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RESEARCH PAPER

Evaluation of insect pest infestation and yield losses in maize crop in Maina, district Malakand

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Key Message: The present study evaluates the major influence of insect pests including maize stem borer, aphid, shoot fly, armyworm, and maize jassid, on maize crop. The study measured infestation rates and resulting yield losses, emphasizing the need for prompt pest control measures to reduce economic losses.

Abstract

Maize (*Zea mays*) is the third most significant cereal crop in Pakistan. It plays a crucial role in the local diet and serves as a vital component in livestock fodder and poultry feed. Moreover, it has gained commercial importance in the food industry, contributing to the production of items such as corn oil, cornflakes, popcorn, and Rafhan. Its yield is severely affected by insect pests. Therefore, this study investigated the insect pest infestation and associated yield losses in maize crops in Maina, District Malakand. The experiment recorded the percentage of plant infestation by insect pests and quantified the resultant losses. Maize stem borer (*Chilo partelus*) exhibited a significant infestation of 23.50 %, followed by maize aphid (*Rhopalosiphum maidis*) at 15 % during the tasseling stage. Shootfly (*Atherigona soccata*) showed early-stage infestation with 9 %, and maize jassid (Zygenia sp) appeared with a population of 2 jassids/sweep net. Armyworm (*Mythimna unipuncta*) was also identified as a pest with 7.1 % plant infestation. The cumulative grain losses due to these pests were calculated as 1112 kg/ha. Maize cultivation in Pakistan holds significant economic importance, contributing to various sectors, and sustaining local diets. In this context, effective pest management strategies are crucial for optimizing maize yields. The study provides valuable insights into the dynamics of insect pest infestation and emphasizes the need for proactive measures to mitigate yield losses in maize cultivation.

Keywords: Aphids, Armyworm, *Chilo partelus*, Food industry, Insect pest, Livestock fodder, Maize

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Introduction

Maize (*Zea mays*), a member of the Poaceae family, is an annual, determinate crop and holds the position of the third most significant cereal crop in Pakistan. Predominantly cultivated in NWFP and Northern Punjab, it ranks as the second most essential cereal crop in the Northern areas, following wheat. Maize plays a crucial role in the local diet and serves as a vital component in livestock fodder and poultry feed. Furthermore, maize holds significant commercial value within the food industry, playing a significant role in the production of various staples such as corn oil, cornflakes, popcorn, and Rafhan (Mohammed et al., 1986). Its versatility extends across multiple sectors, with approximately 35 % allocated for direct human consumption, 25 % for animal feed, 25 % for poultry consumption, and the remaining 15 % utilized in industrial applications like starch, alcohol, and seed production (Mohammed et al., 1986). Countries with substantial maize cultivation areas include Argentina, Brazil, China, Hungary, India, Indonesia, Italy, Mexico, Philippines, South Africa, Romania, United States, and Yugoslavia (Ramchandra, 2013). Maize grains are a valuable source of protein, fat, starch, vitamins, and minerals including calcium, phosphorus, and sulfur. Its cultivation extends across Khyber Pakhtunkhwa contributing significantly to the agricultural landscape (Ozcan, 2009). In Pakistan, approximately 944 thousand hectares of land are dedicated to maize cultivation, yielding an average of 1643.2 thousand tons (Agriculture Statistics of Pakistan, 2000). Similar to other regions in the country, maize takes center stage as the primary kharif crop in the Northern Area. Farmers typically sow densely and gradually thin out surplus plants, as fodder is as crucial to them as the grain itself.

