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Insect Pollinators and Their Impact on Maize Yield in District Swat Khyber Pakhtunkhwa, Pakistan

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Abstract

The research on the diversity and population of pollinators and their effect on the yield Pollinators play a critical role in the agriculture sector, contributing significantly to crop quality and yield, especially in insect-mediated pollination. Among these, *Apis mellifera* stands out, accounting for 34-35% of pollination services globally. This study explores the diversity, population, and impact of pollinators on the yield of three maize varieties—Azam, Jalal, and Kaptan—in both caged and uncaged conditions. A total of eight pollinator species belonging to Hymenoptera, Diptera, and Coleoptera were recorded. Apis mellifera was the most abundant species, followed by *Apis dorsata*, *Cotinis nitida*, and *Xylocopa pubescens*. Significant differences were observed between morning and afternoon pollinator populations, with the latter recording higher numbers. Yield analysis revealed that uncaged crops significantly outperformed caged crops across all parameters, including 1000 grain weight, cob length, and number of grains per cob. The Azam variety exhibited the highest yield among the three varieties studied. Restricted pollinator activity in caged conditions resulted in reduced yields, highlighting the essential role of pollinators in maize production. Furthermore, the use of pesticides and habitat destruction emerged as major threats to pollinator populations, necessitating conservation efforts such as providing food, shelter, and diverse floral resources. This study underscores the importance of pollinators not only for agricultural productivity but also for maintaining ecological balance.

Introduction

Zea maize falls under family *Poacea*. Maize comes on the third place among the cereal crops after wheat and rice in Pakistan. It is a kharif crop which is always planted from mid of July to mid-August and in general harvested from mid of September to mid of October. As among high yielding cereal crops, Maize has a great impact on the developing countries, because the maximum people use it directly as food. Its grain is utilized by some individuals while in most nations it is utilized in production of corn flour. Sown area is 1 million hectares and its annual production level stands at 1.3 million tons. They have played a very big role in facilitating the increase in production of this hybrid varieties. According to US Statistic of Agriculture, in 2019.

Maize is a self-pollinated crop and most of the pollination is by wind. This plant has both the male and female organ it has flowers for pollination. The pollens produced in the anther of the tassels dropping on the hairy ear and pollination is completed. But apart from wind, insects are equally involved in the pollination of maize crops. The pollinators feed on the tassel as their food in form of pollen. The pollens cling on these feet and drop it to the female part when the plant sits on the corn ear. Most crops for fruit, seed and high market value require insect induced pollination as Klein et al pointed out in 2007. The pollination contributes toward 35% of the total crops produce in the world.

About 70% of the fruits and vegetables drawn here showed that their sizes, quality, quantity, and fruiting stability have gradually increased through insect mediated and other animals' pollination. It gives the crops valued in production in the US a worth of 14.6 billion dollars annually. Research has established that the native bees are more effective in pollination than honey bees in watermelons, squashes, tomatoes among others. A worth of 3.1 billion is the pollinating services performed by native pollinators. Gentleman's and Vaughan et al., 2006. A number of globally pollinators are in decline. This has been accompanied by loss of natural habitats and large-scale production of crops which if it has an impact on agriculture, will have severe ramification (Potts et al. 2010).

It is important that pollination existing in the agro ecosystem is preserved for every growing area for crops (Klein et al. 2012). Large-scale landscape composition at a scale of 1.5km is the dominant factor in influencing diversity and abundance of the native pollinator (Rikkets et al. 2008). Previous authors have documented many different ways in which pollinators have been exposed to pesticides. One of the given proposed reasons for the decline in the honey bee colonies is that increased Nosema disease impacted the health of the native bees due to the non-targeted insecticides used for controlling other insects. Because of the existing paradigm shift whereby colony disappearance and reduction of its number forced growers and researchers to dedicate significant efforts to studying bee's community to keep pollination as a useful form of ecosystem service. Primary carriers of extinction are identified several times during a year but the individual exact definition of losses is rather complicated because no all taxa possess the monitoring of standard population

The Bumble bees and solitary bees was found to be reduced by 29% by the British wild life before and after 1980 (Bismeijer et al. 2006).

