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RESEARCH ARTICLE

Analytical Study on the Impact of Management Practices and Experience on Honey Production Efficiency in Iraqi Honeybee Apiaries

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ABSTRACT

The beekeeping sector encountered numerous challenges it is affected by administrative and environmental factors hence this study was conducted pursue to evaluate these factors using descriptive statistical design through honey flow, The sample included 55 beekeepers from several Iraqi governorates The data collected through a structured field survey that included information on demographic beekeepers characteristics, apiary management practices, environmental and health factors affecting colonies in addition productivity indicators, data were analyzed using SPSS software based on descriptive statistics one-way ANOVA at significance level of ($P \leq 0.05$). The results shows a significant effect of year experience on average honey production more than 10 recorded highest average production 12.5 Kg/hive compared to 9.7 for those with 5-10 years and 7.2 Kg/hive for less experienced beekeepers, high productivity associated with increase hive number reaching 13.4 Kg/hive in apiary 100 hives compared to 10.8 and 8.5 Kg/hive in medium and small apiaries respectively, decline of bee blooming plants led to decrease production 9.0 Kg/hive compared to 12.2 Kg/hive in locations that didn't witnessed a vegetative degradation, pesticides was also associated to higher bee mortality rate of 35.6% compared to 18.9% in unaffected apiaries. Colonies infected with *Varroa destructor* and *Nosema* spp. Also has dropped in production to 8.3 and 9.1 Kg/hive, respectively, compared with 12.6 in healthy colonies. These results indicated that honey production is affected by the interaction of many factors, such as administrative environmental, and health factors, highlighting of improving apiary management practices, enhancing beekeeper training programs, and boosting nectar resources to ensure the sustainability of honey production.

Keywords: *Honeybee, Beekeepers, Honey flow*

INTRODUCTION

Beneficial insects perform valued services in our ecosystem and thus benefit us. Honeybees are beneficial insects that contribute to global food security and ecosystem sustainability through their well-known free service: pollination. Even better, farmers can benefit from the valuable products produced

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by bee colonies, improving their economic viability (Samanta *et al.,* 2024). Bees are essential pollinators in the ecosystem and play a major role in maintaining plant density (Satyapriya *et al.,* 2024). Wasef (2015) explained that increasing the area planted with crops important for bees is directly proportional to increasing honey production. Honey production was significantly and positively affected by the total number of beehives, the type of hive, and the distance to an easily accessible forest. Male beekeepers who are heads of households tend to keep bees in groups more often than women. Family age had a significant and negative impact on the likelihood of joining the development program. (Deksisa, *et.al.,* 2024). The presence of flowering plants has a positive effect on honey production and the activity of bee colonies. Fabaceae being the most highly visited by honeybees, followed by Anacardiaceae and Moraceae (Oluwaseyi *et.al.,*2021)

The number of bees searching for food increases with the increase in the number of flowers on the plant, the number of foraging bees increased with plant diversity (Mramba, 2025) Pesticides directly affect and disrupt crucial physiological and behavioral mechanisms in honeybees organophosphates and carbamates function as neuroinhibitors by impeding the acetylcholine neurotransmitter action in the insect nervous system pose potential risks when excessive residues accumulate in combs, The bee products most susceptible to pesticide contamination are honey and then pollen(Sadia *et.al.*, 2024) Pesticides are harmful to pollinators and can cause fatal and near-fatal effects through dermal contact, ingestion, or inhalation of contaminated air (Kumari *et.al.,* 2024) Viruses transmitted by Varroa mites and the interaction with pesticides have a lethal effect on bee colonies) Barasso *et.al.,* 2025) organic beekeeping does not lead to the production of honey with significantly better physical, chemical, nutritional, and sensory properties compared to conventionally produced honey(Stanojevic *et.al.,*2024)

MATERIAL AND METHODS

Study Design and Area

This study was conducted using a cross-sectional descriptive-analytical design during the honey flow in Iraq. The study aimed to evaluate the impact of beekeepers' practical experience and management practices on the efficiency of honey production in Iraqi apiaries. The study included different Iraqi governorates representing the diverse environments for beekeeping in the country. This includes the central and northern regions, to reflect the diversity in environmental and climatic conditions and production systems in place.

