

POLINIZAÇÃO POR *APIS MELLIFERA* NA CULTURA DA SOJA (*GLYCINE MAX*): UMA ANÁLISE COMPARATIVA ENTRE SISTEMAS AGRÍCOLAS CONVENCIONAL E ORGÂNICO

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RESUMO: A soja (*Glycine max*) é uma cultura com característica predominante autógama, no entanto, ainda existe um potencial produtivo na cultura que pode ser explorado com polinização entomófila. O objetivo deste trabalho é demonstrar o efeito da polinização assistida por colmeias de abelhas *Apis mellifera* sobre os índices de produtividade da soja, como estratégia de manejo, apresentando um serviço ecossistêmico como ferramenta de baixo custo e ampla aplicabilidade. O experimento foi conduzido em áreas comerciais com cultivo de soja nos municípios: Caldas Novas – GO (cultivo convencional), Goiatuba – GO (cultivo orgânico). Foi adotado um delineamento experimento fatorial 2x2, com tratamento polinização assistida (com adição de colmeias) e controle (sem adição de colmeias), em cultivo de soja convencional e orgânica. A polinização assistida promoveu aumento na produtividade em área convencional, tendo como principal fator o incremento e a uniformidade no número de grãos por vagem, sendo assim, pode-se dizer que o efeito da polinização assistida é potencializado quando outras variáveis de manejo são otimizadas, como no cultivo convencional tecnificado.

Palavras-chave: abelhas, produtividade, manejo sustentável.

POLLINATION BY *APIS MELLIFERA* IN SOYBEAN (*GLYCINE MAX*) CULTIVATION: A COMPARATIVE ANALYSIS BETWEEN CONVENTIONAL AND ORGANIC FARMING SYSTEMS

ABSTRACT: Soybean (*Glycine max*) is predominantly a self-pollinating crop; however, there remains untapped yield potential that can be enhanced through entomophilous pollination. This study aimed to evaluate the effect of assisted pollination, using *Apis mellifera* hives, on soybean yield components as a management strategy, highlighting its potential as a low-cost and widely applicable ecosystem service. The experiment was conducted in commercial soybean fields located in Caldas Novas, GO (conventional system) and Goiatuba, GO (organic system), Brazil. A 2×2 factorial design was adopted, comparing treatments with and without hive addition in both cultivation systems. In conventional soybean fields, *A. mellifera* presence increased yield, primarily by improving the number and uniformity of grains per pod. Results indicate that the benefits of assisted pollination are maximized when combined with optimized management practices, as observed in technologically advanced conventional systems.

Keywords: bees; productivity; sustainable management.

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1 INTRODUCTION

For an economic system to be considered efficient, it is necessary to produce the maximum possible at the lowest cost with maximum technical efficiency (Rodrigues, 2002). According to Costa and Oliveira (2014), entomophilous pollination plays a crucial role in the sustainability of agricultural production, directly contributing to production stability, increasing the biological efficiency of crops, especially in the formation of fruits and seeds, thus validating ecosystem services as a necessary technology. Other authors, such as Vasques, Costa and Leite (2023), state that artificial methods (carried out by humans, and not by natural agents) become more difficult in the face of natural biotic pollination, which guarantees higher productive quality in agricultural crops.

Honeybees (*Apis mellifera*) stand out as one of the main pollinating species in agricultural environments, due to their foraging behavior, high adaptability, and ease of management (Chiari, *et al.*, 2005). According to Silva (2024), pollination by *A. mellifera* significantly improves soybean productivity (*Glycine (max)*), increasing the number of grains per pod, the weight of the grains, and the number of full pods. According to Wolff, Reis, and Santos (2021), the ecological and economic benefits of pollination by *A. mellifera* outweigh honey production, with cross-pollination being its main contribution.

Gazzoni (2017) states that, although soybeans are a cleistogamous plant, whose flowers can perform fertilization even before floral opening, and self-pollinating, that is, capable of performing pollination using its own pollen, without the action of external agents, several studies indicate an increase in productivity when visitation by bees occurs, especially *A. mellifera*.

According to Moura *et al.* (2022), the effectiveness of pollination varies according to the cultivation system. In conventional environments, there is less diversity of native pollinators, while in organic systems, which favor greater biodiversity and the non-use of chemical inputs, they offer balanced conditions for native pollinators.

