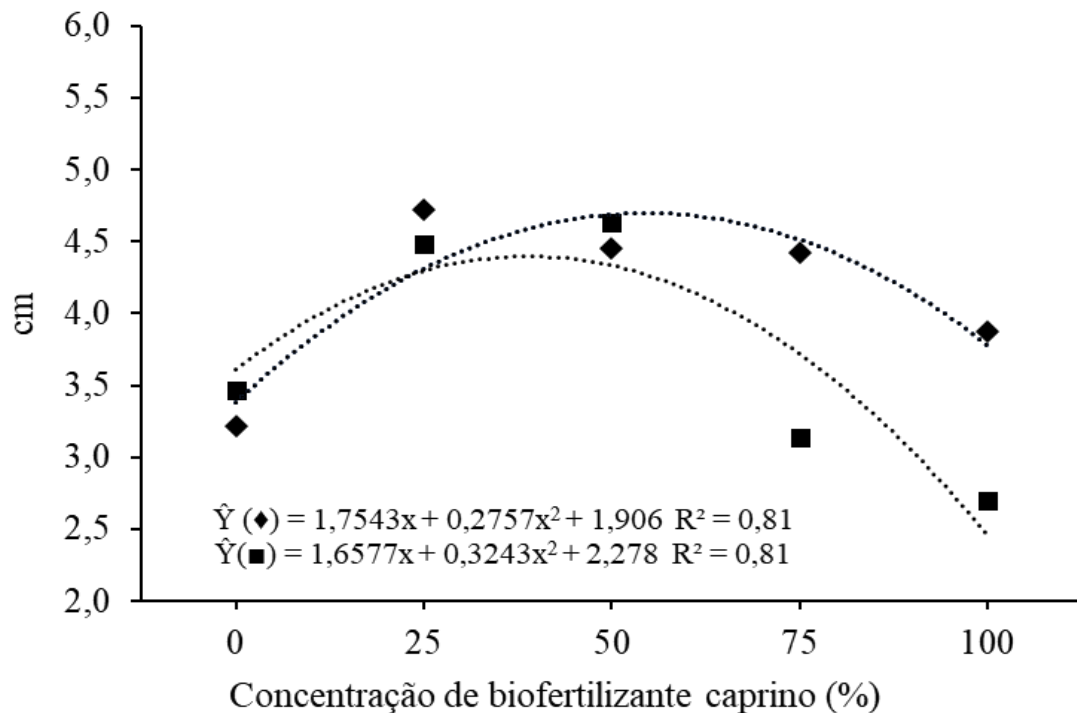


Figure 2. Primary root length (◆) and hypocotyl length (■) under immersion at different concentrations of goat biofertilizer.

The length and width of cotyledons statistically did not differ from the concentrations of goat biofertilizer in which the pork bean seeds were immersed. The bovine biofertilizer applied to pork bean seeds responded to the better transfer of the nutritional reserves contained to the cotyledons, providing larger size (Monteiro, Monteiro, Santos, Lima, & Costa, 2021), which was not observed in this work. As cotyledons are stockpile storage organs intended to provide energy to sustain embryo growth during the seed germination process (Lazaretti, 2020), the size of cotyledons is not interfered with during the process of immersion in goat biofertilizer.

Standardization by seed size contributes to the precision of sowing, which facilitates obtaining the desired plant population. The larger seeds are nourished during their development, with well-formed embryos with more reserves, potentially making the resulting plant the most vigorous (Bianchi, Vilela, Carvalho, Pires, Santos & Bruzi, 2022).

It is possible to observe in Table 1 that the analyzed values of fresh mass and dry mass of all the analyzed variables presented significant difference. The fresh mass of the primary root showed a difference in concentration of 25% and relative to dry mass the concentrations of 25 and 50% showed better results, differing from the other concentrations of goat biofertilizer. The same was observed by Monteiro et al. (2021) using 25 and 50% biofertilizers as an alternative to replace the use of synthetic stimulant by family farmers on pork bean seeds.

Therefore, the 25% concentration of goat biofertilizer provided the best results for fresh and dry mass of hypocotyl (Table 1). From a nutritional perspective, it is assumed that the nutrients present in the biofertilizer, in addition to the large amount of organic matter, can influence the amount of dry matter of the hypocotyl (Monteiro et al., 2021).

