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PP-575 [Pollination and Bee Flora]

Precision pollination in intensive systems: Technological opportunities for linking beekeeping and soybean production

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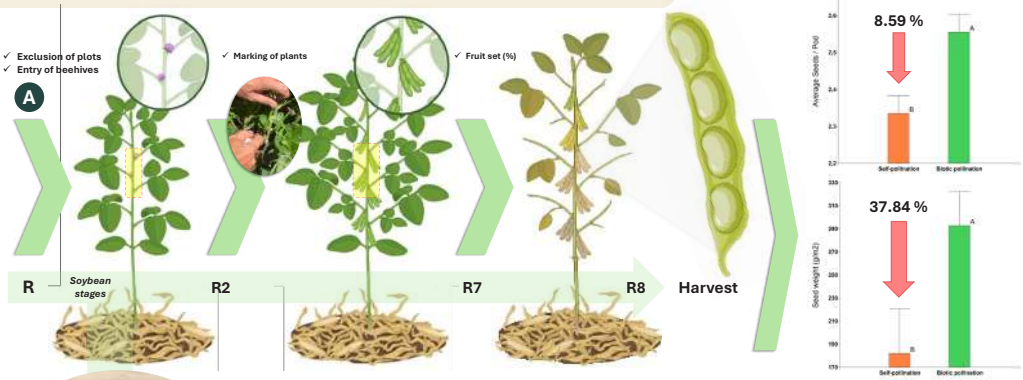
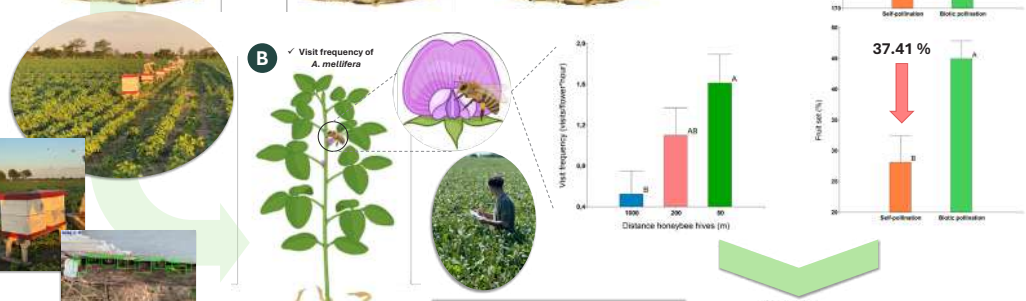
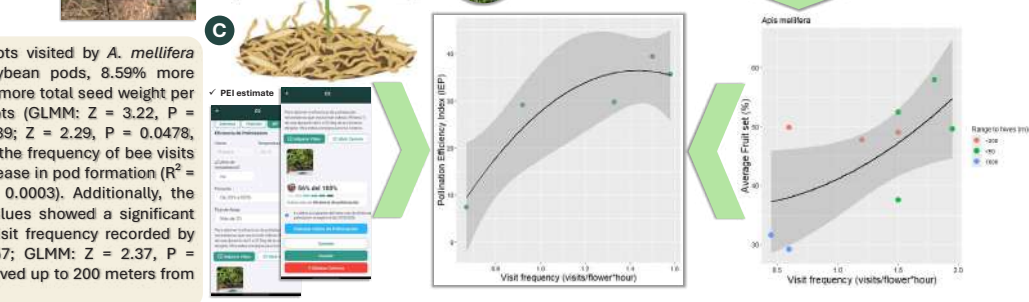
Biotic pollination is essential for food production but remains undervalued in intensive crops such as soybean. Despite growing evidence of the positive impact of pollinators on agricultural productivity, few technological tools are available to monitor their activity in real time and optimize their management in the field.
The development of efficient methods to predict pollinators activity, is crucial to improve the integration of beekepers into production systems.