Although corn cultivation may require fewer inputs compared to crops like cotton, such as plant growth regulators (PGRs) and defoliation, proper and timely scouting for insect pests remains a crucial aspect for achieving optimal corn yields. The primary objective of scouting for any crop, including corn, is to minimize input costs and crop damage while maximizing profitability for the grower. Among the various factors contributing to low maize yields, insect pests play a significant role. Alam (1981) identified approximately 20 arthropod species that pose a threat to maize in Barbados. Parkash et al. (1985) documented the presence of the pyralid *Chilo partelus*, the noctuid *Sesamia inferens*, and the anthomyid Atherigona sp in maize crops. Rahman (1987) listed 24 arthropod pests affecting maize. Karimullah et al. (1992) observed the early and midseason occurrence of cutworm (*Agrotis ipsilon* R.) and armyworm (*Mythimna separata* wlk), while earworm and the corn aphid *Rhopalosiphum maidis* (Fitch) emerged as late-season pests in Kalam. Mashwani (1989) reported cutworms, armyworms, earworms, grasshoppers, and aphids as pests of maize in Swat. According to Reddy and Trivedi (2008), maize crops face the threat of damage from a considerable array of insect pests throughout their growth cycle, starting from sowing to harvest. Among these pests, maize stalk borer (*Chilo partellus* Swinhoe), pink borer (*Sesamia inferens* Walker), shoot fly (*Atherigona soccata* Rondani), shoot bug (*Peregrinus maidis* Ashmead), corn leaf aphid (*Rophalosiphum maidis* Fitch), sugarcane pyrilla (*Pyrilla perpusilla* Walker), and sugarcane leaf folder (*Marasmia trapezalis* Guen.) (Ramchandra, 2013). The aim of this research study is to document the insect pests affecting maize, assess the extent of plant infestation, and quantify losses attributed to these pests. This information serves as a baseline for implementing effective control measures.

Materials and Methods

A field experiment was conducted at the District Director Agriculture Malakand (Maina) focusing on the Azam variety, which was sown on June 2, 2018. Plant-to-plant spacing was maintained at approximately 30cm, with a row-to-row distance of 45 cm. The field underwent regular physical scouting, typically on a weekly basis, to assess insect presence and levels. Following germination, a plant population of 60 per plot was maintained, and standard agronomic practices were uniformly implemented. The study involved two distinct treatments, each replicated 12 times. Treatment T1 (control plot) permitted natural insect infestation, while Treatment T2 (experimental plot) rigorously controlled insect pests to maintain zero infestation. Monitoring of insect pests in the control plots was conducted at 7-day intervals following germination. All insect species found on maize plants were systematically collected during these inspections and subsequently identified in the laboratory, utilizing relevant literature for accurate identification. Additionally, the number of infested plants in each control plot was recorded during each observation to assess the degree of infestation. Upon completion of the experiment, the crop was harvested, and losses attributed to insect pests were calculated using the formula:

Losses in yield = Expected yield (yield of treated plot) − Actual yield (yield of untreated plot)

This comprehensive approach allowed for a thorough assessment of insect pest impact on crop yield, providing valuable insights for future pest management strategies.

Results

During this study the following insect pests were recorded infesting Maize crop:

Maize stem borer (*Chilo partellus*)

The current investigation identified the maize stem borer as a significant threat. Its damaging effects were observed to commence approximately two weeks after germination, around the 10^{th} of July, and persisted until the first week of October (Table 1). The primary cause of destruction was attributed to its caterpillars, which, upon hatching, initially consumed leaves before tunneling into the stems. Mature larvae typically measured between 20 to 25 mm in length, displaying a dirty grayish white colour with a black head. Pupation occurred in the lower segment of the stalk. Adult specimens manifested as yellowish-gray moths, approximately 25 mm across when their wings were extended. Monitoring of maize stem borer infestation was conducted at 7-day intervals by recording the total number of infested plants within each plot (Table 1). The data revealed an onset of infestation during the final week of July, recording a minimal 1.55 % infestation rate, which progressively increased to a peak of 23.5 % from the last week of July through the first week of September. The results provided a comprehensive breakdown of the percentage of infested maize plants by various insect pests on specific dates, highlighting the complex dynamics of the crop's interaction with stem borers.

