Effect of Farming with Alternative Pollinators "FAP" on faba bean crop in two different regions

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Abstract

This study evaluates the effect of Farming with Alternative Pollinators (FAP) approach in faba bean cultivation in Morocco's Marchouch and Settat regions. This study aims to compare FAP fields—surrounded by different marketable habitat enhancement plants (MHEP) such as coriander, clover, canola, lupinus, sulla and buckwheat, with monoculture faba bean control. The FAP fields showed significantly greater pollinator abundance and diversity. In addition, FAP is an ecologically sustainable strategy for fauna enhancing in different agroecosystems in arid environments such as Settat and Marchouch regions.

Introduction

Legumes have been used since the agricultural revolution, dating back to the Neolithic period, and their presence has expanded to large-scale cultivation up to the present day, due to their nutritional value for humans and animals. Currently, they are important components in most agricultural systems. These crops are characterized by their easy adaptation to different environments, thus playing a key role in human nutrition. In addition to its nutritional importance, faba beans, like other legumes, play a significant role in soil fertilization. They are used in rotation with cereals because they offer benefits for soil enrichment with nitrogen, thanks to the atmospheric nitrogen fixation by their root nodules. This contributes to increasing soil fertility levels in nitrogen and organic matter, reducing the need for chemical fertilizer (Ait Taadaouit et al., 2021). Faba beans are a crop that depends on pollinators (Marzinzig et al., 2018). With roughly equal amounts of self and cross-pollination occurring based on the insect pollinators, they are self-fertile (Kimura et al., 1997). Honeybees (*Apis mellifera*), bumblebees (genus *Bombus*), and digger bees (genus *Anthophora*) are the primary pollinators of faba beans in Europe. In Morocco, the main flower visitors are Honeybees (*Apis mellifera*), and digger bees (*Eucera* sp and *Anthophora* sp) (Bencharki et al., 2022; Sentil et al., 2022).

Pollinators are essential for improving around 35% of worldwide crop production; they are related to crops which are more able to support natural enemies, especially in arid areas with irrigation systems. Wildflowers may be profitable for pollinators, AS this focused strategy in the tradition of diverse farming systems like FAP but it is different (Christmann et al., 2021). The FAP incorporates nesting and water support using affordable local materials and recycled waste. Two pilot projects—conducted in Uzbekistan and Morocco—evaluated the effects on net income per area for cucumber and sour cherry cultivation, confirming the agronomic feasibility of replicating FAP in different countries (Christmann et al., 2017). The vital role of pollinators in sustaining ecosystems and boosting agricultural yields is gaining greater recognition globally. Pollinators facilitate the reproduction of 87% of flowering plant species and contribute to over 75% of the world's most important food crops. Unfortunately, pollinators have significantly declined over the last two decades (Zhang et al., 2025), As a result, pollination services may become less available for wild and/or domesticated plants and more costly due to higher rental fees for honeybees, The primary factors contributing to pollinator loss are land-use changes, agricultural intensification, pesticide use, plant extinction and invasive species. Approximately half of the planet's territory is deserted, and over 40% of it has been turned into agricultural land. Agricultural practices are negatively impacting natural habitats and floral resources required to sustain pollinators (Lawson et al., 2025).

Objective

This study aims to (1) identify the main flower visitors of faba bean in the Settat and Marchouch regions, (2) test whether the FAP approach increases diversity and abundance of flower visitors in faba bean FAP field compared to monocultural control field.

Methodology

1. Experimental design

The study was conducted in two types of agricultural fields: experimental fields applying the Farming with Alternative Pollinators (FAP) approach, and control fields. In the FAP fields, faba bean was the primary crop, covering 85% of the cultivated area. The remaining 15% was allocated to marketable habitat enhancement plants (MHEP), such as canola, coriander, buckwheat, sulla, clover and lupinus. These habitat plants were selected for their ability to support pollinators and natural enemies while also providing additional income.

In FAP fields, the surrounding habitat plants were sown simultaneously with faba beans to ensure synchronous flowering. In contrast, the control fields were planted entirely with faba bean in monoculture (100%), with no habitat enhancement or diversification. This setup was designed in order to compare the ecological and agronomic outcomes of the two systems—particularly in terms of pollinator abundance (Figure 1).