To the hazards of environment; however, a figure of 54 percent reduction in population of honey bee was witnessed between 1985 and 2005; Similarly, the number and dispersal of lepidopterous pollinators was declined generally. In their reduction of number, the pollinators have been threatened mainly by two factors namely; habitat loss and fragmentation. It is argued that associating wild bees and pollinates with our crops may only be sustained by leaving some of our lands fallow for the various wild bee species to nest on. Altieri and Nicolos, 2015 also indicated that bee abundance was statistically significantly higher in natural and semi- natural vegetation than in any arable crop fields surrounded by monoculture plantations. Some crops require specific attributes from the insect pollinators or the pollinators that need to be used to pollinate it. For instance, long-tongued bees performing a function of pollinators for beans. The five beneficial insect groups such as honeybee, Bumble bees, solitary bees, and hover flies combine to account for about 35.5% in the oil seed production. The European bees account for in the region of 80 per cent of the total pollination work done by insects. The figures have been analyzed that the decrease ratio of honey bees hive across the world is 70% to 34% in 2007. We have also concluded that the efficiency of bee VS non-bees' pollinators; deposition of pollens in one visit to the flowers is low in other insects as compared to hymenopterans.

1 Pakistan Bureau of Statistics, Agriculture revealed that area cultivated for Maize crop for the year 2019-2020 is 24349 & 27293.4 hectares and production of Maize is 1373.9 & 1417.8 tones respectively. In order to investigate on the kind of insect pollinators, how many of them are there, relation of the insect pollinators to the maize plants.

Material and methods

Location of Study and Plot Preparation

This research was conducted at the Agricultural Research Station in Swat during 2021. The maize varieties Azam, Jalal, and Sultan were sown on three separate plots in July. Each variety was further divided into four pairs of rows, with each plot measuring 30 x 10 m². Standard agronomic practices were followed, and no pesticides were sprayed throughout the experiment to maintain natural pollinator activity.

Experimental Design and Caging

The study was designed using a Randomized Complete Block Design (RCBD), with a view of controlling for variation in physical factors that include temperature, aeration and humidities. Because each constructed block consisted of three replications, nine experimental units were put into use. For the caging study, nine cages of nylon cloth measuring 8ft in length, 3ft in width and 3 feet in height were set up. Such cages shielded the tassel from pollinators, and therefore facilitated main contrast between caged and uncaged maize plants for pollinator activities. Hand nets, collection jars, killing agents, and insect pins were employed in the pollinator collection and sample preparations.

Pollinator Options and Sample cooler diversity

Maize tasseling and flowering function after 15-18th whorl leaves emerge, causing tassel to become noticeable to pollinators. Vizitation comes from pollinators was observed early in the morning and also in the afternoon since activity was more prevalent in the afternoon. Insect pollinators were identified and photographed, collected using hand nets, subsequently anesthetized through the application of ethyl acetate, then pinned in collecting vials. The collected specimens were identified through Ascher and Rasmussen (2010) and M. Valan et al. (2012) insect identification keys for the study and labeled specimens are stored in Insect Museum of the Department of Entomology University of Agriculture Peshawar

Population Recording

The number of pollinators was also counted daily for all three maize varieties in 3 randomly chosen 6 m 2 plots. These observations were carried from 9A M to 2 PM with one hour each for morning and afternoon session. The pollinating activity was estimated by counting the number of pollinators starting from the first inflorescence using a finger counter clicker. Mean values were determined weekly and multivariate interaction effects of morning and afternoon samples were deemed significant for pollinator patterns.

How pollinators influence Crop Output

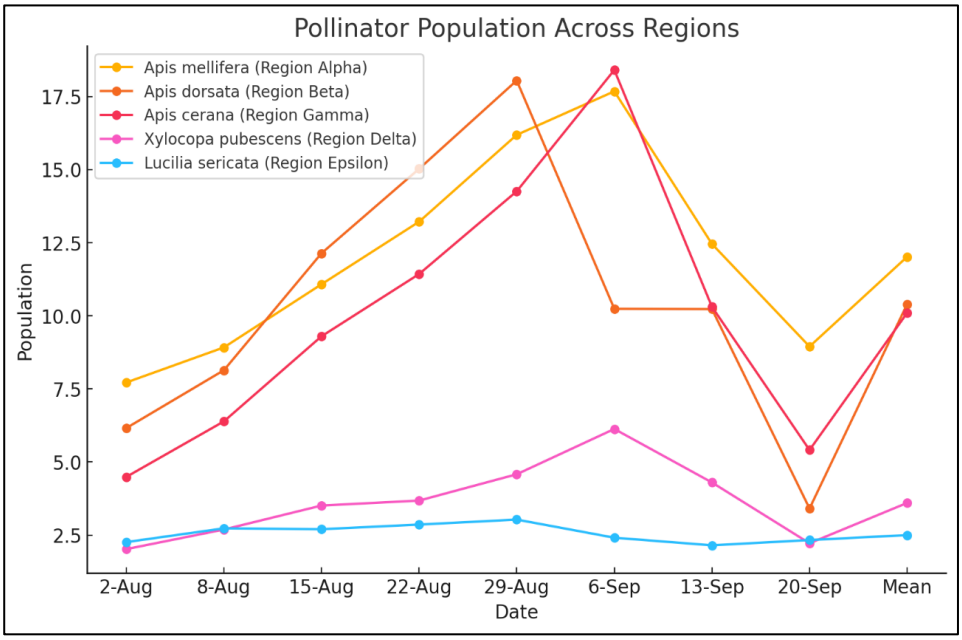
The response of pollinators to maize yield was tested by using caged and uncaged study designs. Yield parameters associated with this study were the number of grains per cob, cob length and 1000 grain weight. Overall, all yield parameters increased in uncaged plots implying that pollinators played a great deal in determining the productivity of maize grains. The caged plots that were kept away from pollinating insects self-documented poor yields thus proving that maize crops rely on pollination by insects.