Aphid (*Rhopalosipum maidis*)

Aphid (*Rhopalosipum maidis*) emerged as the second most damaging pest to maize crops, with its infestation peaking at 6.67 % after mid-September. These soft-bodied insects exhibited a pear-shaped body, possessed a pair of cornicles at the posterior end of the abdomen, and feature relatively long antennae. Their mode of damage involved the extraction of cell sap from leaves, accompanied by the secretion of significant amounts of honeydew. The onset of infestation by the maize stem borer was noted in the initial weeks of August, just before tasseling stage. Initially, the pest predominantly targeted the upper young leaves; however, as its activity progressed, the tassels of the crop became increasingly susceptible. Plants that were not under stress and were growing vigorously were typically not affected. Data in Table 1 reveals a gradual increase in aphid infestation from 3 % in the first and second week of August to a peak of 6.67 % in mid-September, followed by a gradual decline. This emphasizes the temporal progression and intensity of aphid infestation throughout the observed period.

Shootfly (*Atherigona soccata*)

Among the pests, the Shootfly (*Atherigona soccata*) showed a remarkable infestation, with percentages increasing from 3.7 % on 22/07/2018 to 9 % on 05/08/2018, reaching its peak at this date. The infestation by Shoot fly was particularly impactful as it occurred at an early stage, typically starting after mid-July and peaking in the first week of August. This early infestation led to stunted growth and the development of dead hearts in the plants, characterized by wilting and yellowing of the central shoots, while the lateral leaves retained their green color. The trend in Shoot fly infestation highlights the urgency for effective pest management strategies, especially during the critical growth stages of the maize crop to mitigate yield losses caused by this pest.

Armyworm (*Mythimna unipuncta*)

Armyworm (very little hair) had four abdominal prolegs. Larvae often had black bands on the pro legs. They were often observed early in the growing season. The consumption by mature instars led to a torn appearance of the leaf tissue. Unlike fall armyworms, which primarily migrate into fields as adults to lay eggs, these pests tend to infiltrate cornfields in their larval stage. Their infestation typically commenced in mid-July and peaked at a maximum infestation level of 7.1 % in early August, gradually declining thereafter.

Maize Jassids Zygenia Sp

Large masses of tiny insects were observed to take flight when the maize plants were slightly disturbed. These insects proceeded to extract sap from the leaves of the maize plants, causing them to adopt a distinctive copper-red in colour. Their presence became evident in maize fields when the crop reached a height of about one foot, persisting until maturity. Infestations typically began in the first week of August, peaking at a maximum infestation rate of 7.7 %. On average, their population density ranged from 5 to 7 Jassids per three sweep nets (Table 1).

Table 1 Percent infested plants of maize crop by different insect pests recorded on different dates

Date	Stem borer	Aphid	Shoot fly	Armyworm	Jassid
22/07/2018	1.55	0.00	3.7	5.3	0.00
29/07/2018	1.67	0.00	4.8	7.1	0.00
05/08/2018	3.45	3.00	9.00	3.7	5.42
12/08/2018	15.48	5.00	1.9	2.6	6.23
19/08/2018	22.55	6.67	0.00	2.6	6.87
26/08/2018	23.5	1.76	0.00	0.00	7.70
02/08/2018	1.5	1.45	0.00	0.00	5.40
09/08/2018	1.5	1.35	0.00	0.00	0.00

Table 2 Grain yield losses in maize due to insect pests (Kg)

Replication	Yield T1 (Untreated)	Yield T2 (Treated)
1	0.4	1.4
2	0.4	5.50
3	3.0	4.00
4	3.0	5.50
5	4.0	5.0
6	3.20	6.0
7	0.40	0.8
8	3.8	6.20
9	5.0	7.00
10	1.0	2.0
11	2.40	5.0
12	3.5	6.0

Means are significantly different at 5 % level; Loss in yield = 2500-1388 = 1112 kg; LSD value = 0.74; T1 = Untreated; T2 = Treated

Losses in yield due to insect pest

The findings from the investigation on yield losses caused by insect pests are given in Table 2 which presents the extent of yield losses in maize crops attributed to insect infestations. Statistical analysis of the data reveals a significant disparity between the yield of treated plots (2500 kg/ha) and untreated plots (1388 kg/ha). The recorded losses, calculated by deducting the actual yield from the anticipated yield, amounted to 1112 kg/ha, equivalent to a monetary value of 8896 PKR/ha (at a rate of Rs. 8 per kg).