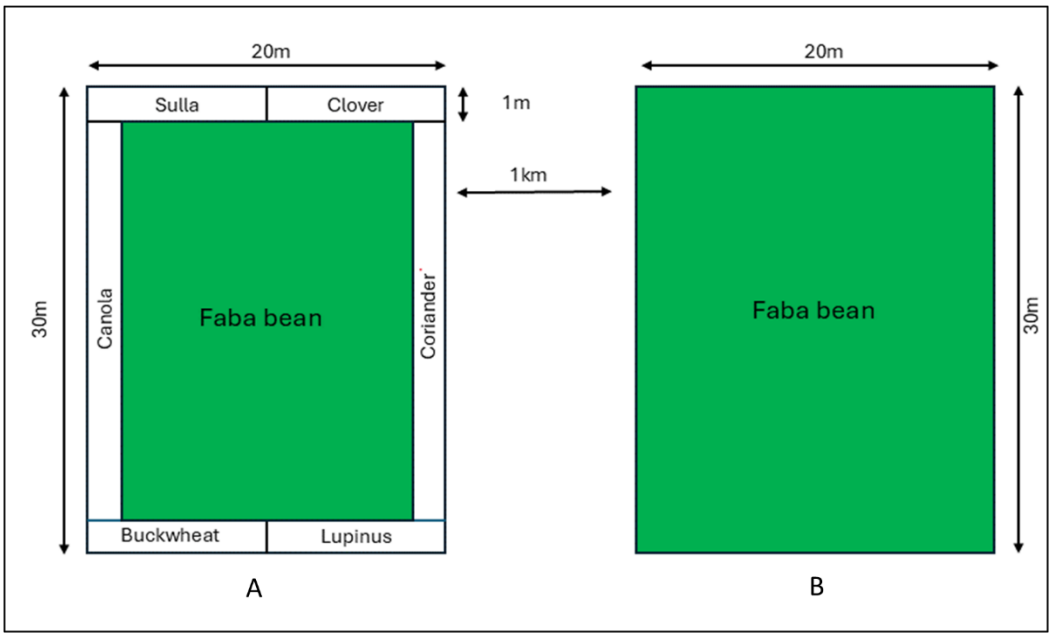

Figure 1: Experimental design: (A) FAP field using different marketable plants along faba bean, (B) control field with only monoculture faba bean

The study was carried out during the 2025 spring season using two fields: one managed under the Farming with Alternative Pollinators approach (Figure 2), and the other as a control (monoculture) (Figure 3). Both fields are planted with the same faba bean variety (AGUADULCE) and they are experiencing similar environmental conditions, which allows for a valid comparison. The FAP field includes the cultivation of additional marketable plants known by attracting pollinators and natural enemies to the main crop (faba bean).

Figure 2: FAP field in Settat region

Figure 3: Control field in Settat region

2. Pollinator sampling

Insect sampling was carried out during the flowering period of both faba bean and the surrounding habitat plants using different techniques to obtain a comprehensive inventory of pollinators and other beneficial insects. Three sampling rounds were conducted at peak bloom: a sweep net captured flying (Figure 4) and surface-dwelling insects over the crop, while an aspirator and pan traps painted in different colors assessed the broader arthropod fauna (Figure 5A, D). Field work conducted on sunny days between 9 am and 4 pm, when insect activity was highest. All specimens were immediately transferred to labelled containers (Figure 5C) for subsequent identification and analysis in the laboratory.

Figure 4: Pollinators sampling

Figure 5: Pollinators Sampling Materials, (A) vacuum, (B) yellow pan trap, (C) sedating containers and ethyl acetate, (D) pan traps

Results

1. The abundance and diversity of pollinators in Settat and Marchouch regions

The results demonstrated that the abundance and diversity of wild pollinators were significantly higher in FAP fields compared to control fields across both regions (Table 1), with a high visitation observed and catched especially of the Andrenidae family in faba bean crop. Figure 6 showing the distribution of total specimen abundance in both fields: FAP vs control in both regions and the difference between the studied regions (Settat vs Marchouch).

