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Occurrence and Abundance of Populations of Three Astigmatid Mite Species In Stored Products Infested With Fusarium Species

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Abstract: **Stored products get heavily infested with Fusarium species, if poorly managed after harvesting. These are considered as pre-harvest fungi. These fungi produce mycotoxins. Poor post-harvest management of stored products cause these fungi continue to grow and hence, the stored products become heavily populated with them. Such stored products infested with heavily populations of Fusarium species and their produced mycotoxins as well as occasional association of various mite species with them deteriorates the quality of such stored products. Such products become unfit for eating. Since mites are adapted to diverse feeding habits due to an evolutionary plasticity. So, some mites are exclusively while others are inclusively fungivorous. So, mites feeding on fungi, interact with both fungi and their mycotoxins, so are adapted to live in the presence of mycotoxins. Mite species, well adapted to feed on fungi species and in turn causing the dissemination of fungal spores, are having a mutualistic relationship with fungi. Both together enhance the occurrence and abundance of each other's populations in a synergistic and cooperative way. In this study, a total of 60 samples of various stored products collected and investigated were only those samples already infested with Fusarium species. The purpose of the study was to evaluate the differential occurrence and abundance of populations of three Astigmatid mite species (*Acarus siro*, *Lepidoglyphus destructor* and *Tyrophagus putrescentiae*) in stored product samples infested with Fusarium species. Among the three Astigmatid mite species studied, only the *Tyrophagous putrescentiae* was found to be associated with all ten species of Fusarium infested samples, followed by *Acarus siro* with six and *Lepidoglyphus destructor* with two Fusarium species. The ten species of Fusarium were categorized according to their suitability/association effect on the occurrence and abundance of three astigmatid mite populations as: (1) Highly suitable (*F. oxysporum*, *F. verticilloides* (2) Suitable (*F. culmorum*, *F. solani* and *F. avenaceum*) and (3) Lowly suitable (*F. subglutinas*, *F. sporotrichioides*, *F. poae* and *F. graminearum*).**

Keywords: **Fusarium; Astigmatid mites; Grain; Storage; Feeding.**

I. INTRODUCTION

During grain storage, proper scientific post-harvest management is necessary for avoiding qualitative and quantitative losses. Proper drying and proper storing in humid free godowns is important. Moreover, the access of insects, rodents and other animals to these storage places should be prevented by taking necessary measures. Poor post-harvest management results in rapid deterioration in grain quality and its nutritive value as well as severe decrease in germination rate. In improperly stored grain, pests, including fungi and mites, start to proliferate and produce metabolites (Sinha, 1979). The important abiotic factors such as grain moisture content, temperature and relative humidity supporting growth are similar for mites and fungi. Mites can live at temperatures from 3 to 41 ˚C and relative humidity of 42% to 99%. The optimum is approximately 25 ˚C with 70% to 90% R.H. Fungi can grow at temperatures of -2 to 55 ˚C and 70% to 90% R.H. The optimum temperature is near 30 ˚C with about 80 % R.H. (Jayas and White, 2003).

Poorly stored grain provides a complex habitat for various groups of interacting microorganisms and arthropods (Sinha, 1979 and Magan *et al*., 2003). Among arthropods, the role of astigmatid mites including their fungivory has been a subject of many studies (Sinha, 1979). Fusarium fungi infect plants in the field before the harvest (Miller, 1995). During storage, fungi continue to grow and produce mycotoxins if the grain is improperly stored (Hope *et al*., 2005 and Osborne and Stein, 2007). Fusarium fungi were present with Pencillium and Aspergillus fungi in store barley and wheat grain in farm facilities under unsatisfactory sanitary conditions (Baliukoniene *et al*., 2003). About 71% of inspected grain samples were infested by mites in the Czech Republic (Stejskal and Hubert, 2008).

The damage caused by mites and fungi is similar and includes discoloration, decrease in nutritional value, production of off-odors, loss in germination rates and deterioration in milling and backing quality (Magan *et al*., 2003 and White *et al*., 1979). However, the difference is in their metabolic activities. Fungi produce mycotoxins and contaminate food with these mycotoxins. Fusarium species produce trichothecenes (deoxynivalenol, T2 and HT2 toxins), fumonisins and zearalenone (Miller, 1995 and Bottalico and Perrone, 2002). Mites produce allergens. World Health Organization and International Union of Immunological societies (WHO/IUIS) have presently characterized 11 allergens produced by stored mites. Together, stored mites and fungi deteriorate the stored products more severely.

