Biological Forum – An International Journal **14(3): 199-203(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Arthropod Diversity and Extent of Infestation in Store Maize Grain Samples

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(Received 09 May 2022, Accepted 30 June, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Maize (*Zea mays* L.) is one of the important cereal crop cultivated in India. Stored insect pests inflict damage to maize crop starting from early stage of ripening to post harvest stage. Due to a lack of understanding about maize storage pests, majority of Tamil Nadu farmers encounter insect pest infestation. An intensive study was carried out in Tamil Nadu Agricultural University, Coimbatore during 2021-22 to explore the important pests associated with stored maize, their diversity, as well as the damage and losses they cause. Maize grain samples were collected from seven major maize growing districts of Tamil Nadu. Biodiversity indices such as Shannon-Weiner diversity index, Margalef richness index, Peilou's evenness index and Berger-Parker index of dominance were measured. A total of five arthropod species belonging to orders Coleoptera and Lepidoptera and one species of Acarina were documented. The highest insect diversity (1.51) was noticed in samples from Perambalur feed industries and the lowest diversity (0.69) was noticed from farm samples collected from Dharmapuri. The predominant pest encountered in stored maize was the rice weevil (*Sitophilus oryzae* Linnaeus) (38.9%) followed by angoumois grain moth (*Sitotroga cerealella* Olivier) (28.2%) and the red flour beetle (*Tribolium castaneum* Herbst) (20.2%). Within five to six months of storage, average grain damage of 53.96 per cent was recorded resulting in losses to an extent of 24.42 percent. The insect pests diversity, their damage and losses they cause increased, as the storage period extended.

Keywords: Maize, storage pests, sampling sites, diversity indices, *Sitophilus oryzae*, grain damage, weight loss.

INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop, ranking third in India (APEDA, 2020). Maize is native to Central America and Mexico and has adapted to a wide range of agro climatic situations. It serves three functions in the Indian subcontinent: as a staple food, feed, and fodder, particularly for farmers with limited land holdings, promoting food security and income generation (Lakshmi Soujanya *et al.,* 2017). It has numerous applications in corn-based industrial products, and the demand for maize export has been increasing year after year due to its higher nutritional value. It is mostly grown in the Indian states of Gujarat, Madhya Pradesh, Rajasthan, Bihar, Uttar Pradesh, Tamil Nadu, and Telangana. In Tamil Nadu, the area under maize cultivation is 3.33 lakh ha with a production of 24.76 lakh tonnes and productivity of 7424 kg/ha (INDIASTAT, 2020). Maize is stored after harvesting, either for use as seed or for human consumption or to obtain a favourable market price at times (Reddy and Pushpamma 1980).

One of the greatest barriers to achieving food security in emerging and underdeveloped nations is post-harvest loss during storage (Rounet, 1992). More than 37 species of arthropod pests have been linked to maize grains in storage (Abraham, 1996). Insect pests and diseases have a significant influence in diminishing production and productivity, as well as germination potential during the storage period (Mollah *et al.,* 2016). Majority of the maize growers lack knowledge on the storage pests occurring in maize and subject their produce to improper storage conditions which results in both qualitative and quantitative losses. The present study was conducted to assess the major arthropod pests of stored maize and the extent of damage caused by them under storage conditions.

MATERIALS AND METHODS

Survey area and sampling of maize grains. A laboratory study was conducted from December to May (2021-2022) in the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore with grain samples obtained from major maize growing districts of Tamil Nadu to find out the status of arthropod pests infesting stored maize, their damage and losses. Approximately, 1 kg of sample was collected from major maize growing districts of Tamil Nadu *viz.* Coimbatore, Salem, Namakkal, Dharmapuri, Trichy, Perambalur and Virudhunagar. Preferably, the maize grains were obtained from farmer's stored produce besides collecting from Departmental stores, bulk storage godowns and feed industries. Each sample was tightly packed in a paper bag after tagging with information on the location, date of collection, etc. and brought to the laboratory for further scrutiny (Firidissa, 1999).

Collection and identification of insects. Laboratory observations were made at the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore, at weekly intervals for 6 months at a room temperature of 28±3ºC and relative humidity of 65±10%. Samples were sieved at every inspection over a 2 mm mesh sieve (Abraham, 1996) and all the fractions were examined. Later, the insects were removed, counted and catalogued and were preserved as dry specimens or preserved in 70% ethyl alcohol for identification at a later stage. The detailed analysis of specimens was done with a Leica SA8PO and photographed with a Leica M205C microscope (with LAS X Application Suite montage software). Identification was done by using taxonomic keys provided by Akter *et al.* (2013); Koehler *et al.* (2006); Rita Devi *et al.* (2016); Sowmya *et al.* (2020), besides referring to books, journals, pictures and comparison with already identified specimens.