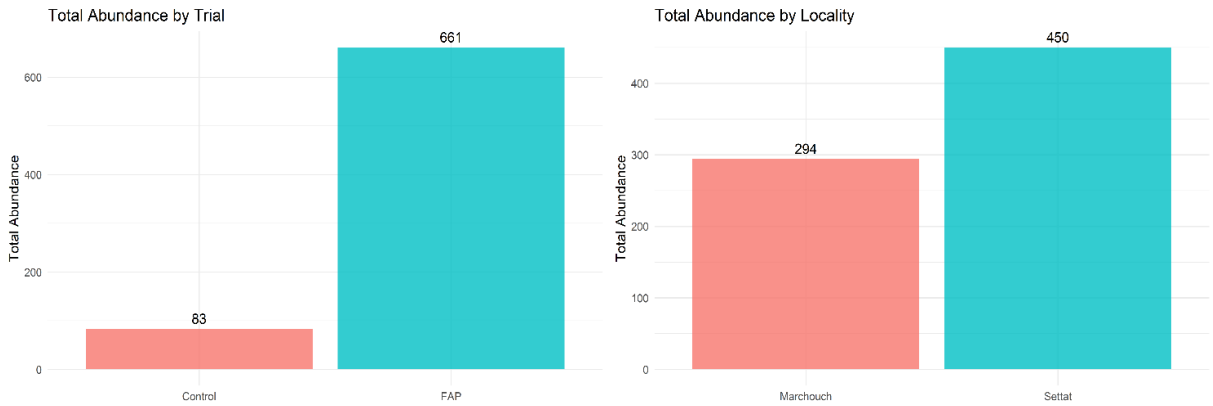

Figure 6: Total Pollinator Abundance by Treatment (FAP vs Control) and by Location (Settat vs Marchouch)

In the first graph (abundance by trial), which illustrates the total abundance of specimens according to the applied treatments across both regions, a particularly pronounced difference is observed between FAP and control fields. The FAP fields yielded 661 specimens, representing approximately 89% of the total individuals collected. In contrast, the control accounted for only 83 specimens, corresponding to 11% of the total. The absolute difference between the two treatments is therefore 578 specimens, indicating that abundance under FAP was about 7.96 times higher than in the control. This result clearly highlights the strongly positive effect of the FAP treatment on specimen accumulation and occurrence compared to the control.

In addition, in the second graph (abundance by locality), a notable difference is also evident between the two sites. The locality of Settat recorded 450 specimens, accounting for approximately 60.5% of the total individuals collected. In comparison, the locality of Marchouch yielded only

Table 1: The abundance and diversity of pollinators in Settat and Marchouch

Regions				Genus	Family	Groups
Settat		Marchouch				
FAP	Control	FAP	Control			
62	4	121	2	*Apis*	Apidae	**Bees**
26	10	36	3	*Eucera*		
4	0	1	1	*Xylocopa*		
5	0	1	1	*Nomada*		
6	0	0	0	*Ceratina*		
102	8	51	23	*Andrena*	Andrenidae	
0	0	1	0	*Panurgus*		
75	0	8	3	*Hylaeus*	Colletidae	
7	0	8	2	*Halictus*	Halictidae	
3		7	1	*Lasioglossum*		
0	0	1	0	*Sphecodes*		
0	0	0	1	*Nomiapis*		
0	4	4	0	*Osmia*	Megachilidae	
1	0	3	0	*Megachile*		
0	3	0	1	*Chelostoma*		
1	0	0	0	*Lithurgus*		
2	0	0	0	*Polistes*	Vespidae	**Wasps**
0	0	1	0	*Cerceris*		
0	3	0	1	*Episyrphus*	Syrphidae	**Hoverflies**

294 specimens, representing 39.5% of the total. The difference between the two localities is 156 specimens, indicating that abundance in Settat was about 53% higher than in Marchouch. This observation suggests that Settat provides more favourable environmental conditions for specimen accumulation and occurrence than Marchouch.

Results in Figure 7 show that 89% of flower visitors were recorded in FAP fields, compared to only 11% in control fields. At the regional scale, Settat accounted for 60.5% of the total abundance, whereas Marchouch contributed 39.5%. These differences were statistically significant (Figure 7).