Study Sample

The study sample was selected using stratified random sampling to ensure appropriate representation of the various categories of beekeepers. The sample included beekeepers who manage apiaries with different hive numbers, Levels of experience (number of years of practice), and management intensity. The total number of participants in the study was 55 beekeepers. The sample size was determined based on similar previous studies in the field, and to achieve acceptable statistical accuracy for testing the hypotheses.

Data Collection

The data were collected in the field using a structured questionnaire. Designed specifically for this study, the questionnaire was distributed to participating beekeepers through direct personal interviews and field visits to apiaries during the production season. Before participating, all beekeepers were informed of the research objectives and what their participation would entail. Their verbal or written consent was obtained. The information provided will be kept confidential and used just for scientific research purposes. Participation was entirely voluntary.

Study Instrument

The questionnaire consisted of four main sections covering the independent and dependent variables in the study. This is as follows:

Section One: Demographic Information and General Characteristics of Beekeepers

This section included data on age, years of experience in beekeeping, the number of hives owned by the beekeeper, the location of the apiary (governorate/region), and educational level.

Section two: Management and technical practices

This section evaluates the management practices implemented in the apiary. It includes questions about:

- Repeatedly examining and detecting hives.
- Queen management (queen rearing, queen replacement).

- Supplementary feeding practices (types, timing).
- Control methods of diseases and parasites.
- Brood management and hive organization.
- Dealing with stressful environmental conditions (pasture shortage, climate change).

Section Three: General Hive Health and Environmental Stresses

This section discusses the environmental and pathological factors affecting bee health and productivity, including:

- The extent of the spread of diseases and parasites (such as Varroa destructor and Nosema spp.)
- The extent of exposure to pesticides in the apiary area.
- Providing sources of nectar and pollen and assessing the extent of decline in flowering vegetation area.
- Beekeeper's observations on the impact of environmental factors on bee activity.

Section Four: Indicators of Productivity

This section included quantitative data on the apiary's productive performance, the most important of which are:

- Average honey production per hive (kg/hive) during the production season.
- Rate of hive loss during the season (mortality).
- Stable production across different seasons.
- The extent to which sales are affected by imported honey (estimated percentage).

Statistical Analysis

The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS, IBM Corp., Armonk, NY, USA), version [insert version number used]. The statistical analysis strategy was based on the following steps:

1. Descriptive Statistics: The arithmetic means were calculated, and standard deviations were used to describe the characteristics of the sample and the variables under study.
2. One-way analysis of variance (One-way ANOVA): Use the one-way ANOVA test to compare average honey production between different groups according to the study variables (Such as experience levels, apiary size, and presence of diseases). This test aims to determine whether there are statistically significant differences between the averages of three or more groups
3. Post-hoc comparison test: In case of significant differences, using analysis ANOVA, the least significant difference LSD test was used to conduct pairwise comparisons between groups and identify the source of the subtle differences.
4. Level of statistical significance: A statistical significance level was adopted at a probability value (P-value) of less than or equal to 0.05 ($P \leq 0.05$) for differences to be accepted as statistically significant.

The results were presented as tables showing the means, standard deviations, LSD values, and significance levels for each variable.

