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REVIEW PAPER

A Literature Review and Statistical Analysis of Turkish Agricultural Data: Assessing Crop Dependence on Insect Pollinators in Türkiye

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Abstract

The study delves into the critical role of pollination in shaping the quality and quantity of agricultural products. Insect pollination, with a primary focus on *Apis mellifera* L., is identified as an indispensable element in the development of a significant proportion of global agricultural crops. Moreover, the study underscores the multifaceted benefits of insect pollination, not only enhancing crop production but also elevating the overall quality of produce. Fruits and oilseeds are cited as beneficiaries of bee pollination, resulting in larger, higher-quality crops with extended shelf lives. Commercial crop pollination relies mainly on managed honeybees. The study elucidates the versatility, cost-effectiveness, and adaptability of honeybee colonies for pollination purposes. However, it is noted that honey bee populations are dwindling due to factors such as parasites, pesticide usage, limited floral resources, and *Nosema* spp. infection, which poses a potential risk to agricultural crop pollination. The research focuses on insect pollination due to its crucial role in the process. The goal of this study is to find out what percentage of Turkish crops depend on insects to pollinate them. Data on plants requiring insect pollination were obtained through a comprehensive literature review, while data on Turkish agricultural products were sourced from the Turkish Statistical Institute. This comprehensive study explores the vital role of insect pollinators in Turkish agriculture. This statement highlights the crucial role of plant and animal production in meeting the nutritional needs of societies, while emphasizing the importance of increasing the size of agricultural cultivation areas to enhance overall agricultural productivity.

Introduction

It is impossible to overestimate the significance of plant and animal production, as well as their quality and efficiency improvements, in providing appropriate nutrition for societies, according to the Food and Agriculture Organization of the United Nations (UNICEF, 2021). Extending the area under cultivation is a key step in the right direction for boosting agricultural output (Bhandari, 2020). Increasing yield from a given area is one of the most important variables in increasing agricultural output (Gomiero et al., 2011).

Developed nations are using intensive production tactics to increase their overall agricultural production levels (UNICEF, 2021). Good Agricultural Practices (GAP), which aims to address food-borne illnesses and environmental issues, have been popular in agriculture in recent years (Burrell, 2011).

Pollination contributes to the quality and quantity of the products. Pollination by insects is a crucial factor in the development of the vast majority of agricultural crops worldwide. Insects play a crucial role in the pollination of many fruits, vegetables, and crops; of the approximately 300 commercial crops around 84% have been pollinated by insects, primarily *Apis mellifera* L. (Klein et al., 2006). Pollination services provided by honey bees and wild bees have declined in recent decades (Kevan & Viana, 2003). Its loss is due to agricultural expansion, monoculture, disease and parasites, intensive pesticide usage, urbanization, and fragmentation (Stanton et al., 2018; Wan et al., 2021). If insect pollinators diminish or become extinct, humans will be unable to consume a variety of foods (Klein et al., 2006). Insect pollination has additional advantages for crop quality.

Pollination of plants by bees is not only essential for crop production but also improves the overall quality of the produce. Fruits that have been pollinated by bees are larger, have fewer deformities, and score higher on commercial quality scales. Fruits that have been pollinated by bees have longer shelf lives because their sugar-to-acid ratios are more optimal, and they are also more robust (Klatt et al., 2014). Pollination of oil crops by bees not only improves the quality of the fruit they produce, but it also improves the quality of the oil produced by such crops. For example, bee pollination led to an 18% rise in the weight of oil seeds and a 20% increase in their market value. Oil seeds that are pollinated by bees contain higher levels of oil and lower levels of chlorophyll (Bommarco et al., 2012).

Pollination of intensively farmed commercial crops is almost entirely dependent on managed pollinators, with only a small percentage coming from wild insects (Richards, 1993). Honey bees are the most important commercial pollinators, and they are responsible for at least 90 percent of all commercial pollination (Free, 1970; Richards, 1993). Although some species of bees, such as alkali bees, mason bees, leafcutter bees, and bumble bees, are used for commercial pollination, honey bees are by far the most important commercial pollinators (McGregor, 1976).