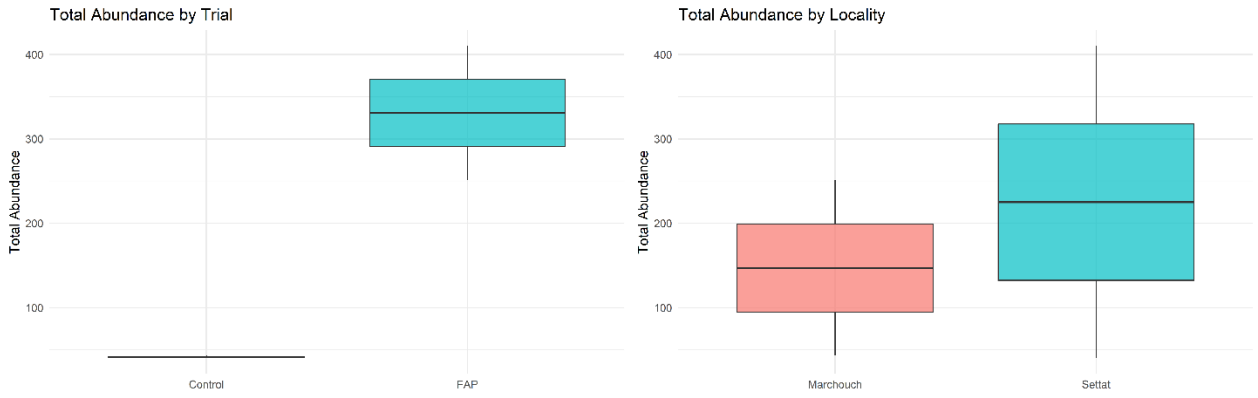

Figure 7: The boxplot illustrates the total abundance of flower visitors by trial (FAP vs. Control) and by locality (Marchouch vs. Settat).

2. Taxonomic composition and distribution of pollinators

The rank abundance curve of pollinator genera in the Settat region clearly demonstrates the positive effect of the FAP approach on pollinator communities compared to monoculture field. FAP field show a higher richness of genera and more distribution of abundances, indicating a stronger support for dominant and abundant pollinator taxa. In FAP fields, the most abundant genera were *Andrena* (102 individuals), followed by *Hylaeus* and *Apis* (both close to 90 individuals). Other genera such as *Eucera*, *Ceratina*, *Halictus*, *Nomada*, and *Xylocopa* also showed considerable representation. In contrast, control fields displayed much lower abundances, with *Eucera* and *Andrena* leading (≈10 individuals), while genera such as *Apis*, *Osmia*, and *Chelostoma* were recorded at very low levels (less than 10 individuals), and most other genera barely reached a single record.

Therefore, both taxonomic diversity and total abundance of pollinators were markedly higher in FAP fields compared to control fields. The FAP field promoted greater genus richness and a more balanced distribution of abundances across taxa, whereas control fields were dominated by a limited number of low-abundance genera. These findings highlight the positive impact of FAP on pollinator diversity and community structure in the Settat region.

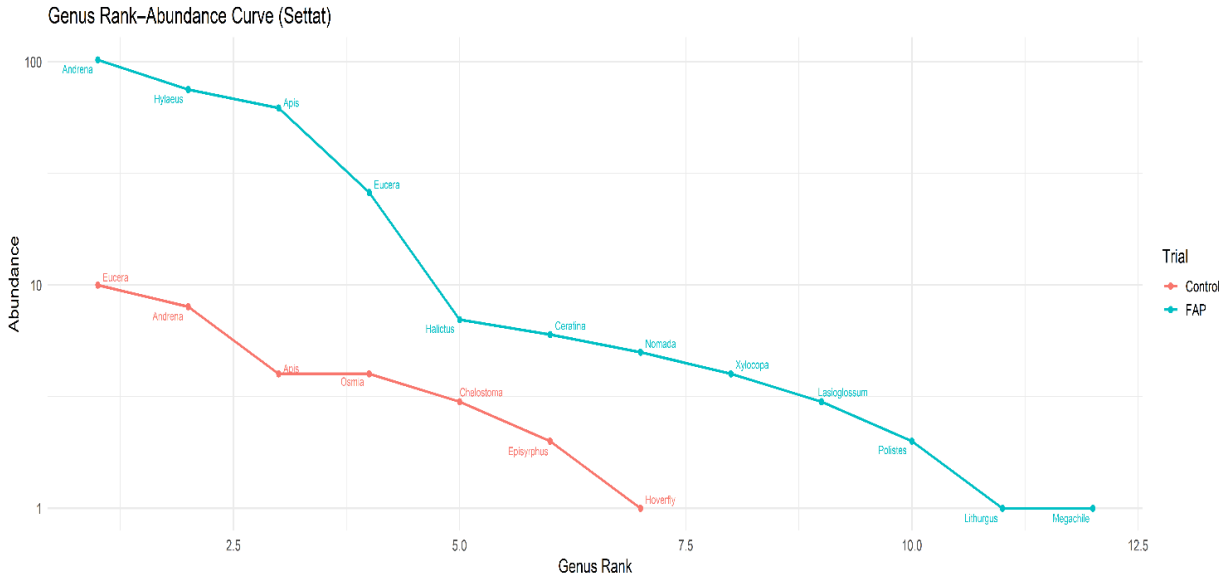

Figure 1 : Rank-abundance curve of pollinator genera in the Settat region under FAP and control treatments