Statistical analysis and grain yield. Println

It also emerged that the use of improved seeds responded positively to the statistical analysis and grain yield as presented below:

Hundred seed weight, number of seeds per cob, as well as cob length were statistically analyzed for means and comparison using analysis of variance (ANOVA) method with a software Statistix 8.1. For mean comparisons to determine population and yield effects of pollinators on the three maize varieties, LSD test was used. Analysis was done on ten cobs per treatment where 1000-grain weight was determined using 0.01 digital weighing machine, grains/cob counted by hand and cob length data analyzed statistically. The outcomes reiterated the fact that pollinator activity has a direct impact on the yield of maize and therefore has considerable relevance in the agricultural production matrix.

Date	*Apis mellifera* (Region Alpha)	*Apis dorsata* (Region Beta)	*Apis cerana* (Region Gamma)	*Xylocopa pubescens* (Region Delta)	*Lucilia sericata* (Region Epsilon)
2-Aug.	7.72	6.16	4.49	2.02	2.26
8-Aug.	8.92	8.14	6.39	2.69	2.73
15-Aug.	11.08	12.14	9.3	3.51	2.7
22-Aug.	13.22	15.03	11.43	3.68	2.86
29-Aug.	16.19	18.05	14.26	4.58	3.03
6-Sep.	17.68	10.24	18.41	6.13	2.41
13-Sep.	12.46	10.23	10.31	4.3	2.15
20-Sep.	8.95	3.41	5.41	2.22	2.33
Mean	12.02	10.4	10.1	3.6	2.5



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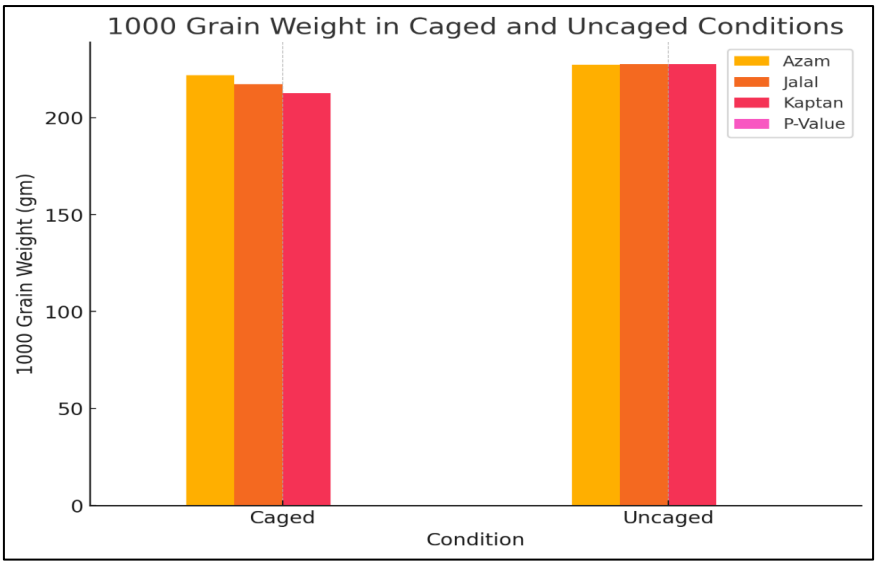
Condition	Azam	Jalal	Kaptan	*P*-Value
Caged	221.92	217.38	212.48	0.01
Uncaged	227.45	227.54	227.56	



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Metric	Azam (Caged)	Jalal (Caged)	Kaptan (Caged)	Azam (Uncaged)	Jalal (Uncaged)	Kaptan (Uncaged)	*P*-Value
Length of Cob (inches)	9.73	9.41	8.66	13.11	12.97	13.11	0.04
Number of Grains per Cob	319.84	227.13	210.71	382.33	383.4	383.13	0.02