To consider more vigorous seedlings, it is important to have vigorous seeds, which provide greater transfer of dry mass from their reserve tissues to the embryonic axis, in the germination phase, giving rise to seedlings with greater mass, due to the greater accumulation of matter (Nakagawa, 1999). As a benefit of the use of biostimulants, one can mention the increase in plant growth and development, coming from the stimulus of division, differentiation and cellular stretching (Castro, Pacheco, & Medina, 1998).

**Table 1.** Fresh mass and dry mass of primary root, hypocotyl and cotyledons of pork bean seeds, immersed in different concentrations of goat biofertilizer.

Concentrations	Fresh mass (g)			Dry mass (g)		
	Root	Hypocotyl	Cotyledons	Root	Hypocotyl	Cotyledons
0%	1.12 b	6.40 b	38.26 b	0.12 b	1.46 b	26.55 to
25%	2.75a	6.94 b	35.06 c	0.21a	1.32 b	23.98 ab
50%	0.96 b	11.43a	42.97 to	0.16a	1.64a	24.98 ab
75%	1.27 b	4.42 b	41.02 to	0.05 b	0.77 c	25.31 ab
100%	0.95 b	6.37b	38.69 b	0.06 b	0.87c	22.61 b
Medium	1.41	7.11	39.20	0.12	1.21	24.69
CV%	33.17	17.31	4.27	39.74	17.57	6.22

The averages followed by the same letter in the column do not differ statistically by Tukey's 5% probability test. CV (%) - Coefficient of variation.

The 50% and 70% concentrations of goat biofertilizer resulted in an increase in the fresh matter of cotyledons, presenting a high stimulus to the growth of cotyledons (Table 1). This increase is associated with the greater facility that the seed finds to absorb the goat biofertilizer in its physiological processes leading to an increase in the fresh matter of the cotyledons. The control brought about a greater production of dry mass of cotyledons, with an increase occurring as the application of the concentrations of the goat biofertilizer increased. These applications promoted adequate nutritional conditions for good development, consequently greater accumulation of hypocotyl dry matter.

The application of the goat biofertilizer brought about a significant increase in the dry mass of cotyledons (Table 1), favoring germination, as well as a greater accumulation of dry mass in the cotyledons. According to Monteiro et al. (2021), using bovine biofertilizer applied to pork bean seeds promoted higher production of dry matter from cotyledons.

According to Popinigi (1985), physiological quality is the ability of seeds to perform vital functions related to their germination, vigor and longevity, and the high quality of seeds is directly reflected in the next generation for a series of situations related to vigor, plant uniformity and presence of diseases transmitted by seeds, directly influencing productivity.

Biofertilizer is a livelihood strategy for family farming, as it is low cost, and there is a need for government policies to reuse animal and plant waste, and it can be used to strengthen the future agricultural sector (Sharif, Katan, Ahmad, Hussin & Ismail, 2022).

The use of animal manure and plant waste is an organic alternative for the development of sustainable agricultural fertilizers, can contribute to the development of compensation systems and expand the circulation of agricultural production, together with the conservation of ecosystem services. In addition, to search for new alternatives for the use of these agricultural by-products, contributing positively to the conservation of the agro-ecosystem and the reuse of these residues that are often discarded inadequately, bringing with them serious problems for health and the environment, which merit more attention in future research.

5 FINAL CONSIDERATIONS

The application of the goat biofertilizer at a concentration of 50% and 75% proved to be efficient in the seed germination process. However, the 25% concentration of goat biofertilizer indicated higher emergence speed, provided an increase in the morphological characteristics of the pig bean seeds.

The use of goat biofertilizer was effective in germination, seeds and plant vigor. In addition to being an ecological, economic and sustainable alternative to synthetic fertilizers, it not only increases agricultural production but also reduces environmental pollution.



Further studies on the applications of biofertilizer as seed biostimulant in different species are needed. Biofertilizers are a huge untapped resource with great potential in the agricultural sector, and additional research should be undertaken to discover and exploit their potential.

