SUSCEPTIBILITY OF THE LIFE STAGES OF SITOPHILUS ZEAMAIS AND TROGODERMA GRANARIUM LARVAE TO NITROGEN ATMOSPHERE IN MINISILOS

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ABSTRACT

The traditional method of storage and the use of insecticidal protectants on grains in Nigeria have attendant problems and risks both to the consumer and operator. Silo usage in Nigeria was also discouraged because of physical problems of moisture migration and condensation and consequently spoilage of the stored commodity. The possible use of nitrogen as insect control method in minisilos to replace the traditional methods of insect control in storage was tested.

Tests were done to determine the exposure time required to kill all the life stages of maize weevils, Sitophilus zeamais, and the larvae of khapra beetles Trogoderma granarium. They were carried out in airtight minisilos of 0.65 m^3 capacity, in the environment produced by maize of 13.5% moisture content stored under near to pure nitrogen.

Various exposure times required to kill developing maize weevils and larvae of khapra beetles at 27°C ± 1°C were observed in the conditions representing real inert gas silo storage practices. The eggs and the adult stages of maize weevils were more susceptible to anoxia than the larval and pupal stages. The duration of exposure required to kill the eggs, larvae, pupae and adults of maize weevils were 4.0, 7.5, 8.0 and 3.0 days respectively, while 5.0 days exposure to nitrogen killed all the larvae of khapra beetle.

The number of live insects at the beginning and the end of a ten weeks storage trial of maize at 13.5% was assessed in minisilos under

nitrogen and controls in air. A full kill of all stored product insects was achieved in nitrogen, while a very high insect infestation persisted in the controls.

INTRODUCTION

About 10 million tons of Nigerias' major staple food crop viz. sorghum, millet, maize and rice are produced annually; 10-25% of the grains are however lost annually to stored product insects.

Various methods used to control insect infestation include the traditional methods of smoking, use of local plants, sand and ashes and recently modern technology ushered in the use of chemicals which are mainly organic poisons. The use of chemical protectants on grains in storage was immediately accepted because they are cheap, effective in small quantities, persistent and broadly toxic and require very little labour for their employment, until attendant problems and risks both to the consumer and operator were identified. Some insecticides leave undesirable taint effect on seed and also damage the viability of the seeds. Cases of insects developing resistance to insecticides are very frequent. Consequently new products keep coming into the storage business and this requires more extension time to convince our farmers to adopt the new insecticides. To replace the use of insecticides in our grains therefore, a cue was taken from the claim of Assoreni (Shejbal, 1978, 1979) that storing grains in silos purged with nitrogen will eliminate:

(a) Toxicity of insecticides to both consumer and operators
(b) Insect resistance, developing in response to insecticides
(c) Problems of insect reinfestation, since the storage structure is airtight.

A small scale trial of controlled atmosphere storage of maize in minisilos was jointly conducted by NSPRI Nigeria and Assoreni of Rome to determine the effect of Nitrogen on the life stages of maize weevils and larvae of khapra beetles, in Nigeria.

A summary of the exposure time required to kill adults, pupae, larvae and egg stages of rice weevil was given to be 2, 18.4, 8.9 and 9.3 days respectively (Lindgren and Vincent, 1977).

MATERIALS

The atmosphere for testing the effect of nitrogen on the life stages of maize weevil and the larvae of khapra beetle was provided by 0.3 tonnes of 13.5% moisture maize stored in minisilos of 0.5 m^3 capacity. Two minisilos were used and each consists essentially of two main parts, a long cylindrical body contains the insect cage introduction point which is a perforated metal tube reaching 2/3rd of the diameter of the minisilo, it is equiped with a rapid closing valve. By this arrangement the composition and relative humidity of the atmosphere inside the minisilos and in the insect cages was maintained the same.

The insect cages were of cylindrical shape made of plexiglas. The cage was 2 inches long and 1 inch in diameter. Both ends of the cylindrical cage were covered with 60 mesh per inch nylon nets to allow free movement of air. The lid of the cage was equiped with a handle for easy and quick introduction and removal of the insect cages in the minisilos.

The maize weevils and khapra beetles used were from laboratory cultures reared on sorghum and cowpeas respectively at 26 $\pm$ 1°C and 70% $\pm$ 5% r.h.

The eggs,larvae and the pupae of maize weevils were obtained by exposing disinfested sorghum (sorghum kernels were deep frozen for 7 days before use) to egg laying adult weevils for 5 days in the Nigerian Stored Products Research Institute's rearing room. The life stages of the developing maize weevil progeny were estimated on the basis of developmental activities reported in earlier papers (Shariff and Mills, 1971) who correlated days from oviposition with developmental stages by using daily radiographing of infested kernels and confirmed the stages by measurements of larvae head capsules. For this test, therefore, ages of the life stages of maize weevils in sorghum kernels were taken as follows: 7 days after start of oviposition = eggs, 16 days after start of oviposition = larvae, 28 days after start of oviposition = pupae.

The larvae of khapra beetle used were from laboratory cultures. The adult beetles were reared on disinfested "Black-eye" beans under 27°C $\pm$ 1°C and 70% $\pm$ 5% r.h. conditions. Forty khapra beetle larvae

were selected (active) for this test. The larvae were put on disinfeste "Black-eye" beans in the special insect cages that fitted the insect cage compartment the of the minisilos.