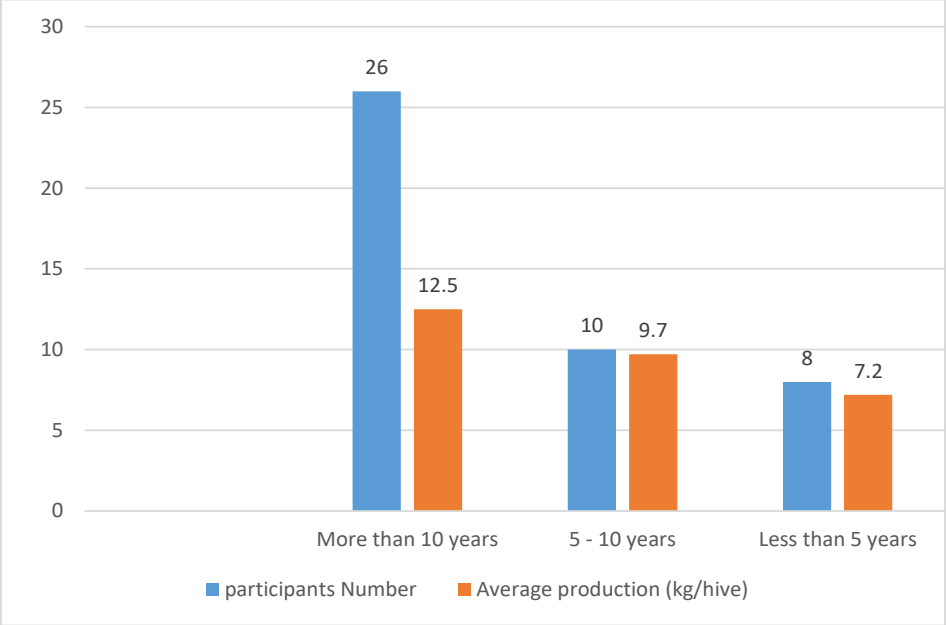
RESULTS AND DISCUSSIONS

The effect of an experience period on honey production

The results of the statistical analysis showed Average honey production varies significantly depending on the beekeeper's experience level ($p < 0.05$). The average production for beekeepers with more than 10 years of experience was 12.5 kg/hive compared to 9.7 kg/hive for beekeepers with 5–10 years of experience, 7.2 kg/hive for beekeepers less than 5 years old with a value of (LSD 0.05) of 1.8 kg/hive. Since all differences between the means exceeded the LSD value, these are statistically significant. This indicates that increased practical experience among beekeepers is directly related to increased hive productivity. As a result of improved technical and managerial skills acquired over time, beekeepers with extensive experience are more efficient at selecting appropriate apiary sites. This includes managing diseases and parasites such as Varroa destructor, regulating supplemental feeding, managing brood and queen, and timing honey harvesting to coincide with peak flowering periods.

These results are consistent with the Food and Agriculture Organization of the United Nations (FAO)2021 report, which emphasized that the accumulated experience of beekeepers contributes to increased production efficiency and improved honey

Figure1: Effect of the experienced period on honey production



quality through sound management practices. The number of years of experience is one of the most important factors determining apiary productivity and beekeepers' income in developing countries (Jeil *et al.,* 2022). Beekeepers with more experience recorded higher production and higher economic revenues (Schouten, C. N., 2020). A study also showed that applying good beekeeping management practices, which develop with experience, leads to improved colony survival and increased honey production. (Underwood *et al.,* 2023)

Despite the clear positive relationship between experience and production, other contributing factors, such as bee race, availability of nectar pastures, apiary size, climatic conditions, and level of technical support, cannot be excluded. Overall, these results confirm that long practical experience substantially increases the productivity of honeybee colonies, highlighting the importance of strengthening training and capacity-building programs for beginner beekeepers to improve production efficiency at the national level.