REFERENCES

- Aragão, C. A., Lima M. W. P., Morais, O. M., Ono, E. O., Boaro, C. S. F., Rodrigues, J. D., Nakagawa, J. & Cavariani, C. (2001). Fitorreguladores na germinação de sementes e no vigor de plântulas de milho super doce. *Revista Brasileira de Sementes*, 23(1), 62-67.
- Aragão, C. A., Dantas, B. F., & Alves, E. (2003). Atividade amilolítica e qualidade fisiológica de sementes armazenadas de milho super doce tratadas com ácido giberélico. *Revista Brasileira de Sementes*, 25(1), 43-48.
- Ambrosano, E. J., Salgado, G. C., Otsuk, I. P., Patri, P., Henrique, C. M. & Melo, P. C. T. (2018). Organic cherry tomato yield and quality as affect by intercropping green manure. *Acta Scientiarum Agronomy*, 40(36530), 1-8. <https://doi.org/10.4025/actasciagron.v40i1.36530>
- Amaro, H. T. R., Costa, R. C., Porto, E. M. V., Araújo, E. C. M. & Fernandes, H. M. F. (2020). Tratamento de sementes com produtos à base de fertilizantes e reguladores de crescimento. *Pesquisa Agropecuária Gaúcha*, 26(1), 222-242. <https://doi.org/10.36812/pag.2020261222-242>
- Bettiol, W., Tratch, R. & Galvão, J. A. H. (1998). *Controle de doenças de plantas com biofertilizantes*. Jaguariúna: EMBRAPA-CNPMA. Circular Técnica, 02, 22.
- Brasil. (2004). *Decreto-Lei nº 4.954 de 14 de janeiro de 2004*. Aprova o Regulamento da Lei no 6.894, de 16 de dezembro de 1980, que dispõe sobre a inspeção e fiscalização da produção e do comércio de fertilizantes, corretivos, inoculantes ou biofertilizantes destinados à agricultura, e dá outras providências. Diário Oficial da República Federativa do Brasil, Brasília, 141(10).
- Bomfim, C. A. (2016). *Biofertilizante Hortbio®: características microbiológicas e efeito na qualidade da alface*. 147p. Dissertação (Mestrado em Biologia Microbiana). Programa de Pós-Graduação Biologia Microbiana, Universidade de Brasília, Brasília, Brasil.
- Barreto, M. S. (2018). *Biodestoxificação do feijão de porco (Canavalia ensiformis) por fermentação em estado sólido*. 75p. Dissertação (Mestrado em Ciências de Alimentos). Programa de Pós-Graduação em Ciências de Alimentos, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brasil.
- Bianchi, M. C., Vilela, N. J. D., Carvalho, E. R., Pires, R. M. O., Santos, H. O. & Bruzi, A. T. (2022). Soybean seed size: how does it affect crop development and physiological seed quality? *Journal of Seed Science*, 44. <https://doi.org/10.1590/2317-1545v44255400/doi.org/10.1590/2317-1545v44255400>
- Carvalho, L. H., Chiavegato, E. J., Cia, E., Kondo, J. I., Sabino, J. C., Pettinelli Júnior, A., Bortoletto, N. & Gallo, P. B. (1994). Fitorreguladores de crescimento e capação na cultura algodoeira. *Bragantia*, 53.