Honey bee colonies are the sole viable option for ensuring the successful pollination of crops in the event that wild bees do not visit the agricultural area. In comparison to other types of manageable pollinators, honey bee colonies are more adaptable, less expensive, and handier for pollination purposes (Klein et al., 2006). The number of honey bee colonies is decreasing and the most obvious reasons are due to parasites, the use of pesticides, the lack of flowers, and *Nosema* spp. infections. (Genersch, 2010; Goulson et al., 2015). This condition poses a potential risk to the pollination of agricultural crops.

This research is focused on insect pollination because they are the most significant species that play a role in the pollination process (Breeze et al., 2011). This study's objective is to determine the percentage of Türkiye's agricultural crops that rely on the activity of insects for pollination. A literature analysis of plants that need insect pollination was carried out, and the data regarding Turkish agricultural goods were gathered from the Turkish Statistical Institute.

Material and Methods

We made a rough estimate of the proportion of crop output that is attributable to insect pollination. The Turkish Statistical Institute, which is the government institution in Türkiye that is tasked with the responsibility of producing official statistics on Türkiye, was the source from which the data regarding Turkish agricultural products were gathered. Only data from 2020 was analyzed, and spices did not make the cut for the list of crops that were analyzed. The data were broken down into Türkiye's seven distinct geographical regions for analysis. There are 128 different plant species that were discovered, and these plants have been separated into nine distinct categories: leaves, stems, fruits, pods, flowers, roots, bulbs, tubers, and fungus. We individually categorized each of the 128 crops into one of two groups: those whose output did not rise with pollination and those whose production is dependent on animal pollination to at least some extent. By conducting a literature review, we were able to determine the pollination requirements of various

Table 1. Insect Pollination Requirements of Plants

Crop Name	Insect Pollination Requirement	References
Phaseolus vulgaris, Vicia faba, Glycine max, Arachis hypogaea, Gossypium hirsutum, Brassica napus, Sesamum indicum, Helianthus annuus, Papaver somniferum, Carthamus tinctorius, Solanum tuberosum, Ipomoea batatas, Pisum sativum, Vigna unguiculata, Brassica oleracea, Lactuca sativa, Cynara scolymus, Apium graveolens, Beta vulgaris, Portulaca oleracea, Petroselinum crispum, Citrullus lanatus, Cucumis melo, Capsicum annuum, Cucumis sativus, Cucumis melo, Solanum melongena, Solanum lycopersicum, Abelmoschus esculentus, Cucurbita pepo, Cucurbita moschata, Solanum muricatum, Brassica napobrassica, Allium sativum, Allium cepa, Allium ampeloprasum, Raphanus sativus, Persea americana, Musa Sapientum, Ficus carica, Citrus sinensis, Citrus reticulata, Citrus aurantium, Malus domestica, Pirus communis, Cydonia oblonga, Prunus armeniaca, Prunus avium, Prunus cerasus, Prunus persica, Prunus domestica, Eriobotrya japonica, Elaeagnus angustifolia, Ziziphus jujuba, Actinidia deliciosa, Rubus idaeus, Fragaria vesca, Vaccinium myrtillus, Rubus caesius, Prunus dulcis, Castanea sativa, Punica granatumun,	Depends upon insect pollination at least to some extent	Vaz et al., 1998; Free, 1970; Roubik, D. W.; 1995 Rhodes, 2002; Schittenhelm et al., 2006; Crane, 1991; Bichee & Sharma, 1988; Moreti et al., 1996; Dajue & Mündel, 1996; Plaisted, 1980; Jones, 1980; Smith, 1980; Somerville, 1999; Free, 1993; Abel & Wilson, 1998; Pesson & Louveaux, 1984; El-Bakatoushi et al., 2013; Stanghellini et al., 2002; Valantin-Morison et al., 2006; Jarlan et al., 1997a;b; Meisels & Chiasson, 1997; McLaren et al., 1995; Benedek et al., 2006; Slaa et al., 2006; Hamon & Koechlin, 1991; Fuchs & Müller, 2004; Kowalczyk, 2008; Schittenhelm et al., 1997; Kamenetsky & Rabinowitch, 2001; Witter & Blochtein, 2003; Gray & Steckel, 1986; Partap & Verma, 1994; Can-Alonzo et al., 2005; Ish-Am & Eisikowitch, 1993; Willson & Schemske, 1980; Gottsberger, 1999; Westerkamp & Gottsberger, 2000; Chacoff & Aizen, 2006; Sharma et al., 2003; Delaplane,