The rank abundance curve of pollinator genera in the Marchouch region highlights the strong effect of the FAP approach in supporting both pollinator diversity and abundance. In FAP field, the genus *Apis* was dominant (121 individuals), followed by *Andrena* and *Eucera*, each with around 50 individuals. Other genera such as *Halictus, Hylaeus, Lasioglossum, Osmia, and Megachile* were also well represented, reflecting a rich and diversified pollinator community. By contrast, in control fields, abundances were much lower overall, with *Andrena* (23 individuals) as the leading genus, followed by *Eucera*, *Hylaeus*, and *Apis*, but all with considerably reduced numbers compared to FAP field. Most other genera in the control were recorded at very low levels, often close to a single individual, reflecting a less diverse and unevenly distributed pollinator community. Interestingly, genera such as *Xylocopa* and *Nomada* were observed in similar numbers in both treatments, suggesting that not all taxa are equally influenced by the management system.

Overall, taxonomic diversity and total abundance of pollinators were markedly higher in FAP field compared to control one. The FAP field promotes enhanced species richness and a more balanced distribution across genera, whereas control field are characterized by low abundances and the dominance of only a few taxa. This underscores the ecological value of the FAP approach in strengthening pollinator communities in the Marchouch region.

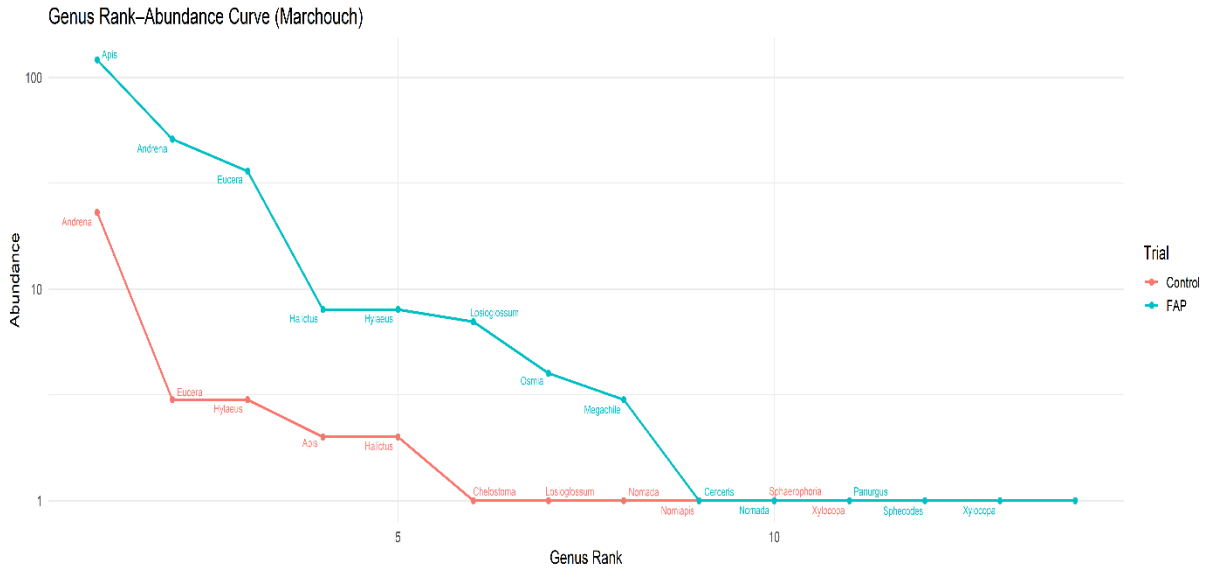

Figure 2 : Rank-abundance curve of pollinator genera in the Marchouch region under FAP and control treatments