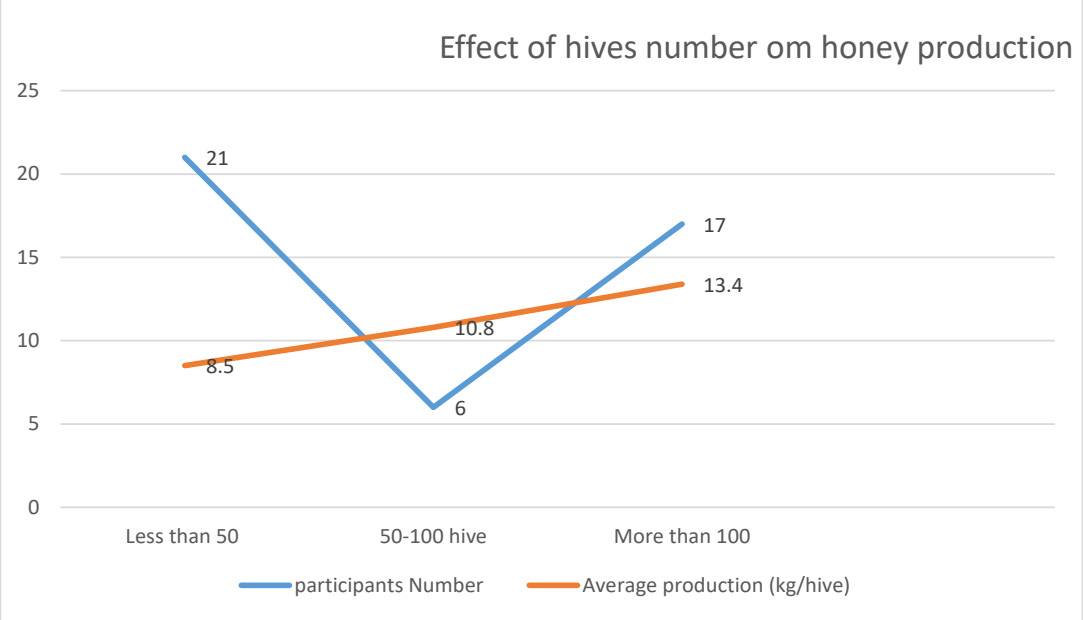
The effect of the number of hives on honey production

It significantly affected the average honey production per hive at the 0.05 significance level ($p < 0.05$). The average production for beekeepers who own more than 100 hives was 13.4 kg/hive; beekeepers who own between 50–100 hives, with an average of 10.8 kg/hive, came second; the lowest recorded production was in the category that owns less than 50 hives (8.5 kg/hive). Since the difference between the means is greater than the LSD (0.05 = 2.0 kg/cell), all differences are considered statistically significant and not due to chance.

These results indicate that an increase in the number of hives is positively associated with higher average honey production per hive. This reflects the positive impact of apiary size on improving production efficiency. This is attributed to the fact that beekeepers who own large numbers of hives often have better technical and organizational expertise. They have greater resources in terms of equipment, transportation, and knowledge of pasture management, feeding timing, and parasite control, which leads to increased productivity. Several studies have illustrated this trend.

The Food and Agriculture Organization of the United Nations (FAO) report (2021) indicated that the size of the apiary and the number of hives are the most important economic and productive factors for beekeeping projects. Large apiaries can implement modern practices such as queen rotation, group supplemental feeding, and large-scale parasite control programs This increases overall efficiency, beekeepers who own larger numbers of hives achieve higher production and greater economic returns as a result of the scale of labor and equipment, in

Figure 2: Effect of hive number on honey production



addition to the accumulation of managerial and technical experience with the expansion of the scale of the activity (Schouten,2020) Similarly, a study by Underwood, R. M., and Lawrence, B. L. (2023) showed that implementing good beekeeping management practices, such as regular queen monitoring, brood control, and hive distribution based on nectar sources, contributes to increased hive productivity. These practices are more readily applicable in apiaries with a large number of hives, given sufficient human and technical resources.

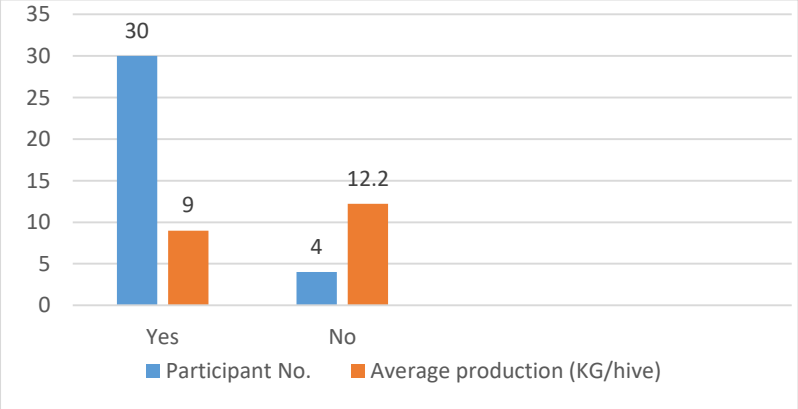
Despite the clear positive relationship between apiary size and productivity. However, this effect may be influenced by other factors, such as the beekeeper's technical expertise, pasture availability, or the use of high-producing breeds. Therefore, it can be concluded that increasing the number of hives in the apiary contributes to raising the average honey production per hive As a result of improved management efficiency, optimal use of resources, and modern practices, These results underscore the importance of encouraging beekeepers to expand their apiaries through well-planned programs that include technical and administrative training to ensure sustainable production and achieve economic efficiency in the beekeeping sector.