- Castro, P. R. C., Pacheco, A. C. & Medina, C. L. (1998). Efeitos de Stimulate e de micro-citros no desenvolvimento vegetativo e na produtividade da laranjeira 'Pêra' (*Citrus sinensis* L. Osbeck). *Scientia Agricola*, 55, 338-341. <https://doi.org/10.1590/S0103-90161998000200026>
- Carvalho, N. M. & Nakagawa, J. (2000). *Sementes: ciência, tecnologia e produção*. 4.ed. Jaboticabal: Funep. 588 p.
- Cantarelli, L. D., Schuch, L. O. B., Rufino, C. A., Tavares, L. C. & Vieira, J. F. (2015). Physiological seeds quality: spatial distribution and variability among soybean plant population. *Bioscience Journal*, 31(2), 344-351. <https://doi.org/10.14393/J-v31n2a2015-22274>
- Coneglian, A., Ribeiro, P. H. P., Melo, B. S., Pereira, R. F. & Dorneles Junior J. (2016). Initial growth of *Schizolobium parahybae* in Brazilian Cerrado soil under liming and mineral fertilization. *Revista Brasileira de Engenharia Agrícola e Ambiental*, 20(10), 908-912.
- Colla, G. & Roupahel, Y. (2020). Microalgae: new source of plant biostimulants. *Agronomy*, 10(9), 1240. <https://doi.org/10.3390/agronomy10091240>
- Dourado Neto D., Dario G. J. A., Barbieri A. P. P. & Martin T. N. (2014). Ação de bioestimulante no desempenho agrônômico de milho e feijão. *Bioscience Journal*, 30(1), 371-379.
- Donato, L. M. S., Rabelo, M. M., David, A. M. S. S., Rocha, A. F., Rocha, A. S. & Borges, G. A. (2015). Qualidade fisiológica de sementes de melão em função do estágio de maturação dos frutos. *Comunicata Scientiae*, 6(1), 49-56. <https://doi.org/10.14295/cs.v6i1.544>
- Du Jardin, P. (2015). Plant biostimulants: definition, concept, main categories and regulation. *Scientia Horticulturae*, 196, 3-14. <https://doi.org/10.1016/j.scienta.2015.09.021>
- Du, C., Chen, W., Wu, Y., Wang, G., Zhao, J., Sun, J., Ji, J., Yan, D., Jiang, Z. & Shi, S. (2020). Effects of GABA and vigabatrin on the germination of chinese chestnut recalcitrant seeds and its implications for seed sormancy and storage. *Plants*, 9(449), 1-15. <https://doi.org/10.3390/plants9040449>
- Embrapa - Empresa Brasileira de Pesquisa agropecuária. (2006). *Mandioca e fruticultura tropical*. Circular Técnica. Cruz das Almas: EMBRAPA, 8p.
- Frezato, P. & Braga, A. A. O., Sorace, M. A. F., Cossa, C. A., Pires, C. E. M.; Machado, V. J. J. & Osipi, E. A. F. (2021). Ação de bioestimulantes e nutrientes via tratamento de sementes na germinação e desenvolvimento de plântulas de *Glycine Max* L. *Brazilian Journal of Development*, 7(2), 18674-18679. <https://doi.org/10.34117/bjdv7n2-486>
- França Neto, J. B., Henning, A. A., Krzyzanowski, F. C., Henning, F. A. & Lorini, I. (2015). *Adoção do tratamento industrial de sementes de soja no Brasil, safra 2014/15*. Informativo ABRATES, Londrina, 25(1), 26-29.
- Gutiérrez, M. M. (2003). *Sementes crioulas: um olhar a partir da colômbia*. In: Carvalho, H. M., (ORG) *Sementes: patrimônio do povo a serviço da humanidade*. 1ª ed. São Paulo: Expressão Popular, 261-277.