Table 1. Insect Pollination Requirements of Plants (continue)

Crop Name	Insect Pollination Requirement	References
Camellia sinensis, Citrus paradisi, Citrus limonum, Mespilus germanica	Depends upon insect pollination at least to some extent	2000; Khan et al., 1986; Pan et al., 2011; Yadav, P K, 2021; Costa et al., 1993; Manino et al., 1991; Wickramaratne & Vitarana, 1985; Miller et al., 2005
Triticum aestivum, Zea mays, Hordeum vulgare, Secale cereale, Avena sativa, Triticosecale Wittm, Cicer arietinum, Lens culinaris, Pisum sativum, Vigna unguiculata, Oryza sativa, Beta vulgaris, Spinacia oleracea, Daucus carota, Agaricus bisporus, Vitis vinifera, Morus nigra, Corylus colurna, Pistacia vera, Jovis Glans, Ceratonia siliqua, Diospyros kaki, Olea europaea	Does not require insect pollination	Allan, 1980; Russell & Hallauer, 1980; Starling, 1980; Geiger & Miedaner, 2009; Brown, 1980; Larter & Gustafson, 1980; Gritton, 1980; Ladizinsky et al., 1984; Free, 1970; Major et al., 1993; Smith, 1980; Free, 1993; Simon, 2010; Sampson et al., 2001; Chacoff & Aizen, 2006; Mulberry, 2023; Olsen et al., 2000; Crane, 1991; Polito et al., 2004; Dafni et al., 2012; Phipps et al., 2003; Miura, 1982

crops. The plants that required insect pollination were given in Table 1.

Result and Discussion

Pollination is an essential biological mechanism for preserving the diversity and productivity of several plant species. Honey bees are among the most important pollinators for agricultural products, including fruits, vegetables, and nuts. Honey bees are extraordinarily effective in gathering nectar and pollen, and they can transport and transmit pollen grains from flower to flower. This procedure increases the likelihood of effective fertilization, seed generation, and fruit growth. Without the pollination of honey bees, many crops would experience large production losses, resulting to economic losses and food shortages (Breeze et al., 2011).

Farmers have long recognized the value of honey bees for crop pollination, and as a result, they are commonly used as pollinators in agriculture. Concerns have been expressed concerning the sustainability of food production as a result of the global fall of honey bee numbers due to factors including habitat loss, pesticide use, and diseases. Researchers have been studying alternative pollinators, such as wild bees, flies, and beetles, as well as devising measures to increase honey bee health and variety to reduce the detrimental effects of honey bee decline on agriculture (Garibaldi et al., 2014).

Table 2 gives us a more in-depth look at the proportion of crops in each region that require insect pollination to some extent, as well as the proportion of crops that do not require insect pollination to any significant degree. The percentage of all crops that require insect pollination is 72.7%, which is in line with the trend that has been observed globally, which is that insect pollinators play an important part in agriculture.