Discussion

Maize stem borer has been consistently identified as a significant pest in maize crops, with various studies supporting its prevalence in Pakistan, India, and Ceylon, as reported by Khan (1967), Atwal (1976), Ghouri et al. (1978), Mohyuddin & Attique (1978). Karimullah et al. (1992) emphasized its status as a late-season pest, with the population kept in check during the early season monsoon rains. However, as the monsoon season concluded, there was a high surge in its population. In our study, we observed a maximum plant infestation of 9 % by the shoot fly, a finding at odds with the report by Kumar and Chander (1984), who documented a higher plant infestation rate of 26.21 % in maize crops. This discrepancy highlights the variability in pest dynamics and the need for further research to understand and manage these challenges. Further supporting the prevalence of maize stem borer as a pest in the region, Rehman (1987) reported its infestation in maize crops in both India and Pakistan. This collective evidence highlights the importance of continued care and research efforts to develop effective strategies for mitigating the impact of maize stem borer on crop yields.

Amjad et al. (2015) conducted a study to examine how various plant traits affect the resistance of maize against *Chilo partellus* (Swinhoe). Ten different maize genotypes were assessed, consisting of seven hybrid types (FH-292, FH-810, FH-793, FH-930, FH-949, FH-963, and FH-985) and three commercial varieties (Agaiti-2002, Com-6625, and Com-32F-10). Their susceptibility or resistance to the pest was evaluated based on a range of physico-chemical plant traits. The findings highlighted that the genotype Com-6625 exhibited high resistance, displaying the lowest level of infestation at 5.63 %. Following closely were Agaiti-2002 (5.69 %) and FH-810 (6.06 %), both demonstrating resistance against *Chilo partellus*. Conversely, FH-949 displayed high susceptibility, recording the highest infestation rate at 19.45 %, trailed by FH-963 (15.21 %) and FH-985 (12.10 %). The observed trend in pest infestation indicated a continuous increase, ultimately reaching a peak at 21.43 %. These results emphasize the significance of plant traits in influencing the resistance of maize genotypes against *Chilo partellus*, providing valuable insights for future agricultural practices and pest management strategies.

In the research conducted by Naz et al. (2003) in KARINAJuglote, Northern Areas, an investigation into the insect pests affecting maize and their associated losses was carried out. The maize stem borer *Chilo partelus* emerged as a significant threat, leading to a substantial 24.5 % infestation of plants. Following closely behind was the maize aphid *Rhopalosiphum maidis*, with a 15 % infestation observed during the tasseling stage. The shootfly *Atherigona soccata* presented an early-stage threat, resulting in a 5 % infestation of plants. Concurrently, the population of maize jassids Zygenia sp was recorded at 5 individuals per 3-sweep net. The cumulative impact of these insect pests led to a calculated grain loss of 1112 kg/ha. In a related work by Willers et al. (1999), the application of remote sensing in pest scouting was explored. Pests, such as the Bollworm Complex in cotton, were noted for creating distinctive effects on plants, including a buckshot effect on leaves, leaf rolling, or the complete destruction of plants. Sucking pests were identified as contributors to the reduction in leaf moisture content, consequently affecting the chlorophyll levels in plants, which in turn led to variations in spectral images. The research explored the prospect of detecting these impacts utilizing a range of remote sensing methodologies, encompassing satellite imagery, airborne images captured from chartered or model planes, as well as imagery obtained from tethered balloons. Furthermore, a comprehensive analysis of the costs and benefits associated with each remote sensing technique was conducted, with a focus on their applicability to agricultural extension in developing countries, particularly in the context of Pakistan.