The impact of declining flowering plants on honey production

The results of the statistical analysis showed significant differences ($p < 0.05$) between the two groups, with the average honey production for beekeepers who observed a decline in plants reaching (9.0) kg/hive. This is significantly lower than the production of beekeepers who did not notice this decline (12.2) kg/hive. In contrast, the standard deviations of both groups were similar (2.8 and 3.0, respectively), indicating relative homogeneity of value deviations within each group. These results indicate that the decline in vegetation cover reduces the availability of nectar and pollen sources necessary for bee feeding. This reduces gathering activity and leads to a decline in honey production.

Numerous studies have indicated that a rich and balanced plant diversity is one of the most important factors that support colony productivity and overall health (Klein *et al.,* 2007; Potts *et al.,* 2010). Other research has also shown that a lack of diversity in nectar and pollen sources leads to chronic nutritional stress in bees it negatively affects metabolic efficiency and increases susceptibility to diseases and parasites(Di Pasquale *et al.,* 2016) These factors combined explain the lower average honey production in areas suffering from deteriorating vegetation cover, or in dry seasons when flowering is less frequent. These results underscore the importance of plant diversity and the sustainability of nectar pastures as a key element in successful beekeeping and achieving high productivity. Therefore, it is recommended to encourage the cultivation

Figure 3: The effect of beekeepers' observation of declining vegetation cover on the average honey production per hive

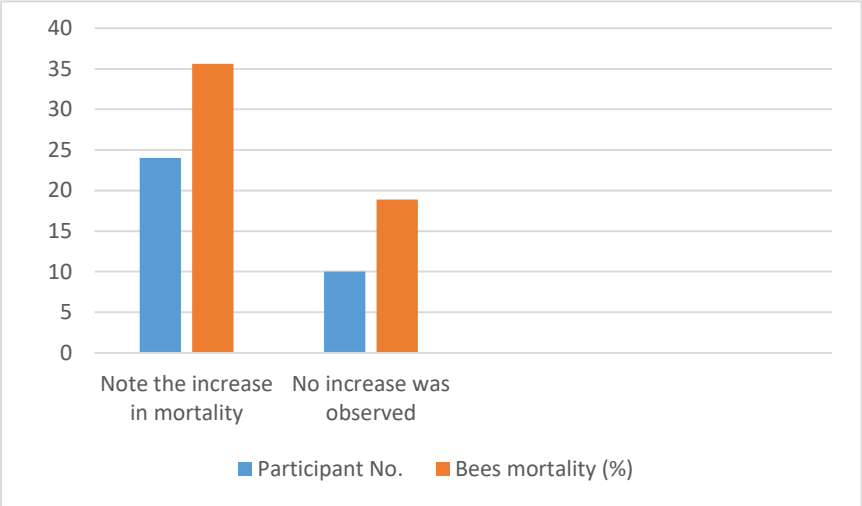


of native nectar-producing plants such as *Trifolium alexandrinum* (Egyptian clover) and Wild mustard (*Sinapis arvensis*), as well as preserving the natural green spaces surrounding the apiaries to enhance the food resources for the bees.