Table 2. Crop Production in Various Regions of Türkiye Depending on Insect Pollination

Geographic Locations of Türkiye	Crops, to some extent depend on insect pollination	Crops do not require insect pollination	Total number of crops produced
Mediterranean Region	72.4%	27.6%	127
Eastern Anatolia Region	70.5%	29.5%	95
Aegean Region	72.4%	27.6%	123
South-eastern Anatolia Region	71.1%	28.9%	97
Central Anatolia Region	70.2%	29.8%	104
Black Sea Region	72.7%	27.3%	110
Marmara Region	72.4%	27.6%	116
Overall	72.7%	27.3%	128

The Mediterranean region contains the greatest number of crops (127), with 72.4% of them requiring insect pollination in some capacity and 27.6% not requiring insect pollination. Similarly, in the Aegean region, 72.4% of the crops require insect pollination, compared to 27.6% of the crops that do not. Similar crop distribution exists in the Marmara region, with 72.4% of crops requiring insect pollination and 27.6% not requiring it.

Eastern Anatolia, on the other hand, has the lowest proportion of crops (70.5%), with 29.5% not requiring insect pollination. Similarly, the region of south-eastern Anatolia has a greater proportion of crops (28.9%) that do not require insect pollination. The region of Central Anatolia has a higher proportion (29.8%) of crops that do not require insect pollination, whereas 70.2% of crops are pollinated by insects.

The Black Sea region stands out in terms of the number of crops that do not require insect pollination, accounting for 27.3% of crops in the region. This could be attributable to the environmental factors and the vegetation of the region, which may favor self-pollinating crops.

In Türkiye, around 72.7% of crops require insect pollination, whereas 27.3% do not. Around 84% of the 264 crops used for food production in Europe depend on insect pollination, illustrating the importance of pollinators in European agriculture (Underwood et al., 2017). The proliferation of fruit orchards and high-value cash crops, such as oilseed rape has increased the need for insect pollination services in China (Zou et al., 2017). In some regions, the reduction of natural pollinator populations and the excessive use of pesticides pose a threat to crop output and food security (Vanbergen & Initiative, 2013).

Conclusion

One of the greatest obstacles honey bees and other pollinators face is habitat loss caused by alterations in land use patterns. As agricultural practices intensify and expand, natural habitats are transformed into monoculture fields devoid of the variety of flowering plants required to sustain pollinator populations. This may result in food shortages, economic losses, and detrimental effects on biodiversity (Kremen et al., 2007). In addition, the use of pesticides can harm pollinators, diminishing their numbers and threatening their health (Sánchez-Bayo & Wyckhuys, 2019). Additionally, honey bees and other pollinators are vulnerable to diseases and parasites, such as *Varroa destructor* (vanEngelsdorp et al., 2010).

To resolve these troubles, researchers have been studying alternative pollinators and developing strategies to improve the health and diversity of honey bees. For instance, wild bees, flies, and beetles have been identified as potential alternative pollinators, and research indicates that they can pollinate certain crops effectively (Garibaldi et al., 2014). Efforts to restore and improve natural habitats, such as wildflower meadows and hedgerows, can also provide pollinators with valuable resources and improve their health (Kremen et al., 2007).

Insect pollination is required for 72.7% of crops in Türkiye, with the highest number of crops found in the Mediterranean, Aegean, and Marmara regions. Eastern and southeastern Anatolia have the lowest proportion of crops necessitating insect pollination. The Black Sea region has the highest proportion of crops that do not require insect pollination, possibly as a result of the region's climate and vegetation. The study also emphasized the significance of pollinators in agriculture, as approximately 84% of food-producing crops in Europe depend on insect pollination. We argue that protecting honey bees and alternative pollinators is essential to maintaining crop productivity and food security.

Ethical Statement

There are no ethical issues with the publication of this article.

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Conflict of Interest

The authors declare that there is no conflict of interest.

Author Contributions

Author 1: Investigation, Writing – review & editing,

Author 2: Investigation, Writing – review & editing; Supervision, Formal Analysis

Author 3: Investigation, Writing – review & editing

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