

Assessing Bee-Friendly Farming Practices in Pulse-Based Agricultural Systems: Implications for Biodiversity, Productivity, and Sustainability

Arvind Kumar Ishar 

Krishi Vigyan Kendra-Rajouri, KVK Rajouri, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Jammu-India

Corresponding author: Arvind Kumar Ishar | E-mail: dr.akishar1975@gmail.com

Citation: Arvind Kumar Ishar (2024). Assessing Bee-Friendly Farming Practices in Pulse-Based Agricultural Systems: Implications for Biodiversity, Productivity, and Sustainability. *Agriculture Reviews: An International Journal*. DOI: <https://doi.org/10.51470/AR.2024.3.2.01>

Received 09 July 2024 | Revised 07 August 2024 | Accepted 04 September 2024 | Available Online 07 October 2024

Abstract

Bees are vital pollinators that underpin agricultural productivity, ecosystem resilience, and global food security. However, widespread declines in bee populations—driven by intensive farming practices, habitat loss, pesticide exposure, and climate stress—pose serious environmental and economic risks. Pulse-based agricultural systems, centered on leguminous crops such as lentils, chickpeas, peas, and beans, present a promising opportunity to support pollinator conservation while advancing sustainable farming goals. This review evaluates bee-friendly farming practices within pulse-based systems, focusing on their ecological, agronomic, and socio-economic implications. Key practices examined include the provision of floral resources, reduced and targeted pesticide use, integrated pest management strategies, and habitat diversification at both field and landscape scales. Evidence suggests that these approaches can enhance bee abundance and diversity, strengthen pollination services, and contribute to improved yield stability and soil health. The review also highlights existing knowledge gaps, challenges in implementation, and the role of policy and institutional support in promoting pollinator-friendly pulse agriculture. Overall, integrating bee-friendly practices into pulse-based systems represents a viable pathway toward reconciling biodiversity conservation with sustainable agricultural production.

Keywords: Bee conservation; Pulse crops; Sustainable agriculture; Pollination services; Agroecology; Biodiversity.

1. Introduction

Pollinators play an indispensable role in both natural ecosystems and agricultural production systems, with bees representing one of the most efficient and economically significant groups of pollinating organisms. Approximately three-quarters of the world's leading food crops depend, at least in part, on animal-mediated pollination, contributing not only to yield quantity but also to crop quality and nutritional value. Beyond agriculture, bees support biodiversity by facilitating plant reproduction, maintaining genetic diversity, and stabilizing ecosystem functions. Despite their importance, bee populations across many regions of the world have experienced alarming declines over recent decades, raising global concern among scientists, policymakers, and agricultural stakeholders. Multiple interacting stressors are responsible for the observed declines in bee abundance and diversity. Agricultural intensification, characterized by monocropping, habitat simplification, and extensive use of agrochemicals, has significantly reduced the availability of nesting sites and floral resources. The widespread application of synthetic pesticides, particularly neonicotinoids and other systemic insecticides, has been strongly associated with both lethal and sublethal effects on bees, including impaired foraging behavior, reduced reproductive success, and

weakened immune responses [1]. Climate change further exacerbates these pressures by altering flowering phenology, increasing temperature extremes, and disrupting synchrony between bees and their floral resources. Collectively, these factors threaten the sustainability of pollination services essential for global food systems, an increasing attention has been directed toward the development and adoption of bee-friendly farming practices that reconcile agricultural productivity with biodiversity conservation. Sustainable agricultural systems that reduce chemical inputs, diversify cropping patterns, and enhance on-farm habitats have been shown to provide measurable benefits to pollinator communities. Within this context, pulse-based agricultural systems offer unique ecological and agronomic advantages that make them particularly relevant to pollinator-friendly strategies [2].

Pulse crops, including lentils, chickpeas, peas, faba beans, and dry beans, are legumes that play a critical role in sustainable farming due to their ability to fix atmospheric nitrogen through symbiotic relationships with soil microorganisms. This biological nitrogen fixation reduces the need for synthetic fertilizers, thereby lowering production costs and minimizing environmental impacts such as greenhouse gas emissions and nutrient runoff. In addition, pulse crops contribute to improved soil