Analysis of diversity indices. Margalef Index (α) (Margalef, 1958), Shannon Weiner (H′) index (Shanon and Weiner, 1949), Pielou's evenness index (J) (Peilou, 1966) and Berger-Parker Dominance index (May, 1975) were performed in R Studio version 4.0.4 using vegan package to reveal the diversity, species richness, evenness and dominance of arthropod pests associated with stored maize grains.

Data collection

Grain weight loss: After storing for a period of 6 months, 100 grains were randomly removed from each samples and separated into infested and uninfested seeds. The weight of infested and uninfested seeds was separately recorded and the per cent weight loss was calculated based on the count and weight method (Adams, 1976).

$$\text{Weight loss (\%)} = \frac{(\text{Wu} \times \text{Nd}) - (\text{Wd} \times \text{Nu})}{\text{Wu} \times (\text{Nu} + \text{Nd})} \times 100$$

Where, Wu = Weight of undamaged seed, Nu = Number of undamaged seed, Wd = Weight of damaged seed, Nd = Number of damaged seed

Per cent grain damage: The count approach was used to assess insect damage after 6 months storage period. From each collected samples, 100 grains were chosen at random, and they were divided into categories of damaged and undamaged grains. Following that, the percent grain damage (Lemessa *et al.,* 2000; Wambugu *et al.,* 2009) was determined using the following formula.

$$\text{Per cent grain damage (\%)} = \frac{\text{Number of insect damaged grains}}{\text{Total number of grains}} \times 100$$

RESULTS AND DISCUSSION

Maize grain samples collected from different locations were found to be infested with different insect pests. The major pests observed from samples, their abundance and status are furnished in Table 1 and 2. A total of five arthropod pests were collected from the samples representing Coleoptera and Lepidoptera, besides a mite from Acarina. The rice weevil, *Sitophilus oryzae* (Linnaeus) was the predominant pest followed by Angoumois grain moth, *Sitotroga cerealella* (Olivier) and red flour beetle *Tribolium castaneum* (Herbst). In a similar study conducted in 3 states of USA, Eden (1967) listed out 17 species of insects from farm stored maize, of which *S. oryzae* was found to be the predominant one. Also, in a South Ethiopian sample, Getu (1993) identified *S. cerealella* and *S. zeamais* as the two most important stored maize pests. Maize weevil, grain moth and flour beetle were the most abundant insect pests in stored maize samples of western Ethiopia (Abraham, 1997) and Bangladesh (Alam *et al.,* 2019), confirming our investigations.

The grain weevil, *S. oryzae* has been recorded as a polyphagous pest causing significant yield loss in stored maize grains in India and South East Asian countries (Hossain *et al.*, 2007). Being an internal feeder, *S. oryzae* is capable of causing severe losses to the stored maize grains, both qualitatively and quantitatively. *S. oryzae* was observed in all the seven locations followed by *S. cerealella*, *T. castaneum* and *Acarus siro* in six locations each. According to Margalef richness index (α), Perambalur (1.03) had the maximum number of insect pests (6 insect pests) followed by Trichy (0.84), Namakkal (0.80) (5 insect pests in each), Salem (0.68), Coimbatore (0.63) (4 insect pests in each) and Virudhunagar (0.43) (3 species). In Dharmapuri, only two insect pests were recorded (Table 3). Higher the value of Shannon-weiner index indicates higher the diversity of insect pests in stored maize grains. Shannon index indicated higher insect pest diversity was found in Perambalur (1.51) and Trichy (1.50) which were collected from feed industries and bulk storage godowns and the lowest

diversity was noticed from farm samples collected from Dharmapuri (0.69). Peilou's evenness index showed that higher species evenness in Dharmapuri (0.72) and lower in Perambalur (0.42) (Table 3). According to Berger-Parker index of dominance, *S. oryzae* was dominant in all sampling districts except in Coimbatore (Table 4).

In the present investigation, samples collected from various sampling sites revealed 24.4 percent grain damage resulting in 53.9 percent yield loss within a storage period of six months (Table 5). The variations in per cent grain damage and weight loss in different locations were due to diverse sampling sites. Samples collected from feed industries, bulk storage godowns were prone to severe infestations than famer's store point because of large scale holding of maize grain samples in the former. The per cent grain damage and yield loss is attributed to the combined impact of different stored insect pests, though *S. oryzae* was the major contributor. It was also noticed that the extent of damage increased as the storage time extended. Our literature survey revealed grain losses ranging from a minimum of 10-20 per cent (Hell *et al.,* 2010, Golob, 1984; Giga *et al.,* 1991, Abebe and Bekele 2006,) to as high as 80 percent under unprotected conditions (Schmutterer, 1971; Mutiro *et al.,* 1992; Pingali and Pandey 2001). Within a period of five to six months, upto 80 percent grain loss was realized in grain samples stored at Cameroon (Nukenine *et al.*, 2002) and at Bangladesh (Alam *et al.*, 2019).

Table 1: Arthropod pests associated with stored maize grains.

