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Insect-Fungus Associations influencing seed deterioration in storage

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The present study revealed susceptability of maize and groundnut seed to two insects, *Sitophilus oryzae* and *Rhizopertha dominica* respectively. The insect-fungus interaction confirmed the role of the former insect in transmission of seed-borne fungi, which serve as food, thus, escalating the process of seed deterioration in storage.

Key words : Maize, Groundnut, *Sitophilus oryza*, *Rhizopertha dominica*, Insect-fungus association, Seed deterioration

INTRODUCTION

A number of seed infesting insects generally remain associated with the storage fungi (sikorowski, 1964). Insect infestation is often partly or almost completely dependent on fungus for food, or on the ability of the fungi to pre-digest the substrate (Christensen and Hodson, 1960), while the insect may disseminate the fuugal spores leading to a kind of mutualism and thus posing a serious threat to food security both qualitatively and quantitatively (Dunkel, 1988).

The present study has been designed to see the sensitivity of seeds to insects, the insect-fungus interaction and the subsequent changes of seed health in storage.

MATERIALS AND METHODS

Two types of seeds viz. maize (*Zea mays* cv. Ganga) and groundnut (*Arachis hypogaea* cv. Nizam) which were found to be frequently associated with insects

Siiophilus oryzae L. and *Rhizopertha dominica F.* were used as the test materials for the present study.

The mycoflora in insects and the ability of the insects in causing damage to seeds were determined following Campbell *et al.* (1976). The changes in insect population and the dust weight (of the insect infested seeds) were recorded following Sinha (1984).

Seed germination and the seed health were determined following ISTA (1966). The changes of moisture content and organic dry matter of the seeds were calculated following Roberts and Roberts (1972) and Christension and Kaufman (1969) respectively. Fungal chitin content in seeds were estimated following Nandi (1978).

RESULTS

Initial study showed, that the two insects carried the seed-borne fungal spores both internally and externally. Internally, fungal spores were found to be present in the mouth parts, guts and all along the alimentary canal, whereas externally, large number of fungal spores were evident on insects adhering to their bodies and harboured by the insect bristles.

The study showed maximum increase of the insect population in both *Sitophilus oryzae*—maize (So-m) and *Rhizopertha dominica*-groundnut (Rd-g) combinations (Table 1)' which continued to increase till 12 weeks.

Table 1. Preference of insects to seeds under natural storage condition for 12 weeks.

Types of seed	Weeks	Insect (number)[a]	
		Sitophilus oryzae	*Rhizopertha dominica*
Maize	0	8	8
	4	25	10
	8	54	15
	12	69	19
Groundnut	0	8	8
	4	11	22
	8	19	39
	12	21	48

[a]Mean of five replicates

Mycofloral population as well as fungal chitin content in all seeds (Tables 2 and 3) showed a steady increase throughout the period and exhibited a direct correlation with the extensive damage in both So-m and Rd-g combinations.

Table 2. Effect of insects on different parameters of maize grain health[a] under natural storage conditions for 12 weeks

Types of insect	Week	Grain mycoflora (%)	Grain germination (%)	Chitin content (μg/g)	Dust weight (mg/10 g)	Grain moisture (%)	Grain biomass (g/10 g grain)
Control (without insect)	0	81	80	97	—	14.6	9.65
	4	83	79	139	—	13.9	9.64
	8	86	76	159	—	13.7	9.39
	12	89	75	172	—	13.6	9.22
Sitophilus oryzae	0	81	80	97	—	14.6	—
	4	87	74	161	142	14.7	8.81
	8	91	69	179	787	14.9	8.20
	12	95	59	219	1235	16.0	7.75
Rhizopertha dominica	0	81	80	97	—	14.6	—
	4	83	78	147	—	13.9	9.50
	8	88	75	160	69	13.8	9.22
	12	89	73	181	78	13.8	8.95
LSD (P=0.05)	—	—	—	3.9	4.6	0.28	0.2

[a] Mean of five replicates
'—' indicate not studied

Table 3. Effect of insects on different parameters of groundnut seed health[a] under natural storage conditions for 12 weeks