Apis mellifera bee hives) on soybean productivity indices, as a management strategy, presenting an ecosystem service as a low-cost tool with wide applicability in conventional and organic soybean cultivation.

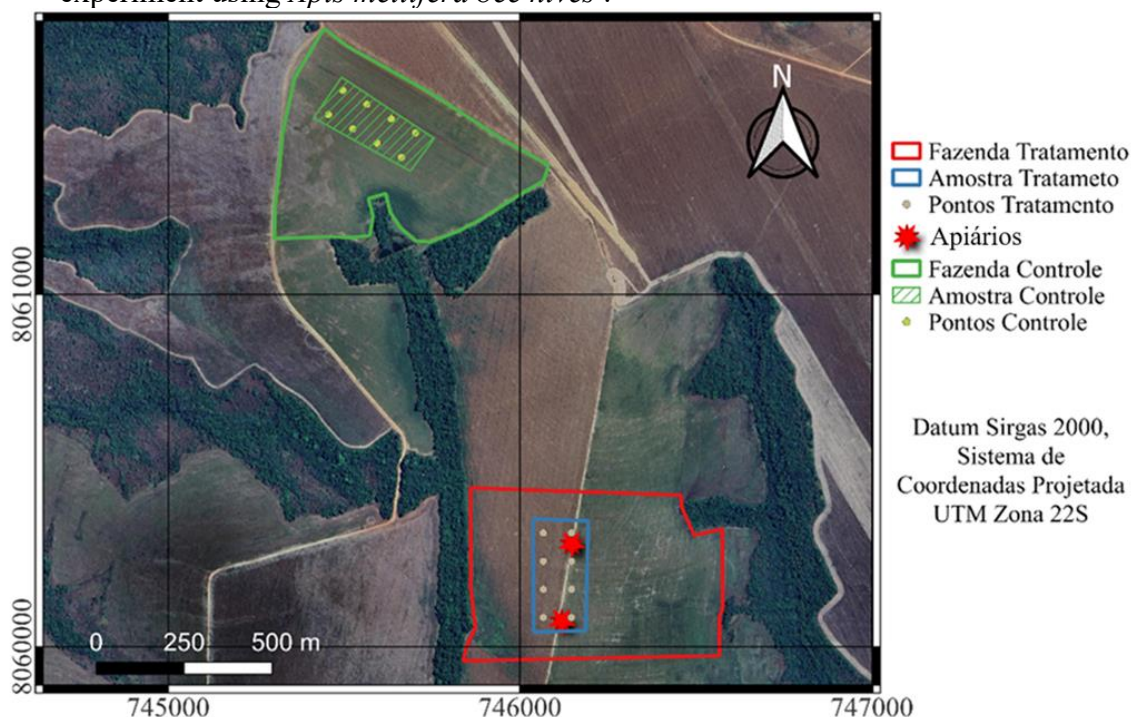
2 MATERIALS AND METHODS

The experiment was conducted in two soybean cultivation areas: conventional planting in Caldas Novas – GO, and organic planting in Goiatuba – GO. The soybean variety used was the same in both locations, cultivated under agricultural management, with appropriate soil practices and phytosanitary control. The terrain is flat, typical of the Cerrado region of Goiás.

Honeybee hives (*A. mellifera*) Langstroth -type beehives were introduced at specific points in the field between the V5 and V6 stages of soybean development. In the Caldas Novas/GO field, 306 beehives were installed, distributed across two apiaries, and in the Goiatuba/GO field, 90 beehives were installed, distributed across three apiaries. The apiaries were 250 meters apart in both areas. The beehives remained in the areas for 20 days.