- Grzybowski, C. R. S., Vieira, E. S. N., Michelon, T. B. & Panobianco, M. (2022). Germination test of *Cordia trichotoma* seeds: a forest species native to Brazil. *Journal of Seed Science*, 44, e202244006. <https://doi.org/10.1590/2317-1545v44258572>
- López, R. E. S. (2012). *Canavalia ensiformis* (L.) D. C. (Fabaceae). *Revista Fitos*, 7, 146-154. <https://doi.org/10.32712/2446-4775.2012.149>
- Lima, A. A., Gonçalves, E. P., Viana, J. S., Souto, P. C., Ferreira, D. T. R. G. & Ralph, L. N. (2018). Desiccation of *Pachira aquatica* Aubl. seeds. *Journal of Agricultural Science*, 10(11), 553-561. <https://doi.org/10.5539/jas.v10n11p553>
- Lazaretti, N. S. (2020). *Causas e reflexos do entrelaçamento das folhas primárias em plântulas de soja*. 62. Dissertação (Mestre em Agronomia). Programa de Pós-Graduação em Agronomia, Universidade Estadual do Oeste do Paraná, Paraná-PR, Brasil.
- Nakagawa, J. (1999). *Testes de vigor baseados no desempenho de plântulas*. In.: Krzyzanowski, F. C.; Vieira, R. D.; França Neto, J. de B. (Ed.). *Vigor de sementes: conceitos e testes*. Londrina: ABRATES, 201-224.
- Maguire, J. D. (1962). Speeds of germination-aid selection and evaluation for seedling emergence and vigor. *Crop Science*, Madison, 2(1), 176-177. <https://doi.org/10.2135/cropsci1962.0011183X000200020033x>
- Medeiros, M. B., Wanderley, P. A. & Wanderley, M. J. A. (2003). Biofertilizante Líquido: Processo Trofobiótico para proteção de plantas em culturas orgânicas. *Revista Biotecnologia Ciência & Desenvolvimento*, 31(7), 40-44.
- Medeiros, D. C., Freitas, K. C. S., Veras, F. S., Anjos, R. S. B., Borges, R. D., Cavalcante Neto, J. G., Nunes, G. H. S. & Ferreira, H. A. (2008). Quality of lettuce seedlings depending on substrates with and without biofertilizer addition. *Horticultura Brasileira*, 26(2), 186-189.
- Mapa - Ministério da Agricultura, Pecuária e Abastecimento. (2013). *Ministério da agricultura, pecuária e abastecimento secretaria de defesa agropecuária*. Portaria nº 16, de 25 de janeiro de 2013. São Paulo: Lex Magister.
- Maghanaki, M., Ghobadiana, B., Najafia, G. J. & Galogah, R. J. (2013). Potential of biogas production in Iran. *Bioresource Technology*, 101, 1153-1158. <https://doi.org/10.1016/j.rser.2013.08.021>
- Marcos Filho, J. (2016). *Fisiologia de Sementes de Plantas Cultivadas*. 2 ed. ABRATES. Londrina, PR, Brasil, 659p.
- Martins, C. C., Unêda-Trevisoli, S. H., Môro, G. V. & Vieira, R. D. (2016). Metodologia para seleção de linhagens de soja visando germinação, vigor e emergência em campo. *Revista Ciência Agronômica*, 47(3), 455-461. <https://doi.org/10.5935/1806-6690.20160055>
- Morzelle, M. C., Peters, L. P., Angelini, B. G., Castro, P. R. C. & Mendes, A. C. C. M. (2017). *Agroquímicos estimulantes, extratos vegetais e metabólicos microbianos na agricultura: Série produtor rural - nº 63*, 1 ed. Piracicaba: ESALQ - Divisão de biblioteca, 96 p.



Monteiro, S. S., Marini, F. S., Santos, D. S., Pereira, E. M. & Vasconcellos, A. (2019). Morfometria de sementes leguminosas produzidas em diferentes espaçamentos. *Revista Verde*, 14(1), 146-149. <https://doi.org/10.18378/rvads.v14i1.5881>

Monteiro, S. S. & Monteiro, S. S. (2020). *Influência de tipos de biofertilizante na germinação de Canavalia ensiformis*. In.: V Congresso Internacional das Ciências Agrárias - COINTER PDVAgro 2020, 5, 1-15. <https://doi.org/10.31692/2526-7701.VCOINTERPDVAgro.0387>

Monteiro, S. S., Monteiro, S. S., Santos, D. S., Lima, J. F. & Costa, J. S. A. (2021). Biofertilizante como bioestimulante na germinação de feijão de porco. *Revista Verde*, 16(1), 09-17. <https://doi.org/10.18378/rvads.v16i1.7755>

Popinigis, F. (1985). *Fisiologia da semente*. 2. ed., Brasília: ABRATES, 289p.

Paula, A. C., Barbosa, L. O., Lima, R., Silva, M. J. R. & Marini, F. S. (2013). Efeito da concentração de urina de vaca como bioestimulante na germinação e vigor de sementes de milho branco. *Cadernos de Agroecologia*, 8(2), 1-5.

Petersen, P., Silveira, L., Dias, E., Curado, F. & Santos, A. (2013). Sementes ou grãos? Lutas para desconstrução de uma falsa dicotomia. *Agriculturas*, 10(1), 36-45.

Ponce, R. M., Pellizzaro, V., Inácio Neto, H. F., Lima, L. H. S. & Takahashi, L. S. A. T. (2017). Quebra de dormência em sementes de *Canavalia gladiata* (Jacq.) D. C. *Revista de Ciências Agrárias*, 40(4), 722-727. <https://doi.org/10.19084/RCA17073>

Pereira, A. E. S., Oliveira, H. C., Fraceto, L. F., & Santaella, C. (2021). Nanotechnology potential in seed priming for Sustainable Agriculture. *Nanomaterials*, 11(2), 267. <https://doi.org/10.3390/nano11020267>

Ramos, D. S. (2021). *Qualidade fisiológica de sementes de soja (Glycine max (L.) Merrill) em resposta ao tratamento com fertilizantes*. 18. Trabalho de conclusão de curso (Graduação em Agronomia). Universidade Federal de Uberlândia Instituto de Ciências Agrárias, Uberlândia, MG Brasil.