Common name	Scientific name	Family	Order	Status
Rice weevil	*Sitophilus oryzae* (Linnaeus)	Dryophthoridae	Coleoptera	Major
Angoumois grain moth	*Sitotroga cerealella* (Olivier)	Gelechiidae	Lepidoptera	Major
Red flour beetle	*Tribolium castaneum* (Herbst)	Tenebrionidae	Coleoptera	Intermediate
Lesser grain borer	*Rhyzopertha dominica* (Fabricius)	Bostrichidae	Coleoptera	Minor
Rice moth	*Corcyra cephalonica* (Stainton)	Pyralidae	Lepidoptera	Minor
Flour mite	*Acarus siro* (Linnaeus)	Acaridae	Acarina	Minor

Table 2: Distribution and relative abundance of arthropod pests associated with stored maize grains.

Arthropod pests	CBE	SLM	NMK	DMP	TRY	PBR	VDR	Relative abundance (%)
Sitophilus oryzae (Linnaeus)	✓	✓	✓	✓	✓	✓	✓	38.9
Sitotroga cerealella (Olivier)	✓	✓	✓	✓	✓	✓	×	28.2
Tribolium castaneum (Herbst)	✓	✓	✓	×	✓	✓	✓	20.2
Rhyzopertha dominica (Fabricius)	×	×	×	×	×	✓	×	0.3
Corcyra cephalonica (Stainton)	×	×	✓	×	✓	✓	×	4.1
Acarus siro (Linnaeus)	✓	✓	✓	×	✓	✓	✓	8.3

✓ indicates presence of species; × indicates absence of species.
CBE – Coimbatore; SLM – Salem; NMK – Namakkal; DMP – Dharmapuri; TRY – Trichy; PBR – Perambalur; VDR – Virudhunagar.

Table 3: Diversity, species richness and evenness of arthropod pests associated with stored maize grains in different maize growing districts of Tamil Nadu.

Location	Shannon-Weiner Index of Diversity (H)	Margalef's Index of Species Richness (α)	Pielou's Index of Species evenness (J)
Coimbatore	1.20	0.63	0.48
Salem	1.21	0.68	0.49
Namakkal	1.43	0.80	0.46
Dharmapuri	0.69	0.26	0.72
Trichy	1.50	0.84	0.47
Perambalur	1.51	1.03	0.42
Virudhunagar	0.91	0.43	0.51

Table 4: Dominance of arthropod pests associated with stored maize grains.

Location	Dominant arthropod	Berger-Parker Index of Dominance
Coimbatore	*Sitotroga cerealella* (Olivier)	0.44
Salem	*Sitophilus oryzae* (Linnaeus)	0.43
Namakkal	*Sitophilus oryzae* (Linnaeus)	0.34
Dharmapuri	*Sitophilus oryzae* (Linnaeus)	0.53
Trichy	*Sitophilus oryzae* (Linnaeus)	0.34
Perambalur	*Sitophilus oryzae* (Linnaeus)	0.35
Virudhunagar	*Sitophilus oryzae* (Linnaeus)	0.54

Table 5: Extent of grain damage and weight loss due to major storage pests of maize.

Location	Sampling sites	Grain damage (%)	Weight loss (%)
Coimbatore	BG, DS	54.67 ± 0.58	24.33±3.34
Salem	FS	46.67±1.16	16.83±0.95
Namakkal	FI	63.00±1.74	35.49±2.57
Dharmapuri	FS	30.34±0.58	12.61±5.13
Trichy	BG, FI	58.67±1.16	30.34±0.43
Perambalur	FI	63.67±1.53	38.03±1.43
Virudhunagar	DS, FI	60.67±0.58	13.30±1.70

All values are Mean±SD
FA – Farmer's Store point; FI – Feed Industry; BG – Bulk storage Godown; DS – Departmental store.

CONCLUSION

Stored insect pests belonging to orders Coleoptera (rice weevil, red flour beetle and lesser grain borer), Lepidoptera (Angoumois grain moth and rice moth) and Acarina (flour mite) were identified and documented in stored maize grains. The dominant pests encountered in stored maize were the rice weevil (*Sitophilus oryzae*) followed by the angoumois grain moth (*Sitotroga cereallela*), and the red flour beetle (*Tribolium castaneum*). Between five and six months of storage, significant grain damage of 53.96 percent and losses of upto 38 percent was caused by these pests. The incidence, distribution of stored insect pests and qualitative or quantitative loss of maize increased with increased storage time. Sound management measures without compromising the quality of the produce to mitigate the major storage pest of stored maize grains is the need of the hour.

Acknowledgements. The authors are grateful to the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore, India for providing necessary facilities during this study.
Conflict of Interest. None.

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How to cite this article: J.M. Nivethika, T. Srinivasan, R. Arulprakash, A. Suganthi and R. Ravikesavan (2022). Arthropod Diversity and Extent of Infestation in Store Maize Grain Samples. *Biological Forum – An International Journal*, *14*(3): 199-203.