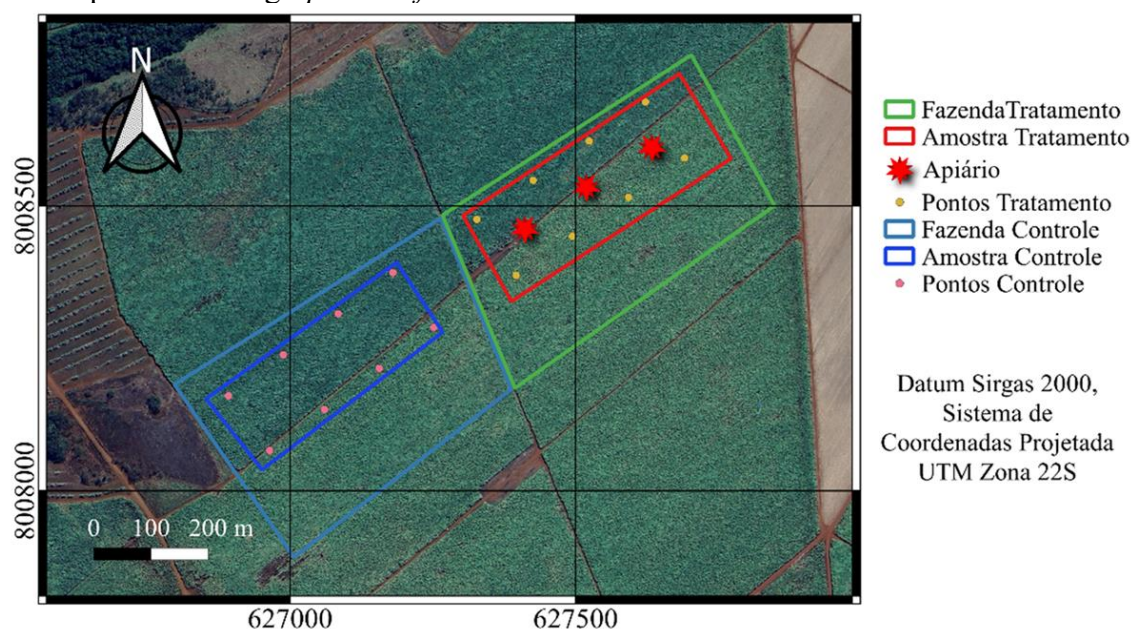
For both crops, a central strip of 5 ha was delimited for sampling, with 8 pre-defined points spaced 80 m apart. The distance between the treatment and control blocks was 800 meters, and the minimum distance between beehives and the control area was 1000 meters (Figures 1 and 2). Soybean plants were collected and stored in nylon bags, identified by sampling point.

Figure 1. Commercial area for conventional soybean production, located in the Municipality of Caldas Novas, Goiás, identifying the areas for implementing the assisted pollination experiment using *Apis mellifera* bee hives .



Source: Author (2024)

Figure 2. Commercial area for organic soybean production, located in the Municipality of Goiatuba-Goiás, identifying the areas for implementing the assisted pollination experiment using *Apis mellifera* bee hives .



Source: Author (2024)

The samples were sent to the Agricultural Engineering laboratory at the State University of Goiás, Central Campus Anápolis – GO, where the following variables were analyzed: productivity (PROD, sacks ha⁻¹),

number of plants (NP, plants.m⁻¹), plant height (AP, m), number of pods per plant (NVP) and number of grains per pod (NGV).

The experimental design adopted was a split-plot factorial design, with a 2x2 factorial

application and eight replications. The main plot factor was crop type (organic soybean vs. conventional soybean), and the subplot factor was the presence of pollination (treatment vs. control).

Statistical analysis was performed using analysis of variance (ANOVA), considering the hierarchical levels of the design. When a significant difference was observed ($p < 0.05$), the means were compared using Tukey's test (HSD) at a 5% probability level to identify which factors presented statistically relevant differences.

3 RESULTS AND DISCUSSION

Analysis of variance demonstrated that the presence of assisted pollination

significantly influenced the variables plant height (PH, m), number of grains per pod (NGV), and productivity (PROD, sacks. ha⁻¹). Furthermore, the interaction between the factors crop type and the presence of assisted pollination showed a significant effect on the variables productivity (PROD, sacks. ha⁻¹), number of plants (NP, plants.m⁻¹), plant height (PH, m), and number of grains per pod (NGV). In contrast, the number of pods per plant (NVP) did not show significance in any of the evaluated situations. This result may be related to the self-pollinating nature of soybeans, since pod formation tends to occur independently of cross-pollination, making this variable less sensitive to the effects of assisted pollination, which may be more pronounced in other agronomic characteristics (Tables 1 and 2).