Rajkamal S.V., Velmurugan, J. S. & Suryakumar, M. (2022). Green entrepreneurs challenges and innovation: the struggles they face. *International Journal of Professional Business Review*, 7(2), 01-11. <https://doi.org/10.26668/businessreview/2022.v7i2.0482>

Silva, F. A. S. & Azevedo, C. A. V. (2009). *Principal components analysis in the software Assistat-Statistical Attendance*. In: World Congress on Computers in Agriculture, 7, 2009, Reno. Proceedings. Reno, American Society of Agricultural and Biological Engineers, 1 CD-ROM.

Sharma, H. S. S., Fleming, C., Selby, C., Rao, J. R. & Martin, T. (2014). Plant bioestimulants: a review on the processing of macroalgae and use of extracts for crop management to reduce abiotic and biotic stresses. *Journal of Applied Phycology*, Dordrecht, 26, 465-490.

Stuchi, J. F. (2015). *Biofertilizante: um adubo líquido de qualidade que você pode fazer/editora técnica*. Brasília, DF: Embrapa, 16 p.



- Silva, M., Andrade, S. A. L. & De-Campos, A. B. (2018). *Phytoremediation potential of jack bean plant for multi-element contaminated soils from Ribeira Valley, Brazil* *Clean. Soil, Air, Water*, 46, 1700321. <https://doi.org/10.1002/clen.20170032>
- Santana, N. A., Ferreira, P. A. A., Tarouco, C. P., Schardong, I. S., Antonioli, Z. I., Antonioli, Z. I., Nicoloso, F. T. & Jacques, R. J. S. (2019). Earthworms and mycorrhization increase copper phytoextraction by *Canavalia ensiformis* in sandy soil. *Ecotoxicology and Environmental Safety*, 182(30), 109383. <https://doi.org/10.1016/j.ecoenv.2019.109383>
- Sajeev, N., Bingbai & Bentsink, L. (2019). Seeds: A unique system to study translational regulation. *Trends in Plant Science*, 24(6), 487-495. <https://doi.org/10.1016/j.tplants.2019.03.011>
- Silva, C. D., Souza David, A. M. S. Soares, M. C., Conceição, E. R. S., Paraizo, E. A., Silva, R. R. P. & Nobre, D. A. C. (2020). Temperaturas e regulador de crescimento na germinação de sementes de alface. *Revista Cultura Agrônômica*, 29(3), 337-347. <http://dx.doi.org/10.32929/2446-8355.2020v29n3p337-347>
- Snak, C. & Salinas, A. O. D. (2020). *Vigna* in Flora do Brasil 2020 em construção. Jardim Botânico do Rio de Janeiro. Disponível em: <http://reflora.jbrj.gov.br/reflora/listaBrasil/FichaPublicaTaxonUC/FichaPublicaTaxonUC.do?id=FB83863>. Acesso em: 22/12/2022.
- Shariff, S., Katan, M., Ahmad, N. Z. A., Hussin, H. & Ismail, N. A. (2022). Towards achieving of long-term agriculture sustainability: a systematic review of Asian farmers' modern technology farming behavioural intention and adoption's key indicators. *International Journal of Professional Business Review*, 7(6), 01-52. <https://doi.org/10.26668/businessreview/2022.v7i6.1130>
- Timm, P. J., Gomes, J. C. C. & Morselli, T. B. (2004). Insumos para agroecologia: Pesquisa em vermicompostagem e produção de biofertilizantes líquidos. *Revista Ciência & Ambiente*.
- Teixeira, I. R., Borém, A., Araújo, G. A. A. & Andrade, M. J. B. (2005). Teores de nutrientes e qualidade fisiológica de sementes de feijão em resposta à adubação foliar com manganês e zinco. *Bragantia*, 64(1), 83-88. <https://doi.org/10.1590/S0006-87052005000100009>
- Xu, L. & Geelen, D. (2018). Developing biostimulants from agro-food and industrial by-products. *Frontiers in Plant Science*, 9, 1-25.