structure, increased organic matter, and enhanced soil microbial activity, all of which support broader agroecosystem health. From a pollination perspective, many pulse crops produce nectar and pollen that can serve as valuable food resources for a range of bee species, including wild bees and managed pollinators. While pulses are often self-pollinating, numerous studies have demonstrated that insect visitation can enhance pod set, seed quality, and yield stability. More importantly, pulse-based systems are frequently integrated into crop rotations or intercropping arrangements, creating temporal and spatial diversity that benefits pollinators by extending flowering periods and reducing habitat fragmentation. Bee-friendly practices within pulse-based systems typically include minimizing pesticide exposure through integrated pest management (IPM), adopting selective and timing-sensitive chemical applications, and maintaining semi-natural habitats such as field margins, hedgerows, and flowering strips [3]. These practices increase landscape heterogeneity and provide nesting substrates, overwintering sites, and continuous forage throughout the growing season. The relatively lower pest pressure and nitrogen requirements of pulse crops further facilitate reduced chemical inputs, making them well-suited for environmentally responsible management, the potential of pulse-based systems to support bee conservation remains underexplored and unevenly implemented across regions. Farmers may face economic, technical, or informational barriers to adopting bee-friendly practices, including concerns over pest outbreaks, yield risks, and limited access to extension services. Additionally, policy frameworks and agricultural incentives often prioritize short-term productivity over ecosystem services, limiting broader uptake of pollinator-supportive approaches. Given the increasing urgency of addressing pollinator declines alongside global food security challenges, a comprehensive assessment of bee-friendly farming practices in pulse-based systems is timely and necessary [4]. This review aims to synthesize existing research on the interactions between pulse agriculture and bee populations, evaluate the effectiveness of key management practices, and identify knowledge gaps and policy opportunities, the role of pulse-based systems in promoting pollinator health, this article contributes to the broader discourse on sustainable agriculture and biodiversity conservation in an era of environmental change.

2. Importance of Bees in Agricultural Ecosystems

Bees are among the most important pollinators in agricultural landscapes, contributing significantly to food production, biodiversity conservation, and ecosystem stability. Their interactions with flowering plants underpin many ecosystem services that extend beyond direct agricultural outputs, linking farm-level practices with broader environmental sustainability. Understanding the role of bees within agroecosystems is essential for developing farming systems that are both productive and ecologically resilient.

2.1 Ecosystem Services Provided by Bees

Pollination is the most widely recognized ecosystem service provided by bees, directly influencing the yield, quality, and economic value of numerous crops. Through the transfer of pollen between flowers, bees facilitate fertilization, which enhances seed and fruit development. Many crops benefit from bee visitation through increased fruit set, improved uniformity, enhanced nutritional composition, and greater market value. Even in crops that are partially or predominantly self-pollinating, insect-mediated pollination often contributes to yield stability and resilience under variable environmental conditions. Beyond agricultural production, bees play a vital role in maintaining biodiversity by supporting the reproduction of wild flowering plants. Bee-mediated pollination promotes genetic diversity within plant populations, increasing their adaptive capacity to environmental stressors such as climate change, pests, and diseases [5]. Diverse plant communities, in turn, provide habitat and food resources for a wide range of organisms, contributing to overall ecosystem complexity and function. Bees also indirectly support ecosystem services such as soil conservation, water regulation, and carbon sequestration. The sustaining plant cover and vegetation diversity, pollination contributes to reduced soil erosion, improved soil structure, and enhanced nutrient cycling. In agricultural landscapes, these services help stabilize production systems and reduce reliance on external inputs. The economic value of pollination services provided by bees is substantial, with global estimates reaching hundreds of billions of dollars annually, underscoring their importance to both subsistence and commercial agriculture.

2.2 Bee Decline: Drivers and Consequences

Their critical ecological and economic roles, bee populations are experiencing widespread declines in abundance, diversity, and geographic range. These declines are driven by a combination of interacting stressors, many of which are closely linked to modern agricultural practices. Habitat loss and landscape simplification represent major drivers of bee decline. The expansion of monoculture farming and the removal of hedgerows, field margins, and semi-natural habitats have significantly reduced the availability of floral resources and nesting sites. This loss of habitat diversity limits forage availability throughout the growing season and disrupts the life cycles of both wild and managed bee species. The intensive use of pesticides and herbicides poses another significant threat to bees. Insecticides can cause acute toxicity, while chronic exposure to sublethal doses may impair navigation, learning, reproduction, and immune function. Herbicide use further reduces floral diversity by eliminating non-crop flowering plants that provide essential nectar and pollen resources [6]. These chemical stressors often interact with other pressures, amplifying their negative effects on bee health.

