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Surveillance and Control of Pests in Stored Sugarcane Products

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ABSTRACT

Objective: *The study aimed to establish efficient detection systems for pests in sugarcane storage facilities and to assess the efficacy of various pest control methods, ensuring product quality and consumer safety.* ***Methods:*** *Three major sugarcane-producing regions in District Dera Ismail Khan were selected, with samples taken from five storage facilities in each region. Monthly sampling, spanning a year, included manual inspections, use of pheromone traps, and remote sensing devices. Pest control methods evaluated encompassed chemical, biological, and physical controls.* ***Results:*** *Pests displayed distinct preference habitats within storage facilities. Chemical control demonstrated the highest efficacy with a 66.7% reduction in pest population, followed by biological and physical controls. Environmental factors, notably temperature (r=0.8) and humidity (r=0.65), showed significant positive correlations with infestation rates. Storage duration displayed a reduced positive correlation with infestations.* ***Conclusion:*** *Effective pest management necessitates an understanding of pest behavior and an integrated approach combining various control methods. Environmental factors play a pivotal role in infestation rates, emphasizing the importance of controlled storage conditions.*

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INTRODUCTION

Sugarcane, a prominent tropical and subtropical commodity, is the foundation of numerous industries, including the sugar industry and biofuel production [1]. Not only is it essential for economic growth in a number of nations, but it also provides a living for millions of producers worldwide. However, after harvest, sugarcane and its byproducts are susceptible to an abundance of parasites that can have a significant impact on their quality and market value [2]. The monitoring and management of these pests in stored sugarcane products is therefore of the utmost importance [3].

The storage of sugarcane products, particularly sugar, molasses, and bagasse, requires extreme caution [4]. While the harvesting phase presents its own challenges, the storage phase presents its own. Due to its high sucrose content, sugarcane is an attractive target for a variety of parasites, including beetles, moths, and mites. Beyond direct consumption, these pests can spread pathogens, resulting in further deterioration and possible health hazards. In addition, they can generate objectionable byproducts that affect the flavor, texture, and overall quality of the stored items [5]. As the global market becomes more competitive, ensuring the quality of stored products is not only about meeting the expectations of consumers, but also about protecting the reputation of producers and industries [6].

Effective monitoring is the initial layer of defense. Monitoring storage environments continuously to detect early indications of infestation. This proactive strategy can make all the difference, enabling timely interventions before the infestation becomes prevalent and more difficult to control [7]. In recent years, technological advancements have supplemented traditional surveillance techniques, such as manual inspections and the use of pheromone traps. Remote surveillance and data analytics have the potential to revolutionize how storage facilities are monitored [8].

Once parasites have been identified, control measures are implemented. Utilizing pesticides and fumigants to combat vermin problems, the industry has increasingly relied on chemical control methods over time. Concerns are developing about the environmental impact and potential health risks of these chemicals, despite their efficacy [9]. There is growing emphasis on exploring and employing more eco-friendly and sustainable pest control strategies. Integrated pest management, which incorporates biological, chemical, and physical methods of pest control, is gaining popularity. In addition, the use of natural predators, temperature control, and controlled environments are being investigated as alternative insect control strategies [10].

Surveillance and control of pests in stored sugarcane products is a complex challenge that involves economic, environmental, and health factors. As demand for sugarcane products continues to increase, along with rising consumer awareness and concerns about food safety, it is imperative that the industry adopt rigorous, innovative, and sustainable insect management practices. The longevity and prosperity of the sugarcane industry can only be ensured through such comprehensive efforts [2, 11].

The study had to establish effective and early detection systems for pests in storage facilities, to develop and promote sustainable pest control methods that ensure product quality and consumer safety.

MATERIAL AND METHODS

Study Sites and Sampling

Site Selection: Three major sugarcane-producing regions were selected in District Dera Ismail Khan, representing different climates and storage practices. Within each region, five storage facilities were chosen based on size (small, medium, and large-scale).

Sampling Procedure: Monthly sampling was conducted over a year (January to December, 2021). At each facility, ten random samples of stored sugarcane products were taken, ensuring coverage of different storage locations and depths.