The effect of pesticide use on bee mortality

Table 4 shows the effect of beekeepers' observation of the presence of pesticides in the apiary environment on the honeybee mortality rate. The results showed significant differences ($p < 0.05$) between the two groups. The mortality rate among beekeepers who observed an increase in mortality reached (35.6%). This is significantly higher compared to those who did not observe an increase in deaths (18.9%). The standard deviations were also close (4.2 and 3.8, respectively), indicating relative homogeneity within each category. These differences are attributed to the toxic effects of pesticidesespecially nerve agents such as imidacloprid, which. Nerve agents such as imidacloprid, which belongs to the neonicotinoid group, and Deltamethrin, a pyrethroid, are among the most commonly used. It works by disrupting nerve transmission, causing gradual paralysis and ultimately the insect's death. (Simon-Delso *et al.,* 2015) Chronic exposure to low concentrations of these pesticides can also lead to behavioral disturbances, such as reduced return to the hive, and the bees' ability to navigate and collect nectar deteriorates. (Henry *et al.,* 2012). These results are consistent with those of Sánchez-Bayo and Goka (2014). Continuous exposure to pesticide residues, whether from treated crops or from contaminated water, leads to increased mortality rates and a decline in colony strength in the long term. The effects of pesticides are not limited to adult individuals only, It even extends to the

Figure 4: Effect of pesticide use on bee mortality



larvae through contaminated food this weakness the population colony structure these result underscore the importance of implementing integrated pest management (IPM) program to reduce of use highly toxic pesticides and encourage the use of bioavailable alternatives to bees such as vegetable oils or natural extracts monitoring pesticide residue levels is also recommended in hive products (wax, honey, pollen grain) to ensure safety of colony and it's products.

5- The spread of diseases among bees and their impact on production

The table (5) shows the effect of dominant diseases type on in honeybee colonies in the average of honey production (kg/hive) the result of the statistical analysis shows significant difference between groups the lowest average honey production was recorded in hives infected with varroa mites (8.3 kg/hive) followed by hives infected with nosema (9.1kg/hive) while healthy hives from diseases achieved the highest production (12.6kg/hive) the standard deviation values were also relatively close (2.9-3.2) indicating acceptable homogeneity in data within each category.

These results reflect the negative impacts of both Varroa destructor and Nosema spp. on colony efficiency and honey production. The varroa mites are one of the most influential pathogens affecting honeybees worldwide. They feed on hymenopteran and weaken bees' immune system, increasing their susceptibility to viruses. (Rosenkranz *et al.,* 2010). The outbreak also leads to a decrease in the number of worker bees and a decrease in the efficiency of gathering nectar, which is interpreted as a decline in honey production (Martin *et al.,* 2012).

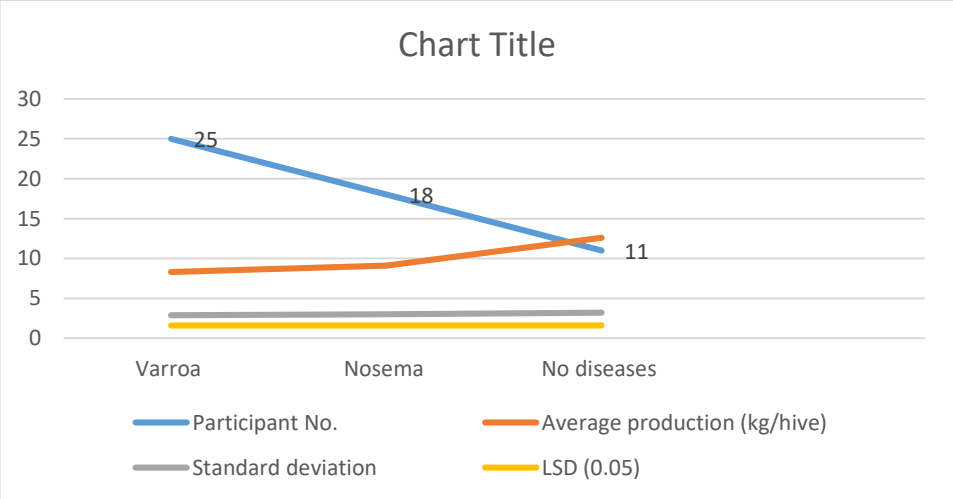
As for Nosema disease (*Nosema ceranae and N. apis*) its microscopic intestinal parasites that infects the midgut of bees this causes digestive disturbances and lack of nutrient absorption this negatively impacts gathering activity and honey production (Higes *et al.,* 2010) these results confirm the effective control of parasitic diseases is a key pillar to improving honey production these result also recommended the importance implementing integrated bee health program this include regular monitoring of parasite, limited use of therapeutic chemicals and enhancing bee's natural immunity through balanced nutrition and the provision of pasture with plant diversity