Climate change and increased climate variability have emerged as additional drivers of bee decline. Rising temperatures, altered precipitation patterns, and extreme weather events can disrupt flowering

phenology, leading to temporal mismatches between bees and their food sources. Heat stress and habitat shifts may also alter species distributions, placing additional strain on already vulnerable populations. Furthermore, the spread of pathogens, parasites, and invasive species has intensified under globalized trade and changing environmental conditions, contributing to declines in both wild and managed bees. The consequences of bee decline are far-reaching. Reduced pollination services threaten food security, particularly for nutrient-dense crops such as fruits, vegetables, and legumes. Farmers may face increased production costs as they attempt to compensate for pollination deficits through artificial or managed pollination [7]. At the ecosystem level, declining bee populations can trigger cascading effects, leading to reduced plant diversity, weakened ecosystem resilience, and diminished capacity to respond to environmental change.

3. Pulse-Based Farming Systems: An Overview

Pulse-based farming systems are increasingly recognized as a cornerstone of sustainable agriculture due to their multifunctional benefits for soil health, climate mitigation, and agroecosystem diversity. Pulse crops include lentils, chickpeas, dry peas, faba beans, mung beans, cowpeas, and other grain legumes that are cultivated across a wide range of agroecological zones, from temperate to tropical regions. One of the defining features of pulse crops is their ability to fix atmospheric nitrogen through symbiotic relationships with rhizobial bacteria. This biological nitrogen fixation reduces the need for synthetic nitrogen fertilizers, lowering production costs and minimizing environmental impacts such as nitrate leaching and greenhouse gas emissions. As a result, pulses contribute to improved nutrient-use efficiency and support climate-smart agricultural practices [8]. Pulse crops play a vital role in crop rotation systems by breaking pest and disease cycles, enhancing soil structure, and increasing soil organic matter. Their inclusion in rotations with cereals and oilseeds promotes greater cropping system diversity, which is associated with improved system resilience and reduced vulnerability to biotic and abiotic stresses. Compared to many cereal crops, pulses generally require fewer external inputs, making them suitable for low-input and resource-efficient farming systems. From a pollinator perspective, pulse-based systems offer several advantages. Many pulse crops produce flowers that provide nectar and pollen resources for bees, particularly during periods when alternative floral resources may be limited. While some pulses are capable of self-pollination, bee visitation can enhance yield components, seed quality, and overall productivity. Moreover, pulse crops are often integrated into diversified landscapes that include intercropping, cover cropping, and conservation practices, all of which can improve habitat availability for pollinators, pulse-based farming systems align well with agroecological and regenerative agriculture principles, which emphasize reduced chemical inputs, biodiversity enhancement, and ecosystem service provision. These characteristics position pulses as a strategic component of bee-friendly agriculture, offering

opportunities to support pollinator conservation while maintaining productive and economically viable farming systems.

4. Bee-Friendly Farming Practices in Pulse-Based Systems

The integration of bee-friendly practices within pulse-based farming systems offers a strategic approach to enhancing pollinator conservation while maintaining agronomic productivity. Pulses possess biological and management characteristics that make them well suited for practices that support pollinator health at both field and landscape scales.

4.1 Floral Resource Availability

Floral resource availability is a key determinant of bee abundance and diversity in agricultural systems. Pulse crops produce flowers that supply nectar and pollen to a wide range of bee species, including managed honey bees (*Apis mellifera*), bumblebees (*Bombus* spp.), and numerous solitary bee species. Although many pulses are capable of self-pollination, bee visitation can enhance pollen transfer efficiency and contribute to improved reproductive success [9]. Several farming practices can significantly enhance floral resource availability within pulse-based systems. Mixed cropping and intercropping with flowering companion species increase the diversity and continuity of floral resources across the growing season. The selection of pulse varieties with extended or staggered flowering periods can further reduce temporal gaps in forage availability, supporting bees throughout their active life stages, the inclusion of flowering field margins, hedgerows, and buffer strips provides critical supplementary forage and nesting habitats. These semi-natural features often host native flowering plants that bloom before or after pulse crops, ensuring continuous resource provision. Such practices not only benefit bees but also enhance overall farmland biodiversity and ecosystem service provision.