Table 1. Mean squares for pollination experiment by *Apis mellifera* in soybean cultivation (Treatment, with and without assisted pollination) in conventional and organic cultivation systems (CUL), in which the following variables were evaluated: plant height (PH, m), number of plants (NP, plants.m⁻¹), number of pods per plant (NPP), number of grains per pod (NGV) and productivity (PROD, sacks.ha⁻¹). Where numbers followed by * indicate significance by the F test at 5% probability.

FV	GL	AP	NP	NVP	NGV	PROD
		QM				
REP	7	53,429	5.188	239.281	0.003	16.310
CUL	1	6188.281	41.041	202.155	0.118	3750.646
Error 1	1	6188.281	41.041	202.155	0.118	3750.646
Treat	1	55,651*	0.130	521,725	0.013*	1850.448*
CUL*	1	3.781*	19,876*	47,848	0.030*	765.382*
Treatment						
Error 2	20	-247.72	3,541	179,713	0.002	-47.902
Total:	31					

Source: Author (2024)

Table 2. Averages of the agronomic parameters productivity (PROD), number of plants (NP), plant height (AP) and number of grains per pod (NGV) as a function of the type of soybean cultivation (organic - SO and conventional - SC) and the presence or absence of the treatment (assisted pollination). Identical letters, lowercase in the row or uppercase in the column, do not differ from each other by Tukey's test at 5% probability.

Var	PROD		NP		AP		NGV	
	Yes	No	Yes	No	Yes	No	Yes	No
ONLY	57.8Ab	52.3Ab	13.4Aab	15.1Aa	81.0Ab	79.0Ab	2.5Ab	2.6Aab
SC	89.2Aa	64.2Bb	12.7Aab	11.3Ab	109.5Aa	106.1Aa	2.7Aa	2.7Ab

Source: Author (2024)

Productivity did not show significant differences in the organic cultivation area. However, in the conventional cultivation area, the presence of the treatment resulted in higher productivity when compared to the control treatment. When comparing the areas subjected to the treatment, soybeans grown in a conventional system showed higher productivity compared to those grown in an organic system. On the other hand, in the control treatment, both areas showed similar productivities.

Among the production components, the number of grains per pod (NGV) was one of the variables that showed significant variation in response to assisted pollination treatment, especially in the conventional cultivation area. The presence of *A. mellifera* favored cross-fertilization of flowers that, otherwise, might not result in viable seeds. This effect is consistent with what was reported by Chiari. *et al.* (2005), who highlight the role of bees in promoting genetic variability and increasing the reproductive efficiency of soybeans.

Regarding productivity (Table 2), it was observed that the pollination treatment provided superior results only in the conventional area, indicating that the benefits of bee presence are directly associated with environments with greater agronomic investment and productive potential. In fact, when the system is well managed, with adequate fertilization, soil preparation, and cultural practices, bees act as a complementary factor, maximizing the crop's expression (Gazzoni, 2017; Gazzoni; Barateiro; Santos, 2022; Silva, 2024). According to Wolff, Reis, and Santos (2021), the main contribution of bees goes beyond honey production, with cross-pollination being one of the most valuable ecological services for family and commercial agriculture.

In organic areas, where no response to treatment is evident, the absence of significant differences can be explained by limitations in other agronomic factors, such as pest control and lower nutrient availability, which restrict the full utilization of pollination services. Thus, the benefits of pollination assisted by *A. mellifera* tend to be more evident in contexts where other management variables are already

optimized (Aizen ; Harder , 2009; Vasques; Costa; Leite, 2023).

Therefore, the planned introduction of pollinators in commercial areas can represent an efficient strategy for increasing soybean productivity, especially when associated with sustainable agricultural practices. Valuing this natural service is essential in the face of the growing demand for food and the limitations of conventional production models (Costa; Oliveira, 2014).

4 CONCLUSIONS

A. mellifera bee hives promotes increased productivity in conventional areas, with the main factor being the increase and uniformity in the number of grains per pod, demonstrating the importance of pollination even in self-pollinating plants.

The work carried out demonstrated that the effect of assisted pollination is enhanced when other management variables are optimized, such as in conventional technified cultivation , good soil use practices, and sound agronomic decisions. Thus, it is concluded that the implementation of beehives represents an efficient and sustainable practice, especially in crops with high productive potential.

The need to integrate assisted pollination into agricultural planning, as a sustainable practice and a way to increase productivity, in order to better understand the interactions between cropping systems and ecosystem systems.

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