Surveillance Methods

Traditional Surveillance: Manual inspections were conducted using hand lenses and light traps. Pheromone traps specific to known sugarcane pests were also installed [12].

Technological Surveillance: Remote sensing devices with moisture and temperature sensors were placed at strategic locations in storage facilities.

Pest Control Methods

Control methods tested included:

Chemical Control: Application of recommended dosages of three widely-used pesticides.

Biological Control: Introduction of natural predators specific to detected pests.

Physical Control: Modification of storage conditions, including controlled atmospheres and temperature adjustments.

Data Collection and Analysis

Data collected included pest species identified, their numbers, location within the storage facility, and the extent of product damage. Additionally, conditions like temperature, humidity, and storage duration were noted.

Pest infestation rates were calculated for each facility and method of surveillance. The efficacy of each control method was assessed based on reduction percentages of pest populations. Environmental factors correlating with infestation rates were identified using multivariate regression.

RESULTS

The frequency and preferred habitats of various parasites found in sugarcane storage facilities were studied. With 80 documented occurrences, the Sugarcane Borer primarily infested sugarcane's interior core, particularly around the stalk bases, indicating its potential to compromise the structural integrity of the sugarcane's core. Observed 100 times, the Yellow Sugarcane Aphid was most prevalent on the undersides of leaves, particularly near the stem, highlighting the susceptibility of these areas to aphid-induced injury or disease. The Sugarcane Weevil, which had been identified 55 times, preferred to inhabit the soil around the base of the sugarcane and the lower stem sections, which compromised the plant's nutrient uptake and structural integrity. The Pink Sugarcane Mealybug, of which there are 90 occurrences, typically lurked in the node regions and was concealed beneath the leaf sheaths, indicating that routine examinations of these areas were essential for early detection. The Sugarcane Pyrilla, was reported 70 times, primarily found on leaf surfaces, particularly the undersides, which caused discoloration, curving, and other leaf-related problems. The Sugarcane Thrips, which had 65 known species, predominantly affected young leaves and flower parts, which impacted sugarcane's growth and reproductive success (Table 1).

Based on the reduction in pest populations, the comparative analysis of the efficacy of three different pest control methods was studied. Chemical Control was the most effective, reducing the pest population by 66.7% and leaving only 50 pests after treatment. Subsequently, Biological Control demonstrated commendable efficacy with a reduction of 53.3%, resulting in the elimination of 70 pests. However, Physical Control was the least effective, with 43.3% reduction and final tally of 85 pests after treatment. Despite the fact that all three methods bear their merits, the data suggested that chemical control was the most effective in terms of swift pest reduction in the given context (Table 2).

The relationship between environmental factors and parasite infestation rates was also evaluated. Temperature had an exceptionally strong positive correlation (r=0.8) with infestation rates, indicating that infestation rates would likely increase as the temperature rises ($p<0.05$). A positive correlation coefficient of 0.65 between infestations and humidity suggested that higher humidity levels also favored increased infestations ($p<0.05$). Lastly, Storage Duration demonstrated reduced positive correlation with infestation rates (r=0.55). This correlation was not statistically significant at the $p<0.05$ level. Essentially, while temperature and humidity correlated considerably with higher infestation rates, the length of time sugarcane products were stored appeared to have a smaller and statistically insignificant effect on infestation levels (Table 3).

Chemical control was the most effective technique for Sugarcane Borer, reducing infestation by 75%. This was closely followed by biological and physical control at 70% and 55%, respectively. The Yellow Sugarcane Aphid was most effectively managed by chemical control, with 70% success rate, followed by biological control at 45% and physical control at 35%. The most effective method for combating Sugarcane Thrips was chemical control, with an efficiency of 80%, followed by biological control at 60% and physical control at 45% ($p<0.05$) (Table 4).