4.2 Reduced Pesticide Use

Pulse-based farming systems generally require fewer chemical inputs than intensive cereal monocultures, creating opportunities to reduce pesticide exposure for pollinators. Bee-friendly pesticide management focuses on minimizing both lethal and sub-lethal impacts on bees. Key practices include avoiding neonicotinoids and other systemic insecticides known to persist in plant tissues and contaminate nectar and pollen. When pesticide use is unavoidable, timing applications outside peak bee foraging periods—such as applying treatments during late evening or night—can substantially reduce exposure risks. The use of selective pesticides with lower toxicity to non-target organisms further contributes to pollinator protection. Alternative pest control approaches, including mechanical weeding, crop rotation, and biological control agents, are increasingly adopted in pulse systems [10]. These strategies reduce chemical dependence while maintaining acceptable pest suppression levels, supporting both crop health and pollinator safety.

4.3 Integrated Pest Management (IPM)

Integrated Pest Management (IPM) represents a cornerstone of bee-friendly agriculture by prioritizing ecological approaches to pest control. IPM combines regular pest monitoring, economic threshold-based decision-making, biological control agents, and cultural practices to minimize unnecessary pesticide use [11]. In pulse-based systems, IPM has been shown to significantly lower pesticide residues in floral resources, thereby reducing chronic exposure risks for bees. By limiting broad-spectrum pesticide applications, IPM also mitigates sub-lethal effects on bee behavior, navigation, foraging efficiency, and reproductive success. Importantly, IPM strategies can maintain effective pest control without compromising crop yields, making them economically viable for farmers.

Table 1. Bee-Friendly Farming Practices in Pulse-Based Systems and Their Ecological Impacts

Bee-Friendly Practice	Description	Benefits for Bees	Agronomic and Environmental Benefits
Diversified pulse cropping	Inclusion of pulses in rotations, intercropping, or mixed cropping systems	Increased floral resources and foraging diversity	Improved soil fertility, nitrogen fixation, reduced fertilizer inputs
Extended flowering periods	Use of pulse varieties with staggered or longer flowering phenology	Continuous nectar and pollen supply	Enhanced pollination services and yield stability
Reduced pesticide use	Limiting or eliminating systemic and broad-spectrum pesticides	Lower mortality and sub-lethal effects on bees	Reduced chemical residues, improved ecosystem health
Integrated Pest Management (IPM)	Combination of biological, cultural, and mechanical pest control	Reduced exposure to harmful agrochemicals	Sustainable pest control and long-term yield protection
Field margins and hedgerows	Maintenance of flowering non-crop habitats	Nesting sites and additional forage	Increased landscape biodiversity and resilience

Table 2. Key Challenges, Research Gaps, and Future Research Priorities in Bee-Friendly Pulse-Based Farming Systems

Area	Current Limitation	Research Gap	Recommended Future Direction
Bee-pulse interactions	Limited long-term and regional studies	Lack of comparative, multi-year datasets	Establish long-term monitoring across agroecological zones
Pulse crop breeding	Focus primarily on yield and stress tolerance	Floral traits rarely considered	Develop pollinator-supportive pulse varieties
Pest management	Farmer reliance on chemical control	Insufficient evaluation of IPM effectiveness for pollinators	Optimize IPM strategies balancing pest control and bee safety
Farmer adoption	Limited awareness and economic incentives	Socio-economic barriers underexplored	Strengthen extension services and policy incentives
Sustainability assessment	Yield-focused evaluation metrics	Pollinator indicators often excluded	Integrate bee diversity and abundance into sustainability frameworks

4.4 Habitat Diversification and Landscape Complexity

Habitat diversification at both field and landscape scales is essential for sustaining healthy pollinator populations. Pulse-based systems naturally lend themselves to diversified management due to their role in crop rotations and mixed farming systems. Crop rotations incorporating legumes, cereals, and cover crops enhance habitat heterogeneity and temporal resource availability. The maintenance of non-cropped habitats—such as grass strips, riparian buffers, and conservation set-asides—provides nesting sites and refuge areas for wild bees. Agroforestry practices and diversified farm landscapes further enhance structural complexity, supporting a wider range of pollinator species and functional traits. Collectively, these practices strengthen ecological connectivity, allowing bees to move across landscapes in search of food and nesting resources, thereby improving population persistence and resilience.

5. Impacts on Bee Diversity and Abundance

A growing body of evidence indicates that diversified pulse-based farming systems support higher bee abundance and species richness compared to simplified monoculture systems. The availability of diverse floral resources and reduced chemical exposure create favorable conditions for both managed and wild pollinators. Pulse-based systems increase foraging opportunities by providing nectar and pollen during critical periods, while diversified habitats enhance nesting availability. Wild bees, in particular, show strong positive responses to landscape heterogeneity and reduced pesticide pressure.