Together, mites and fungi affect the occurrence and abundance of each other. Mites graze on fungi and are involve in the dominance of mycotoxigenic fungal species due to their role in dispersal of fungal spores (Aucamp, 1969 and Magan *et al*., 2003). In Czech Republic, an association between mites and 14 mycotoxin producing fungal species, mainly *Aspergillus* spp. and Penicillium spp., has already been reported in heavily infested grain stores (Hubert *et al*., 2004a). Field studies of mite-fungi associations with stored products will help us to determine the mite feeding preferences, grazing behavior on fungi and their occurrence and abundance influenced by what fungi these feed on. It will help to understand the interaction between mites and fungi and suggest a good possible treatment that would lead to the elimination of grain losses.

Since, Fusarium species are pre-harvest fungi. So, these fungi reach to stored products by vertical transmission with ease and magnify in their population if post-harvest management is improper. Further, infestation of such fungi infested stored products with stored mites amplifies the deterioration rate of stored products. The aim of this study was to evaluate the differential suitability of Fusarium species for the support of growth of three astigmatid stored mite species. The study was limited to samples positive for Fusarium species and three astigmatid mite species. A total of sixty samples, each weighing 250 grams, of varied food types but all infested with Fusarium fungi, were collected and investigated for the associations of particular fusarium species with the mite species. The effect of food samples infested with fusarium species on the occurrence and abundance of populations of 3 Astigmatid mites were determined. *Tyrophagous putrescentiae* was found to be most frequently mite species present with all 10 species of fusarium, followed by *Acarus siro* in 6 and *Lepidoglyphus destructor* in only 2.

2. MATERIALS AND METHODS

A total of 60 stored products samples of different types infested with Fusarium fungi were collected. Each sample was 250 grams. Only those samples infested with fusarium fungi were collected and investigated for the studies of occurrence and abundance of populations of 3 Astigmatid mite species in association with a particular Fusarium species. A total of 10 fusarium species were identified in all 60 Fusarium infested samples. The fusarium species identified were: *F. avenaceum, F. culmorum, F. graminearum, F. oxysporum, F. poae, F. solani, F. sporotrichioides, F. subglutinas, F. tricinitum and F. verticillioides*. The 3 Astigmatid mites studied were: *Acarus siro*, *Lepidoglyphus destructor* and *Tyrophagous putrescentiae*. After the identification of Fusarium species associated with stored products samples, samples were subjected to Tullgren-Berlese method for mite extraction with 80% ethanol for 4-5 days. Camel brush was used to transfer the extracted mites to cavity blocks containing 60% lactic acid as a clearing agent. These cavity blocks were covered with lid and kept in an oven at temperature 37 ˚C for 2-4 days. Then these cleared mites were mounted in Hoyer's medium onto slides and then observed under a dissection microscope for identification of mite species present. The mites were counted for each sample and total population was noted down. However, occurrence and abundance of populations of only 3 mite species were considered in this study.

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3. RESULTS

Out of the total 60 stored-product samples of various types each of 250 grams weight, 44 samples were infested with *Tyrophagous putrescentiae* populations. For *Tyrophgous putrescentiae*, the maximum mean population density of 300 individuals in 8 samples infested with *Fusarium oxysporum*. These mites were found to be present with all 10 species of Fusarium fungi species but with differential frequencies of occurrence and abundance. *Tyrophagous putrescentiae* was found with minimum mean populations of 120 in two samples infested with *F. avenaceum*. *Acarus siro* was found in 12 samples with maximum mean population density of 285 individuals in two samples infested with *F. graminearum*. Out of the 6 Fusarium species with which Acarus was found, the minimum mean population density was 25 individuals in two samples infested with *F. culmorum*. *Lepidoglypus destructor* was found in only 4 samples with a maximum mean population density of 225 individuals in two samples infested with *F. subglutinans.* Out of the 2 Fusarium species with which *L. destructor* was found, the minimum mean population density was 170 individuals in two samples infested with *F. graminearum*. The following tables depict the results of study.

Table 1: Occurrence (presence '+' and absence '-') of 3 Astigmatid mite species with Fusarium species infested stored-products.

S.No	Fusarium Species	*Acarus siro*	*L. destructor*	*T. putrescentiae*
1	***F. avenaceum***	-	-	
2	***F. culmorum***	+	-	+
3	***F. graminearum***	+	+	+
4	***F. oxysporum***	+	-	+
5	***F. poae***	-	-	+
6	***F. solani***	+	-	+
7	***F. sporotrichioides***	-	-	+
8	***F. subglutinans***	+	+	+
9	***F. tricinctum***	-	-	+
10	***F. verticillioides***	+	-	+
Total		**6**	**2**	**10**

The table 1 shows that *Tyrophagus putrescentiae* mites have been found associated with all 10 fusarium species. However, *Acarus siro* and *Lepidoglyphus destructor* have been found associated with only 6 and 2 fusarium species. Only the two species of Fusarium (*F. graminearum* and *F. subglutinas*) were found to be associated with populations of either one of the 3 Astigmatid mite species.