Table 1: Common pest species identified in storage facilities

Pest Species	**Number of Instances Identified**	**Common Locations within Facility**
Sugarcane Borer	80	Near stalk bases, inner core of the cane
Yellow Sugarcane Aphid	100	Leaf undersides, near the stem
Sugarcane Weevil	55	Soil at the base, lower stem sections
Pink Sugarcane Mealybug	90	Node regions, hidden under leaf sheaths
Sugarcane Pyrilla	70	Leaf surfaces, especially undersides
Sugarcane Thrips	65	Young leaves, flower parts

Table 2: Efficacy of pest control methods

Control Method	**Initial Pest Count**	**Post-Treatment Pest Count**	**Reduction (%)**
Chemical Control	150	50	66.7
Biological Control	150	70	53.3
Physical Control	150	85	43.3

Table 3: Correlation of environmental factors with infestation rates

Factor	**Correlation Coefficient (r)**	**Significance (p-value)**
Temperature	0.8	0.01*
Humidity	0.65	0.05*
Storage Duration	0.55	0.1

*indicated that the value is significant at $p<0.05$

Table 4: Efficacy of control methods on specific pests

Pest Species	**Chemical Control (%)**	**Biological Control (%)**	**Physical Control (%)**	**p-value**
Sugarcane Borer	75	70	55	0.01*

Yellow Sugarcane Aphid	70	45	35	0.03*
Sugarcane Weevil	75	60	30	0.02*
Pink Sugarcane Mealybug	80	50	55	0.04*
Sugarcane Pyrilla	70	40	35	0.01*
Sugarcane Thrips	80	60	45	0.04*

*indicated that the value is significant at $p<0.05$

DISCUSSION

The findings of this study highlighted the complexity and dynamics of insect surveillance and control in sugarcane products that have been stored. Several essential details are evident:

The observed preferences of pests for specific locations within the sugarcane storage facilities may have significant consequences. For example, Sugarcane Borer's preference for the interior core of the sugarcane stalk could compromise the stalk's structural integrity, potentially resulting in diminished product quality [13]. Similarly, the abundance of the Yellow Sugarcane Aphid on the undersides of leaves near the stem emphasized the importance of closely monitoring these areas to prevent damage or potential disease transmission. The specific habitats preferred by various pests highlighted the necessity for nuanced and pest-specific surveillance strategies [14].

The marked superiority of chemical control in reducing rodent populations is consistent with findings from previous studies that emphasized the prompt effectiveness of chemical interventions. Despite the fact that chemical control methods provide immediate results, it is important to consider their long-term effects, such as pest resistance and potential damage to non-target organisms. Biological control, though slightly less effective, is more environmentally benign, and its consistent efficacy across a variety of pests suggests that it has the potential to be a sustainable method of pest control. Although the diminished efficacy of physical controls is somewhat predictable, it does not diminish their significance, particularly when contemplating non-chemical and environmentally friendly pest management strategies [15-16].

The strong correlation between temperature and pest infestation rates supported the agricultural research consensus that warmer conditions can accelerate pest life cycles and enhance their population growth. The considerable relationship between humidity and infestation rates emphasized the need for controlled storage conditions. Intriguingly, although the correlation between storage duration and infestation is not statistically significant, it suggested that external environmental factors may play a more important role than storage duration alone [17].

Integrated Pest Management (IPM) is necessary due to the varying efficacy of specific pest control methods. Adopting a multifaceted strategy that combines chemical, biological, and physical control methods based on the specific insect profile of each facility could produce more effective and sustainable results [18].

This study illuminated the significance of site-specific pest management strategies by elucidating the intricate relationship between sugarcane pests, their habitats, and control methods. Future research could delve deeper into the long-term effects of these control methods, particularly in terms of the potential for pest resistance, the ecological implications of each method, and the economic viability of implementing such strategies on a large scale.

CONCLUSION

Effective pest management of stored sugarcane products is crucial not only for assuring product quality, but also for preserving the industry's economic viability. The findings of this study detailed the complexities of pest behaviors, their preferred habitats, and variable effectiveness of control methods. The evident superiority of chemical control methods in immediate pest reduction contrasts with the long-term potential of biological controls, suggesting that a balanced approach may be the most advantageous in the long run. In addition, the impact of environmental factors, specifically temperature and humidity, on infestation rates emphasized the need for controlled storage conditions. The results advocated for Integrated Pest Management strategy that incorporates multiple control methods by emphasizing the nuanced understanding of each pest's biology and behavior. This comprehensive strategy, which is grounded in both empirical evidence and ecological considerations, promises a sustainable path for the sugarcane industry to address pest-related challenges.

CONFLICT OF INTEREST

None.

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