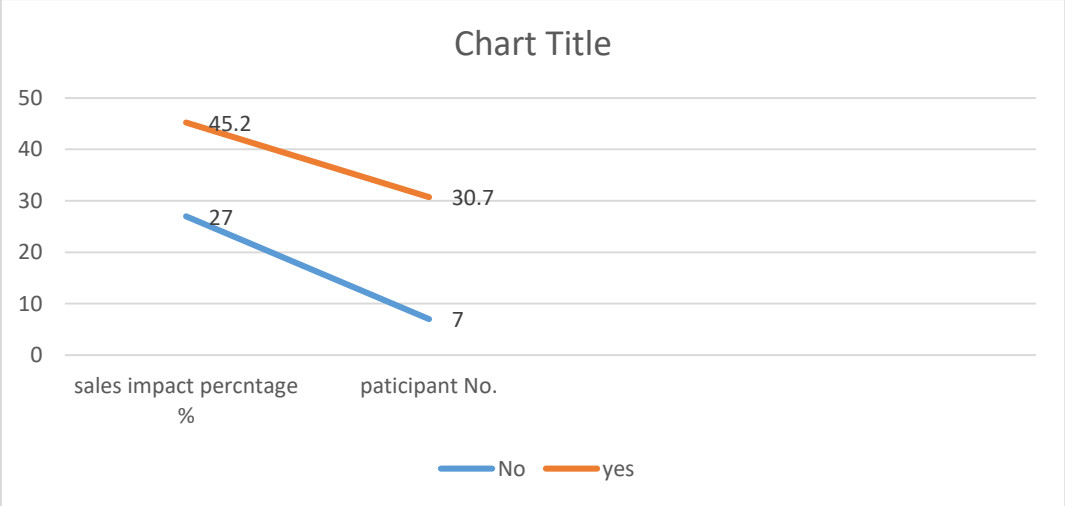
The impact of flooding the market with imported honey on sales

These results indicate that flooding the market with cheap imported honey negatively and significantly impacts the sales of local beekeepers, who find it difficult to market their products at competitive prices. This is attributed to imported honey sold in much lower prices than the costs of producing honey. This creates an unequal market and forces consumers to prefer the cheapest products even if they are of lower quality.

Several studies have illustrated this trend; a report issued by the international trade center indicated (ITC.2020) that the high imports of low-priced honey are leading to a decrease in the market share of local producers and in their ability to compete, especially in the absence of clear protection policies. a cheap

Figure 5: Disease existence and its impact on production





imported honey often mixed with sugary substances and lacks standard specifications, this creates an unfair environment for local producers committed to quality (Garcia *et al.,* 2018)

In Portugal, the entry of cheap imported honey into European markets has led to a decline in profit margins for local beekeepers; some of them are reluctant to pursue the profession (Murilhas, 2012). Food and agriculture organization noted in 2021the problem of imported honey extends to include the risks commercial fraud and the tests show the largescale of it contain added sugar syrup overall, these result confirm that unequal competition from imported honey poses a real challenges for local beekeepers this highlights the importance of regulatory intervention to protect local the national product by imposing strict controls on quality of imported honey.

CONCLUSION

Increased bee colony production is linked to an increase in the beekeeper's working time at the apiary. The number of beehives also affected production growth. One of the most important factors that leads to increased bee production is the vegetation surrounding the apiary. The use of pesticides increases the number of dead bees. Disease affects bee activity. Importing honey from outside the country hurts honey production and beekeepers' enthusiasm for increasing production. The indicators provided by beekeepers are very important, and we recommend that researchers consider them. We also recommend increasing flowering vegetation cover, taking care of beehives, and monitoring for diseases and pests.

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CONFLICT OF INTERESTS

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Originality and Plagiarism: All parts of research have made by us

Consent for Publication: Yes, all authors have agreed to content the article and its publication

Competing Interests: There are no potential conflicts in the research

Data Availability: all research data are mentioned in the context

Author Contributions: all authors contributed in research formed.

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