In Nowshera, Pakistan, maize crops face a persistent threat from the maize stem borer, *Chilo partellus* (Swinhoe). The effective management of this pest necessitates the integration of various control methods. A previous research study was conducted at the Cereal Crops Research Institute Pirsabak, Nowshera, Pakistan, to assess the efficacy of cultural, mechanical, biological, and chemical control methods, both individually and as part of an Integrated Pest Management (IPM) approach (Khan et al., 2015). Results demonstrated significant effectiveness in reducing *C. partellus* infestation across all control methods. But the IPM treatment exhibited the highest efficacy, with *C. partellus* infestation at 2.32 % compared to the control at 12.92 %. Furthermore, the IPM approach yielded the highest maize output, reaching 8.64 ton/ha. This study concludes that IPM is the most effective strategy for controlling *C. partellus* and optimizing maize yield. Ortega's work (1987) reported the global impact of insect pests on maize, categorizing moths as the most destructive, followed by beetles and vectors of disease agents. While field guides like Ortega's primarily focus on pest identification, recognizing beneficial insects is emphasized as a crucial step in developing effective crop protection strategies. Understanding the complex relationships between pests and their natural predators is fundamental to sustainable agricultural practices.

Ramchandra (2013) investigated insect pests complex affecting maize (*Zea mays* Linn.) across various cropping systems and to explore management strategies for major insect pests. This study was carried out at S.V. Agricultural College, Tirupati, during the kharif season of 2012. The findings indicated that the incidence of shoot bug (*Peregrinus maidis*) was notably lower in maize intercropped with fieldbean, clusterbean, and groundnut. However, in sole maize and maize intercropped with cowpea, the population of shoot bugs reached the economic threshold level (ETL) at 75 days after sowing (DAS). Additionally, significant populations of other sucking pests such as leaf hoppers (*Pyrilla perpusilla* and *Proutista moesta*), aphids (*Rophalosiphum maidis*), and pod bugs (*Riptortus pedestris*) were observed in maize. The counts of these pests were diminished in maize intercropped with clusterbean, followed by groundnut. Effective control against aphids was achieved through the application of three granular insecticides: carbofuran 3G (0.7 kg a.i. ha^{-1}), fipronil 0.3G

(0.06 kg a.i. ha^{-1}), and cartap hydrochloride 4G (0.8 kg a.i. ha^{-1}). Additionally, among the sprays tested, rynaxypyr 18.5 % EC (0.005 %) demonstrated efficacy against aphids. Economic analysis revealed that intercropping systems such as maize + clusterbean, maize + fieldbean, and maize + groundnut were economically profitable, with benefit-cost ratios of 1: 3.04, 1: 1.79 and 1: 0.82, respectively. These findings exhibit the practical viability and economic advantages of integrating certain crops in maize cultivation to enhance pest management and overall agricultural productivity. Our research reveals that maize crops experienced losses amounting to PKR 8896 per hectare due to insect pest infestation. While existing literature lacks studies specifically calculating per-hectare losses in maize crops in Pakistan. However, contributions by Saeed (1979) mentioned losses of 60 million rupees per hectare, and Farmanullah (2010) reported losses approximating a million rupees per hectare.

Conclusion

In this research study, we identified the temporal dynamics of insect pests infestation in maize and quantified the resulting yield losses. The maize stem borer emerged as a predominant threat, followed by aphids, shoot fly, armyworm, and maize jassid. The calculated grain losses due to these pests were substantial, amounting to 1112 kg/ha. These findings highlight the pressing need for proactive pest management strategies to minimize economic losses and ensure optimal maize yields. By understanding the complexities of pest interactions and integrating various control methods, such as cultural, mechanical, biological, and chemical approaches, farmers can mitigate the detrimental effects of insect pests on maize cultivation. Moreover, exploring innovative techniques, such as remote sensing, and adopting integrated pest management practices can contribute to sustainable agriculture and enhance food security in the region.

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