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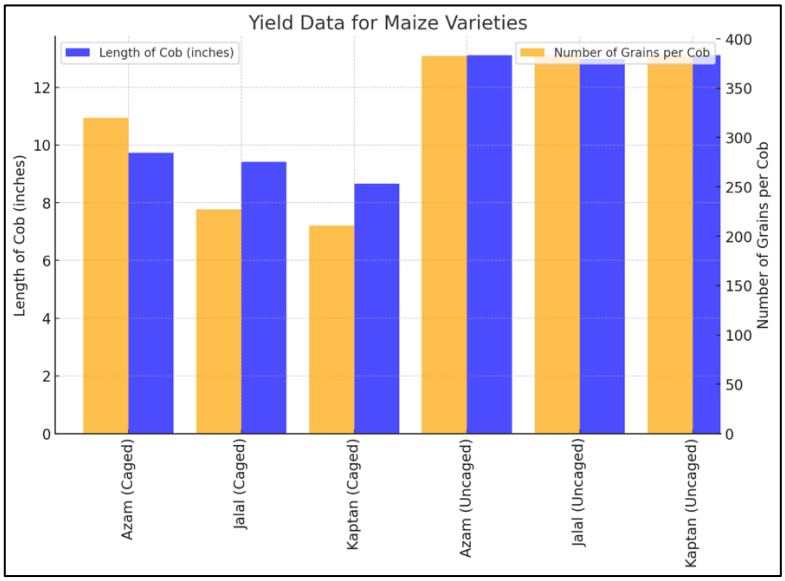

Discussion

Impact of Pollinators on Maize Yield and Diversity of Pollinator Species

Pollinators are vital to agriculture, contributing significantly to crop yields, especially in insect-mediated pollination. The global agricultural value of pollinators is approximately $153 billion, with **Apis mellifera** alone accounting for 34-35% of pollination services (Stein, 2017). Combined natural and insect-mediated pollination enhances both yield and grain maturity uniformity, as also reported by Shakeel et al. (2010).

Pollinator Diversity

This study recorded eight species of pollinators across three maize varieties (Azam, Jalal, and Kaptan). These species spanned three orders: *Hymenoptera* (*Apis mellifera*, *Apis cerana*, *Apis dorsata*, and *Xylocopa pubiscen*), *Diptera* (*Eristalis tenax* and *Leucilia sericata*), and *Coleoptera* (*Cotinis nitida* and *Coccinellid* sp.). Morning and afternoon observations showed significant differences in pollinator populations, with the afternoon yielding higher numbers. The findings align with those of Hung (2018), who emphasized Apis mellifera as a central figure in pollination networks, and Bartomeus (2014), who noted honeybees contribute 90-95% of pollination in vegetable crops.

Hymenoptera

Apis mellifera was the most abundant pollinator, followed by *Apis dorsata* and *Xylocopa* spp. Bumblebees also exhibited higher visitation rates and effectiveness, especially in adverse conditions, due to their pilosity (Faegri and Valido, 2005).

Coleoptera

Beetles such as *Cotinis nitida* and *Coccinella septempunctata* were active pollinators, with *Cotinis nitida* being more prevalent. Their hairy bodies and specialized mandibles enable efficient pollen transfer, as described by Knees (2020).

Diptera

Syrphid flies were more abundant and effective than blowflies. These flies visited 70% of crops and 75% of wildflowers, contributing to ecosystem functions like pest control and organic matter recycling (Doyle, 2020).

Yield Analysis

The yield of uncaged maize plots was significantly higher than caged plots. Azam variety produced the highest yield (654.4 kg), followed by Jalal (432.5 kg) and Kaptan (386.6 kg). The restricted activity of pollinators and limited wind flow in caged plots resulted in lower yields. These findings corroborate Sneep (2006), who highlighted the synergy of natural and insect-mediated pollination, and Laberge (2006), who estimated a 60% yield increase due to insect activity. Parker (2006) similarly reported 25% higher yields in uncaged crops.

Conclusion

Pollinators are indispensable for enhancing crop yield, fruit set, and uniform seed maturation. Their conservation is crucial, as habitat loss, pesticide use, and human activities threaten their populations. Providing shelter, food, and diverse vegetation can boost pollinator diversity and ensure sustainable agricultural production. Among the varieties studied, Azam is recommended for pollination-mediated areas due to its superior yield. Loss of pollinators poses a significant risk to food security and ecosystem balance, necessitating immediate conservation efforts.

Recommendation

Conservation of pollinators through habitat restoration and reduced pesticide use is essential for improving agricultural yields and maintaining ecosystem services. Pollinators not only enhance crop productivity but also ensure better food quality and sustainability.

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