Table 2: Frequency of samples infested with particular combinations of Astigmated-Fusarium species

S. No.	Fusarium Species	*Acarus siro*	*L. destructor*	*T. putrescentiae*	Total samples
1	***F. avenaceum***	**0**	**0**	**2**	**2**
2	***F. culmorum***	**2**	**0**	**4**	**6**
3	***F. graminearum***	**2**	**2**	**4**	**8**
4	***F. oxysporum***	**2**	**0**	**8**	**10**
5	***F. poae***	**0**	**0**	**2**	**2**
6	***F. solani***	**2**	**0**	**6**	**8**
7	***F. sporotrichioides***	**0**	**0**	**2**	**2**
8	***F. subglutinans***	**3**	**2**	**8**	**13**
9	***F. tricinctum***	**0**	**0**	**2**	**2**
10	***F. verticillioides***	**1**	**0**	**6**	**7**
Total		**12**	**4**	**44**	**60**

The table 2 shows that out of the total of 60 samples infested with Fusarium species, 44 samples were infested with T. putrescentiae, 12 with A. siro and 4 with L. destructor. Stored product samples infested with F. avenaceum or F. poae or F. sporotrichioides or F. tricinitum were found to be associated with only T. putrescentaie mite population. Only two

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Fusarium species (F. graminearum and F. subglutinans) were found to be associated individually with all 3 Astigmatid mite species.

Table 3: Abundance of 3 Astigmatid mite populations (Mean population density/250 gram of sample) with Fusarium species infested stored products Astigmatid populations

S. No.	Fusarium species name	*A. siro*	*L. destructor*	*T. putrescentiae*
1	*F. avenaceum*	0	0	120
2	*F. culmorum*	25	0	32
3	*F. graminearum*	285	170	175
4	*F. oxysporum*	110	0	300
5	*F. poae*	0	0	150
6	*F. solani*	140	0	290
7	*F. sporotrichioides*	0	0	180
8	*F. subglutinans*	225	225	295
9	*F. tricinctum*	0	0	210
10	*F. verticillioides*	35	0	295

Table 4: Occurrence and Abundance of *Acarus siro* polutations in stored product samples (250gm each) infested with Fusarium species

S. No.	Fusarium species	Occurrence (+/-)	Samples +tive	Total Mite population	Mean mite population
1	*F. avenaceum*	-	0	0	0
2	*F. culmorum*	+	2	50	25
3	*F. graminearum*	+	2	570	285
4	*F. oxysporum*	+	2	220	110
5	*F. poae*	-	0	0	0
6	*F. solani*	+	2	280	140
7	*F. sporotrichioides*	-	0	0	0
8	*F. subglutinans*	+	3	675	225
9	*F. tricinctum*	-	0	0	0
10	*F. verticillioides*	+	1	70	35
Total		6	12	1865	

Table 5: Occurrence and Abundance of *Lepidoglyphus destructor* polutations in stored product samples (250gm each) infested with Fusarium species

S. No.	Fusarium species	Occurrence (+/-)	Samples +tive	Total Mite population	Mean mite population
1	*F. avenaceum*	-	0	0	0
2	*F. culmorum*	-	0	0	0
3	*F. graminearum*	+	2	340	170
4	*F. oxysporum*	-	0	0	0
5	*F. poae*	-	0	0	0
6	*F. solani*	-	0	0	0
7	*F. sporotrichioides*	-	0	0	0
8	*F. subglutinans*	+	2	450	225
9	*F. tricinctum*	-	0	0	0
10	*F. verticillioides*	-	0	0	0
		2	4	790	

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Table 6: Occurrence and Abundance of *Tyrophagus putrescentiae* polutations in stored product samples (250gm each) infested with Fusarium species

S. No.	Fusarium species	Occurrence (+/-)	Samples +tive	Total Mite population	Mean mite population
1	*F. avenaceum*	+	2	240	120
2	*F. culmorum*	+	4	128	32
3	*F. graminearum*	+	4	700	175
4	*F. oxysporum*	+	8	2400	300
5	*F. poae*	+	2	300	150
6	*F. solani*	+	6	1740	290
7	*F. sporotrichioides*	+	2	360	180
8	*F. subglutinans*	+	8	2360	295
9	*F. tricinctum*	+	2	420	210
10	*F. verticillioides*	+	6	1770	295
Total		10	44	10418	