3. Genus richness and Shannon diversity indices

Genus richness by trial (FAP vs. Control) shows that pollinator richness was markedly higher in FAP fields compared to control fields. In FAP, the average richness reached ≈ 17–18 genera, while in control fields richness dropped to ≈ 12–13 genera. This demonstrates that the FAP field significantly enhances taxonomic richness through the inclusion of marketable habitat enhancement plants (MHEP). These diversified crops offer staggered and complementary flowering periods, ensuring continuous availability of nectar and pollen throughout the season. This mechanism plays a key role in attracting and sustaining a broader spectrum of pollinators, thereby explaining the much higher diversity observed in FAP fields and nesting resources, thereby supporting a broader community of pollinators. The second graph, Genus Richness by Locality, indicates a slight difference between the two regions. Marchouch displayed a higher average richness (≈ 17 genera) compared to Settat (≈ 15 genera). This suggests that local agroecosystem

conditions and landscape heterogeneity in Marchouch may support a wider variety of pollinator genera than in Settat. The graph highlights a similar trend. FAP fields recorded a higher diversity (≈ 5.6–5.8) compared to control fields (≈ 4.0). This confirms not only greater richness but also a more balanced distribution of individuals across genera under the FAP approach, reflecting improved ecological stability and resilience of pollinator communities.

Finally, the fourth graph, Shannon Diversity by Locality, shows that diversity was slightly higher in Settat (≈ **4.3–5.5**) compared to Marchouch (≈ **4.1–5.1**). However, as explained previously, the difference was not statistically significant, indicating that local factors alone do not strongly differentiate pollinator community diversity.

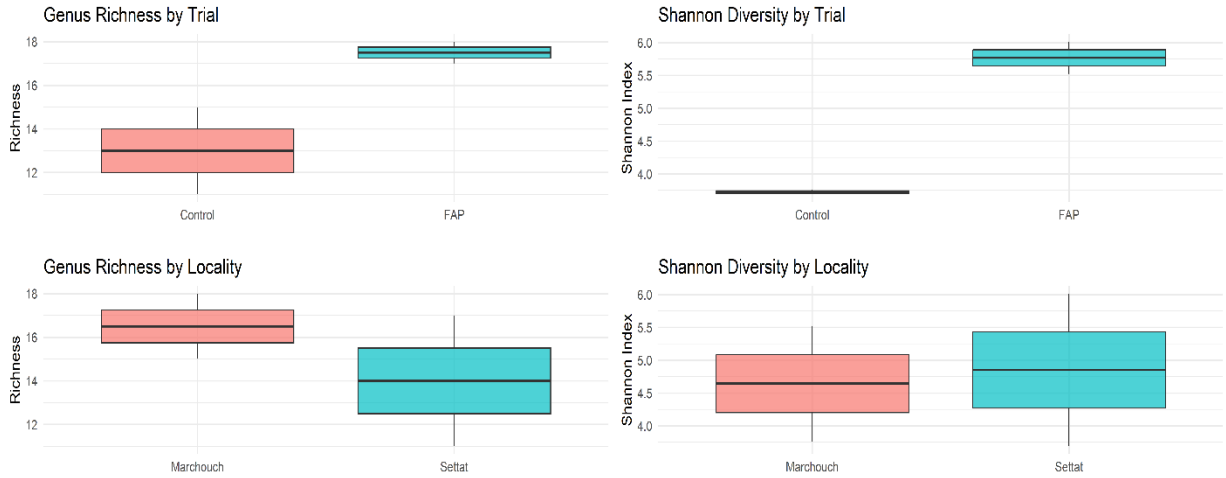

Figure 10 : Genus richness and Shannon diversity of pollinators by trial (FAP vs. Control) and by locality (Settat vs. Marchouch)

Conclusion

In recent years, pollinator conservation has become a major priority for ensuring agricultural sustainability, particularly in regions where ecological pressures and agricultural intensification threaten biodiversity. In this context, our study provides new evidence of the effectiveness of the Farming with Alternative Pollinators (FAP) approach in two contrasting agroecosystems of Morocco, Settat and Marchouch. The integration of Marketable Habitat Enhancement Plants (MHEP) within FAP fields significantly increased the abundance and diversity of wild pollinators, thereby supporting the stability of pollinator communities throughout the flowering period compared with monoculture control fields, and enhancing the overall ecological balance of pollinator assemblages. Our findings demonstrate that the FAP approach not only improves functional biodiversity but also strengthens crop productivity through enhanced pollination

services. Overall, our results underscore the potential of FAP as an effective strategy for reconciling agricultural production and biodiversity conservation, guiding future efforts toward more resilient agroecosystems.

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