The aim of our study was twofold: (1) to evaluate the impact of biotic pollination on soybean yield associated with honeybee hives, and (2) to validate a Pollination Efficiency Index (PEI) to predict the frequency of bee visits to the crop.
To evaluate pollination efficiency, experimental plots (1 m^2) were established in a soybean field in central Argentina, near the city of San Francisco in the province of Córdoba (latitude: 31°26'49" S; longitude: 62°08'43" W). Treatments included pollinator exclusion (self-pollination, n = 4) and exposure to pollinators (biotic pollination), with a focus on *Apis mellifera* **(A)**. Additionally, remote sensors mounted on the hives recorded pollen flow and foraging behavior. Alongside the remote measurements, we estimated the frequency of bee visits through visual observation in the different biotic pollination microplots **(B)**. This allowed us to cross-reference the different parameters.
The PEI, which was calculated at each station using the BeeVAI method to remotely estimate pollination efficiency based on eight parameters (environmental and hive), was related to the observed visit frequency at different distances from the hives to evaluate the correlation between these parameters **(C)**.
We analyzed the impact of pollinators on production parameters and the relationship between bee interaction in the crop and the PEI using generalized linear mixed models (GLMM), taking the distance of each plot from the honeybee hives into account as a random factor.





Our results showed that plots visited by *A. mellifera* produced 37.41% more soybean pods, 8.59% more seeds per pod , and 37.84% more total seed weight per unit area than excluded plots (GLMM: Z = 3.22, P = 0.0081; Z = 3.19, P = 0.0189; Z = 2.29, P = 0.0478, respectively). An increase in the frequency of bee visits was found to lead to an increase in pod formation (R^2 = 0.66; GLMM: Z = 3.59, P = 0.0003). Additionally, the proposed PEI daily mean values showed a significant correlation with the mean visit frequency recorded by field observations (R^2 = 0.57; GLMM: Z = 2.37, P = 0.0180), with a good fit observed up to 200 meters from the hives.



Our results confirm:

- ✓ **Pollination by honeybees in intensive agroecosystems such as soybean fields offers benefits** in terms of both quantity and quality, representing an opportunity for beekeepers.
- ✓ Simultaneously **predicting bee activity in different fields is crucial for optimizing logistics** and activities during pollination services, and the proposed **Pollination Efficiency Index (PEI) is an effective tool for this purpose**.

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Precision pollination in intensive systems: technological opportunities for linking beekeeping and soybean production

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Biotic pollination is essential for food production but remains undervalued in intensive crops such as soybean. Despite growing evidence of the positive impact of pollinators on agricultural productivity, few technological tools are available to monitor their activity in real time and optimize their management in the field. The development of efficient methods to predict pollinators activity, is crucial to improve the integration of beekepers into production systems. Our study aimed to (1) evaluate the impact of biotic pollination on soybean yield associated with honeybee hives and (2) validate a Pollination Efficiency Index (PEI) to predict the frequency of bee visits in the crop. Experimental plots within a central Argentine soybean field were established to evaluate pollination efficacy. Treatments included pollinator exclusion (self-pollination) and exposure to Apis mellifera (biotic pollination), with hive-mounted sensors recording pollen flow and foraging behavior. In the afternoon, data about frequency of bee visits were calculated by visual observation. At the same time, we tested the IEP proposed by BeeVAI, which remotely calculating pollination efficiency using eight parameters (environmental and hive). Pollinator activity was analyzed using Generalized Linear Mixed Models (GLMM), taking into account the distance from each plot to honeybee hives. Our results showed that plots visited by A. mellifera produced 37% more soybean pods than excluded plots (GLMM: $Z = 3.69$, $P = 0.0002$). Increased bee visitation frequency resulted in increased pod formation ($R^2 = 0.66$; GLMM: $Z = 3.59$, $P = 0.0003$). In addition, the average/day values of the proposed IEP, showed a significant correlation with the average visit frequency recorded by field observations ($R^2 = 0.57$; GLMM: $Z = 2.37$, $P = 0.0180$), with a good fit observed up to 200 m from the hives. These results confirm the benefits of honeybee pollination in intensive agroecosystems such as soybean, which represents an opportunity for beekeepers. In this context, remote prediction of bee activity in different fields simultaneously is crucial to optimize logistics and activities during pollination services, and the proposed IEP is an effective tool for this purpose.