Table 6: Frequency of occurrence, samples positive, total population and mean populations of 3 Astigmatid mites

S. No.	Astigmatid mite	Occurrence with Fussarium spp.	Samples +tive	Total population	Mean population
1	*A. siro*	6	12	1865	155
2	*L. destructor*	2	2	790	197
3	*T. putrescentiae*	10	44	10418	238

Table 7: Frequency of Store product samples +tive for a particular Fusarium species and populations of 3 Astigmatid mites

S.No.	Name of Fusarium species	Fusarium +tive samples	*A.siro* population	*L.destructor* population	*T. putrescentiae* population	Total population
1	*F. avenaceum*	2	0	0	140	140
2	*F. culmorum*	4	50	0	128	178
3	*F. graminearum*	8	570	340	700	1610
4	*F. oxysporum*	10	120	0	2400	2520
5	*F. poae*	2	0	0	300	300
6	*F. solani*	8	280	0	1040	1320
7	*F. sporotrichioides*	2	0	0	360	360
8	*F. subglutinas*	13	675	450	2360	3485
9	*F. tricinctum*	2	0	0	420	420
10	*F. verticillioides*	7	10	0	1770	1840
Total	10	60	1865	790	10418	13073

4. DISCUSSION

Astigmatid mite species have been suggested to be primarily fungivorous organisms (Oconor, 1979 and Oconor, 1984). In this study, we observed differential frequencies of occurrence and abundance of 3 Astigmatid mite species. This study found differential frequencies of occurrence of stored product samples infested with a particular type of Fusarium species as well as differential frequencies of occurrence and abundance of any of the 3 astigmatid mite species with them. The Fusarium species were categorized as Highly Suitable, Suitable and Lowely suitable species depending upon the high, medium and low populations of 3 Astigmatid species found in asoociation with them in the studied stored product samples. In general, Fusarium fungi infested stored product sampes harboured least populations of *Acarus siro* and *Lepidoglyphus destructor* suggesting that these fungi are not very suitable source of food for them or are very limited in

fungivory habit. However, *Tyrophagous putrescentiae* was found to be in very dense polulation in a very good number of samples and their presence was with all types of Fusarium species. This high frequency of occurrence and abundance of *Tyrophagous putrescentiae* species suggest that Fusarium species served as a suitable source of food for it and are highly fungivorous in habit. The *Tyrophagous putrescentiae* were found to be relatively broader in rage of Fusarium fungi as a food preference than *Acarus siro* and *Lepidoglyphus destructor* together. *Acarus siro* had broader rage than *Lepidoglyphus destructor*. In some earlier studies, remarkable differences in fungal suitability to mites among the strains of one fungus were determined (Sinha, 1964; Sinha, 1966; Sinha, 1968; sinha and Mills, 1968; Sinha and Whitney, 1969 and Czajkowska, 1970). Higher degree of fungivory has been frequently reported for *T. putrescentae* (Sinha, 1968; Pankiewicz-Nowickal et al., 1984 and Hubert et al., 2004; Nesvorna et al., 2012). Laboratory approaches have been used to examine sthe interactions between the various fungi species and mites (Smrz and Catska, 1989; Smrz et al., 1991 and Nesvorna *et al*., 2012). However, with the current state of knowledge, it is hard to determine whether such an interaction would lead to the suppression or acceleration of Fusarium fungal growth. Extensive microarthopod grazing inhibits fugal growth (Armitage and George, 1986), but moderate microartopod grazing is beneficial for the fungi (Hanlon, 1981 and Hedlund *et at.*, 1991). Fungi may profit from the dispersal of spores attached on the body surface or undigested spores in the excretia (Griffths *et al*., 1959 and Hubert *et al*., 2003). Such dispersion is expected for all the Fusarium fungi consumed by *T. putrescentiae* in stored grain. The mites prefer the wet and humid parts of the grain with temperatures optimal or suboptimal for mite development (Athanassiou *et al*., 2005 and Hubert *et al.*, 2010). And accelerate the growth of fungi. These conditions are often present when post-harvest management is improper, and also occur in hot spots (Sinha, 1961; Sinha and Wallace, 1966; Cook and Armitage, 2003). It has been demonstrated that *T. putrescentiae* had higher growth in grain inoculated with *Aspergillus flavus* than on un-inoculated grain (Franzolin *et al*., 1999). Experimental studies (Nesvorna *et al*., 2012) showed that there is an expected feeding interaction behavior between the *T. putrescentae* and Fusarium fungi when stored grains are infested by both simultaneously. When both mite and fungi simultaneously infest the stored grain, mycotoxins produced by fungi and various allergens of mites as well as residual bodies of both, present a significant and medical hazard.

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