EXPERIMENTAL PROCEDURE

Forty adult maize weevils were put into each insect cage containing disinfested sorghum and introduced into the minisilos. The cages were left in the minisilos for periods ranging from 24 hours to 120 hours. The first batch in nitrogen was removed after 14 hours, removals were made every twenty four hours thereafter and the last batch of the insect cages were removed 120 hours after introduction into the minisil purged with nitrogen.

One hundred kernels of sorghum containing different life stages of maize weevil were put into each of the insect cages and introduced into the minisilos at different periods. Each of the cages containing different designated life stages of maize weevils were purged with nitrogen in the minisilos for periods varying from 24 hours to 240 hours, the insect cages were removed every twenty-four hours.

Forty larvae of khapra beetle were used per each insect cage and introduced for periods varying from 24 to 240 hours in minisilo purged with nitrogen.

Parallel control experiments were conducted in 0.14 tonnes of maize stored in non-air-tight tanks.

After removal from the minisilos the cages containing the designated life stages of maize weevil were kept in the rearing room alongside with their controls to observe progeny emergence. The samples were kept at 27°C and 70% r.h. and examined periodically. Mortality in the immature stages of maize weevils was based on the relative number of adults emerging from treated and untreated samples. The adults of maize weevil and larvae of khapra beetles were also studied under the binocular microscope for a period of time sufficient to confirm the killing effect of nitrogen, since it is known that mortality may be delayed in some fumigants and some fumigants only cause temporary paralysis (F.A.O., 1969).

PRE-PURGING AND POST-PURGING ASSESSMENT OF INFESTATION

The number of live insects at the beginning and the end of the 10 week storage trial of maize at 12.7% moisture was assessed in minisilos under nitrogen and controls in air. This was done by sieving one kilogramme of the shelled maize with 10 mesh per inch sieves. The 1 kg samples were taken at random. The sieved insects were each identified and counted.

Three hundred kernels were selected randomly and incubated at the start and end of the storage period in the rearing room of 27°C and 70% r.h. for 6 weeks. Emerged adults were sieved periodically from the samples and the number was recorded. Counting was terminated at 6 weeks so as not to include the second generation of insects.

RESULTS AND DISCUSSION

Data in Table 1 show a variation in the exposure time required to kill all the live stages of maize weevil and larvae of khapra beetles in nitrogen. The egg and the adult stages of maize weevil were more susceptible in nitrogen atmosphere than the larval and pupal stages. All the larvae of khapra beetle tested were killed after 5 days of exposure to nitrogen. Exposing the adults of maize weevil and larvae of khapra beetle to nitrogen for periods below that required to kill them, only caused temporary paralysis and some of the insects recovered after they were restored to fresh air. Adult emergence was delayed (compared with control in air) in samples containing immature stages of maize weevils when exposed to nitrogen for periods below the required time to kill them.

TABLE 1
Time in days required to kill all adults and developing stages of maize weevil and larvae of khapra beetles in minisilos under 99.9% nitrogen.

Species	Designated stages	Temperature (°C)	Exposure time (days)	Commodity
Sitophilus zeamais	adults	26.5	3.0	sorghum
	eggs	26.5	4.0	"
	larvae	27.0	7.5	"
	pupae	26.0	8.0	"
Trogoderma granarium	larvae	26.5	5.0	beans

TABLE 2

Assessment of insect infestation of maize stored in minisilos at start and end of a ten weeks preservation trial (1 kg samples).

Time (weeks)	Gas	Station	Number of adults					
			Sitophilus zeamais	Cryptolestes sp	Carpophilus sp	Tribolium castaneum	Lasioderma serricorne	Total
0	Nitrogen	Top	10	0	5	9	1	25
		Middle	6	0	3	6	3	18
		Bottom	8	1	6	8	6	29
	Air	Mean sample	9	0	8	4	2	26
	Nitrogen	Top	0	0	0	0	0	0
		Middle	0	0	0	0	0	0
		Bottom	0	0	0	0	0	0
	Air	Mean sample	307	7	21	12	15	362

In Table 2, data indicate that a full kill of all stored product insects was achieved in nitrogen while a very high insect infestation persisted in the controls. From the initial samples of the shelled maize (not yet purged with nitrogen), 1 kg-samples from the top, middle and bottom of the minisilos showed that the maize was very heavily infested by stored product insects which were all eliminated at the end of the storage period in nitrogen.

Table 3 data indicates that 132 maize weevil adults emerged from pre-treatment samples and no emergence at all from samples stored in nitrogen, after incubating samples for six week period in the rearing room, was observed.

TABLE 3
Number of adult insects emerged from incubated samples of maize stored in nitrogen and in air (200 kernels incubated from each treatment).

Treatment	No. of emerged insects	Infestation level, by adult insect counts
Samples of maize before storage in nitrogen	132	heavily infested
Samples of maize after storage in nitrogen	0	not infested at all

Quality deterioration in stored maize is known to be due, in large measure, to insect damage. Storing maize in nitrogen, therefore, has a great potential of residue free control of stored product insects and simultaneous maintenance of quality of stored maize in airtight storage facilities.

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