These benefits contribute to more stable and resilient pollinator communities, capable of sustaining pollination services under environmental stress. Enhanced bee diversity also improves functional redundancy within pollinator communities, reducing the risk of pollination failure if individual species decline [12]. This ecological stability is especially important in the context of climate variability and ongoing environmental change.

6. Agronomic and Socio-Economic Implications

6.1 Crop Productivity and Yield Stability

Bee-friendly practices in pulse-based systems can positively influence crop productivity and yield stability. Although many pulses are self-fertile, partial dependence on insect pollination has been documented for crops such as faba beans, chickpeas, and certain pea varieties. Improved pollination can enhance pod set, seed weight, and uniformity, contributing to more consistent yields, diversified systems are generally more resilient to pests, diseases, and climatic stresses. By supporting ecosystem services such as pollination and biological pest control, bee-friendly pulse systems reduce production risks and promote long-term agricultural sustainability.

6.2 Economic Benefits for Farmers

From an economic perspective, bee-friendly pulse farming can offer multiple advantages. Reduced input costs associated with lower fertilizer and pesticide use improve farm profitability. Enhanced soil fertility and ecosystem services further contribute to long-term productivity and reduced dependency on external inputs, growing consumer demand for sustainably produced food creates opportunities for

pollinator-friendly certification and eco-labeling. Such market incentives can provide price premiums and improve market access, particularly in environmentally conscious markets. Collectively, these agronomic and socio-economic benefits strengthen the case for integrating bee-friendly practices into pulse-based agricultural systems [13]. The Challenges and Research Gaps, the demonstrated ecological and agronomic potential of bee-friendly practices in pulse-based farming systems, several challenges limit their widespread adoption and effectiveness. One major constraint is the lack of long-term, region-specific studies examining bee-pulse interactions across diverse agroecological contexts. Most existing research is short-term or localized, making it difficult to generalize findings or assess cumulative impacts on pollinator populations and crop productivity over time.

Significant knowledge gaps also remain regarding the selection and breeding of pulse varieties optimized for pollinator support. While pulses vary in floral morphology, nectar production, and flowering duration, these traits are rarely considered in breeding programs, which traditionally prioritize yield, pest resistance, and stress tolerance. A deeper understanding of how varietal traits influence bee visitation and pollination efficiency is essential for integrating pollinator considerations into crop improvement strategies. Another challenge involves managing trade-offs between effective pest control and pollinator protection. Although reduced pesticide use and IPM strategies are beneficial for bees, farmers may be hesitant to adopt them due to concerns about yield losses or increased labor requirements. Identifying context-specific solutions that balance pest management needs with pollinator safety remains a critical research priority [14]. Barriers to adoption are particularly pronounced among smallholder and resource-limited farmers. Limited access to knowledge, extension services, financial incentives, and risk-sharing mechanisms can constrain the implementation of bee-friendly practices. Addressing these challenges requires interdisciplinary research that integrates ecological science with socio-economic analysis, as well as participatory approaches that actively involve farmers in knowledge generation and decision-making.

8. Future Directions and Recommendations

To fully realize the potential of bee-friendly pulse-based farming systems, future research and policy efforts should focus on several key areas. First, breeding programs should incorporate floral traits such as nectar availability, pollen quality, and flowering phenology into pulse crop development. Such traits could enhance the value of pulses as pollinator resources without compromising agronomic performance, there is a need to scale up landscape-level conservation strategies that complement field-scale interventions [15]. Coordinated management of habitats across farms—such as connected field margins, cover crops, and semi-natural areas—can amplify benefits for pollinators and strengthen ecological connectivity.

These approaches require supportive policies and incentives that encourage collective action among farmers.

Strengthening farmer education and extension services is also essential. Targeted training programs can increase awareness of the benefits of pollinators, demonstrate practical implementation strategies, and reduce perceived risks associated with changing management practices. Digital tools and participatory learning platforms may further enhance knowledge dissemination, particularly in remote or underserved regions. Finally, integrating pollinator-related indicators into agricultural sustainability assessments can improve monitoring and decision-making. Including metrics such as bee abundance, diversity, and habitat quality alongside yield and economic indicators would provide a more holistic evaluation of system performance [16-17]. Achieving these goals will require close collaboration among agronomists, ecologists, policymakers, extension professionals, and farming communities.