Type of insect	Week	Seed mycoflora (%)	Seed germination (%)	Chitin content (μg/g)	Dust weight (mg/10 g)	Seed moisture (%)	Seed biomass (g/10 g seed)
Control (without insect)	0	74	85	96	—	6.8	9.25
	4	77	80	107	—	6.8	9.25
	8	82	79	131	—	6.3	9.22
	12	87	98	152	—	6.2	9.18
Sitophilus oryzae	0	74	85	96	—	6.8	—
	4	79	78	112	—	6.4	9.20
	8	84	76	143	16	6.4	8.90
	12	91	73	187	30	6.3	8.50
Rhizopertha dominica	0	74	85	96	—	6.8	—
	4	81	78	133	42	6.9	9.11
	8	87	71	152	69	7.5	8.68
	12	97	62	220	115	7.9	8.13
LSD (P=0.5)				4.2	5.6	0.4	0.3

[a] Mean of five replicates
'—' indicate not studied

Initial seed germinability (Tables 2 and 3) which was fairly high in both seeds, decreased markedly after 12 weeks of storage in both So-m and Rd-g combinations.

So-m combinations showed severe damage to both embryo and endosperm of the grains, which were reduced mostly to flinty fragments of hull and endosperm. As a result, dust production was also highest when compared to other combinations of maize (Table 2). In groundnut, the highest dust formation and seed damage was recorded with Rd-g combination (Table 3). It, however, showed lower dust formation and damage to the seeds than that found in So-m set.

Moisture content showed an increase in So-m combination over the initial, while decreased in control and *R. dominica*-maize (Rd-m) combinations (Table 2). In groundnut, control and *S. oryzae*-ground (So-g) combination showed some decrease, whereas Rd-g combination showed increase in moisture content from the initial (Table 2).

Loss of seed biomass due to insect infestation was found to be highest after 12 weeks. *S. oryzae* and *R. dominica* resulted higher loss in case of maize and groundnut respectively than other sets.

DISCUSSION

The insect-fungal interactions in storage are intricate. Storage fungi usually accompany or follow insect infections (Sinha *et al.*, 1962 ; Sinha and Wallace, 1965 ; Wallace and Sinha, 1962). Fungi are essential companions of the storage insects and provide B-vitamins not available in their stored product diet (Dunkel, 1988).

The study distinctly showed susceptability of maize and groundnut to *S. oryzae* and *R. dominica* respectively than the other combinations. In So-m combinations, increase in insect population could have been higher, bnt it was not so inspite of extensive depletion of the food, Over-crowding or accumulation of toxic nitrogenous bi-product or fungal toxins or by a combination of two or more of these factors was responsible for lowering of insect population. (Demianyk and Sinha, 1987). *S. otyzce* caused comparatively more severe and prominant damage of maize grain than that of groundnut seeds by *R. dominica*. The rapid increase in population and large quantities of dust produced by *S. oryzve* in maize indicated extensive feeding and reproduction of the insects.

Insects damages the seeds by feeding and by oviposition. Both of these actions break the pericarp or seed envelope. The inability of an insect to survive, indicated that the seeds were difficult to penetrate, which might partly be responsible for their immunity to insect attack (cf. Mills, 1983).

The mycoflora increased slowly in all cases, except in So-m and Rd-g combinations, where it increased rapidly. Insects are by far the most important vectors of fungal pathogen, which feed on seed thereby causing injury, that subsequently become colonized by fungi (Fennel *et al.*, 1975). The insects carrying spores as it move from seed to seed, bore a minute hole in the seed envelope during oviposition. Subsequently the larva which develops from that egg, creates a large excavation in the seed providing additional surface for the fungi to grow. The dissemination of fungal spores by insects into seeds ultimately cause depletion of biochemical constituents of the seed. Chitin content, which often reflect fungal growth of stored seeds, also coroborated the present finding.

Insect infestation recorded in the seeds, resulted loss in germinability by eating the seed and providing the points of entry of storage fungi. Both insects which normally feed on broken seeds, caused damage to the embroys during the earlier part of the storage whereas more damage was done to endosperm, in both cases, during the later part of storage when the insect number relatively increased.