9. Conclusion

Pulse-based farming systems represent a viable and promising pathway for reconciling agricultural productivity with pollinator conservation. By integrating bee-friendly practices such as reduced pesticide use, habitat diversification, enhanced floral resources, and integrated pest management, these systems can support healthy bee populations while improving soil health, yield stability, and ecosystem resilience. The multifunctional benefits of pulse crops position them as a strategic component of sustainable and climate-resilient agriculture. Promoting bee-friendly pulse systems through targeted research, supportive policies, farmer-centered extension services, and market-based incentives can contribute meaningfully to biodiversity conservation and sustainable food systems. In the face of ongoing environmental challenges, such integrated approaches are essential for safeguarding both agricultural livelihoods and ecosystem integrity.

Declaration

No generative AI tools were used in the research design or data analysis for this review. Language editing assistance, if any, was conducted under full human oversight.

References

1. Pywell, R. F., Heard, M. S., Woodcock, B. A., Hinsley, S., Ridding, L., Nowakowski, M., & Bullock, J. M. (2015). Wildlife-friendly farming increases crop yield: evidence for ecological intensification. *Proceedings of the Royal Society B: Biological Sciences*, 282(1816), 20151740.
2. Layek, U., Kundu, A., Das, N., Mondal, R., & Karmakar, P. (2023). Intercropping with pigeonpea (*Cajanus cajan* L. Millsp.): An assessment of its influence on the assemblage of pollinators and yield of neighbouring non-leguminous crops. *Life*, 13(1), 193.

3. Chopin, Pierre, Alexander Menegat, Göran Bergkvist, Steffen Dahlke, Ortrud Jäck, Ida Karlsson, Marcos Lana et al. "The reflection of principles and values in worldwide organic agricultural research viewed through a crop diversification lens. A bibliometric review." *Agronomy for Sustainable Development* 43, no. 1 (2023): 23.
4. Simanonok, M. P., Otto, C. R., & Smart, M. D. (2020). Do the quality and quantity of honey bee-collected pollen vary across an agricultural land-use gradient?. *Environmental entomology*, 49(1), 189-196.
5. Sharma, D., & Abrol, D. P. (2014). Role of pollinators in sustainable farming and livelihood security. In *Beekeeping for poverty alleviation and livelihood security* (pp. 379-411). Springer, Dordrecht.
6. Potts, S. G., et al. (2010). Global pollinator declines: Trends, impacts and drivers. *Trends in Ecology & Evolution*, 25(6), 345-353. <https://doi.org/10.1016/j.tree.2010.01.007>
7. IPBES (2016). The assessment report on pollinators, pollination and food production. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany.
8. Klein, A. M., et al. (2007). Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B*, 274, 303-313. <https://doi.org/10.1098/rspb.2006.3721>
9. Garibaldi, L. A., et al. (2013). Wild pollinators enhance fruit set of crops regardless of honey bee abundance. *Science*, 339, 1608-1611. <https://doi.org/10.1126/science.1230200>
10. Goulson, D., Nicholls, E., Botías, C., & Rotheray, E. L. (2015). Bee declines driven by combined stress from parasites, pesticides, and lack of flowers. *Science*, 347, 1255957. <https://doi.org/10.1126/science.1255957>
11. Rundlöf, M., et al. (2015). Seed coating with a neonicotinoid insecticide negatively affects wild bees. *Nature*, 521, 77-80. <https://doi.org/10.1038/nature14420>
12. Bommarco, R., Kleijn, D., & Potts, S. G. (2013). Ecological intensification: Harnessing ecosystem services for food security. *Trends in Ecology & Evolution*, 28(4), 230-238. <https://doi.org/10.1016/j.tree.2012.10.012>
13. Westphal, C., et al. (2008). Measuring bee diversity in different European habitats. *Ecological Monographs*, 78, 653-671. <https://doi.org/10.1890/07-1292.1>
14. Stagnari, F., Maggio, A., Galieni, A., & Pisante, M. (2017). Multiple benefits of legumes for agriculture sustainability. *Agronomy for Sustainable Development*, 37, 22. <https://doi.org/10.1007/s13593-017-0445-8>
15. Garratt, M. P. D., et al. (2014). Pollination deficits in UK apple orchards. *Journal of Pollination Ecology*, 12, 9-14.
16. Tscharntke, T., et al. (2012). Landscape moderation of biodiversity patterns and processes. *Ecology Letters*, 15, 577-594. <https://doi.org/10.1111/j.1461-0248.2012.01771.x>
17. FAO (2019). Pollinators and food security. Food and Agriculture Organization of the United Nations, Rome.