The moisture content increase in both So-m and Rd-g combinations, resulted mainly from metabolic moisture released by the thriving insect population. This also reflected the population size and type of seed damage caused by the insects. With their metabolic water and heat, insects evidently increased the water activity and temperature of seed to levels suitable for fungal growth (cf. Agrawal *et al.*, 1957 ; Christensen and Hodson, 1960). As a consequence, fungal spores germinated and hyphae developed rapidly. These fungi, in turn also produced metabolic water and heat (Dunkel, 1988). Thus, infestation by insects mostly accompanied by storage fungi resulted a self-perpetuating system for seed spoilage as pointed out by Sinha (1984).

Insects feed on intact or damaged seeds, transforming the seed energy and nutrients into their own biomass, thus permitting insect multiplication and survival.

The study revealed, higher susceptability of maize and groundnut seeds to *S. oryzae* and *R. dominica* respectively, which lead to more damage of the seeds in natural storage when compared to other combinations.

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REFERENCES

Agarwal, N. S., Christensen, C. M. and Hodson, A. C. (1957). Grain storage fungi associated with the granary weevil. *J. Econ. Entoml.* **50**, 659-663.

Campbell, A., Singh, N. B. and Sinha, R. N. (1976). Bioenergentics of the granary weevil, *Sitophilua granarius* (L.). *Can J. Zool.* **54**, 786-798.

Christensen, C. M. and Hodson, A. C. (1960). Developments of granary weevils and storage fungi in columns of wheat. *II. J. Econ. Entomol.* **53**, 375-380.

Christensen, C. M. and Kaufman, H. H. (1969). Grain storage : The role of fungi in Quality loss. 153 p. Univ. of Minnesota Press Minneapolis, Minn.

Demianyk, C. J. and Sinha, R. N. (1987). Effect of infestation by the larger grain borer, *Prostephanus truncatus* (Horn), and the lesser grain borer *Rhizopertha dominica* (F.) on stored corn. *Environ. Entomol.* **16**(3), 618-624.

Dunkel, Florence V. (1988). The relationship of insects to the deterioration of stored gram by fungi. *Int. J. of food Microb.* 7, 227-244.

Fennell, D. I., Lillehoj, E. B. and Kwolek, W. F. (1975). *Aspergillus flavus* and other fungi associated with insect damaged field corn. *Cereal Chem.* **52**, 314-321.

ISTA (1966). Rules for seed health testing. *Proc. Internat Seed Test Assoc.* **31**, 1-152.

Mills, J. T. (1983). Insect fungus associations influencing seeds deterioration. *Phytopathology*, **72**(2), 330-335.

Nandi, B. (1978). Glucosamine analysis of fungus-infected wheat as a method to determine the effect of antifungal compounds in grain preservation. *Cereal Chem.* **55**, 121-126.

Roberts, E. H. and Roberts, D. L. (1972). Moisture contents of seeds. In : "Viability of Seeds" (ed. E. H. Roberts), p. 424-437.

Sikorowski, P. (1964). Interrelation of fungi and insects to deterioration of stored grains. Washington State University, Institute of Agricultural Sciences, *Tech. Bull.*, 42.

Sinha, R. N. (1984). Effects of weevil (Coloeptera : Curculionidae) infestation on abiotic and biotic quality of stored wheat. *J. Econ. Entomal.* **77**, 1483 1488.

Sinha, R. N., Liscombe, E. A. R. and Wallace, H. A. H. (1962). Infestation of mites, insects and microorganisms in a large wheat bulk after prolonged storage. *Can. Entomol.* **94**, 542-555.

Sinha, R. N. and Wallace, H. A. H. (1965). Ecology of a fungus induced hot spot in stored grain. *Can. J Plant Sci.* **45**, 48-59.

Wallace, H. A. H. and Sinha, R. N. (1962). Fungi associated with hot spots in farm stored grains. *Can J. Plant. Sci.* **42**, 130-141.

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