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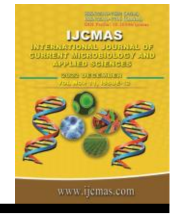

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Effect of Different Storage Materials on the Infestation of Rice Weevil, *Sitophilus oryzae* L. (Coleoptera: Curculionidae) on Stored Rice Grains

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A B S T R A C T

Laboratory experiments were carried out for two years to study the effect of different storage materials on the infestation of *Sitophilus oryzae* on stored rice grains using different storage containers namely gunny-bags, polythene-bags, cloth-bags, polythene coated cloth-bags and earthen pots. Considering the storage material from the present studies, cloth bags registered the highest damaged grain percent with 39.47% at 90 DAS while the lowest was recorded from the polythene bags with 28.31%. At the same time greatest grain weight loss was also recorded from the cloth bags (32.00%) and the lowest from the polythene bags (21.16%). It is also noticed from the results that among the storage materials used, highest population was registered from the cloth bags (435.89 adults) while the lowest population was noted from the polythene bags (303.00 adults) (pooled mean data) at 90 DAS.

Introduction

The rice weevil, *S. oryzae* L. (Coleoptera: Curculionidae), is one of the most important pests of many common cereals and has a worldwide distribution (Gomes *et al.*, 1983). It is also a primary Coleopteran pest of stored rice and wheat (Longstaff, 1981). It was first described by Linnaeus in 1763. The species name of *oryzae* was given because it was found in rice. It occurs throughout the tropics and is also found in warm temperate regions. It is originated from the Oriental Region with traded grains and is now distributed worldwide (Kuschel, 1961). The adult rice weevil is attracted by lights. It is a small snout beetle which varies in size, about 3-4 mm long. Its morphology varies from a dull reddish-brown to black with round or irregular pits on the thorax. The larvae of *S. oryzae* are legless, white to creamy with a small tan head. It is also found to attack other crop grains, such as cereals, nut, split peas (Kern and Koehler, 1994). Grain damages are caused by larvae and adults. Without any control, the grains can be destroyed up to 100% of the stored commodity (Ofuya and

Credland, 1995). The rice weevil cause losses either directly through consumption of the grain or indirectly by producing ‘hot spots’ causing loss of moisture particularly in monsoon and thereby making grain more suitable for their consumption. In tropical countries, outbreak of this pest make the stored rice unfit for human consumption within eight months of storage (Prakash *et al.*, 1987) and also it leads to the reduction of dry mass, the contamination of food with live or dead insects, and the commercial reduction of product values. According to the reports of Bhuiyan *et al.*, (1992) the rice weevils caused 11-16% weight loss of husked rice during 4 months of storage in the laboratory causing both vertical and horizontal infestation. The control and elimination of *S. oryzae* in storage is very difficult as they are internal feeders (Kucerova *et al.*, 2003; Rees, 2007). Cereals are the staple and nutritive food but their storage is not safe due to the attack of certain stored grain insect pests. So, there is an urge to protect them safely from qualitative and quantitative losses (Hagstrum *et al.*, 1999). Even though ultramodern storage facilities are available, farmers in rural India due to their ignorance and lack of extension facilities in the hinterland, still depends upon traditional techniques of storage of food grains, thereby making their grains prone to the infestations of pests during storage (Aslam *et al.*, 2004). Traditionally, rural farmers protect their crops and commodities by proper drying of grains, cleaning containers, and bins so that they are not infested or contaminated with any insect pests. Store aeration and mechanical removal of insects are practiced as well (Mbata, 1992) but these methods are insufficient to guarantee that the commodities are fully prevented from insect infestation.

Materials and Methods

The experiment was laid out in Completely Randomized Design (CRD) at ambient laboratory conditions with three replications with different storage containers *viz.*, gunny-bags, polythene-bags, cloth-bags, polythene coated cloth-bags and earthen pots. Three number of rice germplasms was used namely Jhagarikartik, Mohanbhog and Seshphal. For the observation of effect of different storage materials on grain weight loss due to *Sitophilus oryzae*, a sample of 50g of milled rice grains of each germplasm (*viz.*, Jhagarikartik, Mohanbhog and Seshphal) were weighed and were filled in different storage containers namely gunny-bags, polythene-bags, cloth-bags, polythene coated cloth-bags and earthen pots which were all about 250 g capacity. Afterward ten pairs of newly hatched weevil adults (male and female ratio of 1:1) from the stock culture were released in each container for all the three germplasms. The earthen pots were tightly covered with muslin cloth and rubber band while the others were tied with rubber band only. Three replications were maintained for each treatment and upto 90 days these were kept for observations which were taken before the exposure of the weevil adults as well as 7, 14, 21, 28, 35, 42, 49, 56, 63, 70, 77, 84 and 90 days after exposure or storage. Weight loss of grains was computed by following the formula as suggested by Harris and Linblad (1978)

$$\text{Per cent weight loss} = \frac{\text{Initial weight} - \text{final weight}}{\text{Total weight taken of grains}} \times 100$$

Again for observing the effect of different storage materials on the percentage of damaged grains due to *Sitophilus oryzae* 1300 numbers of sterilized healthy and whole grains of the above mentioned three germplasms were taken and were kept in different storage materials namely gunny-bags, polythene-bags, cloth-bags, polythene coated cloth-bags and earthen pots in which ten pairs of newly emerged weevils were released.

After exposure the infested/damaged grains were counted periodically at weekly intervals at 7, 14, 21, 28, 35, 42, 49, 56, 63, 70, 77, 84 and 90 days respectively. Grains with hole were considered as damaged or infested grains. To determine the percentage of damaged grains, number of grains having holes and normal grains were counted per storage container or replicate. The experiment was replicated three times.

The percentage of damaged grain in each germplasm was calculated by adopting the formula:

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

Lastly, the population build up was recorded by counting separately the total number of adult weevils emerged from each germplasm with different storage materials at 90 days after storage. Population build up values were transformed to square root transformations. Later the data were subjected to statistical analysis.

Results and Discussion

The data furnished in table no. 1 revealed that the infestation of the *S. oryzae* was greatly influenced by the material of the storage containers and there were significant differences among the germplasms as well as the different storage material/ structures.

The percentage of the rice grains infested due to the weevils was recorded to be the highest from the cloth bags at 90 DAS (44.41%) which was followed by gunny bags (40.11%), polythene coated cloth bags (36.38%), earthen pots (31.09%) and the lowest % infested rice grains was recorded from the polythene bags (27.73%) (pooled mean value).

Same trends and results were also observed at 30 and 60 DAS. From the same furnished table it is also evident that the germplasm Mohanbhog registered the highest infested grain % (40.36%) at 90 DAS while it was followed by Seshphal (36.99%) and the germplasm Jhagarikartik showed the lowest % infested rice grains (30.48%) at 90 DAS. When the combine effect of germplasm and storage material was considered the Mohanbhog rice grains stored in cloth bags caused the highest % infested grains while Jhagarikartik rice grains stored in polythene bags registered the lowest % infested grains.Further from the studies it was also observed that, the percent weight loss of the rice grains due to *S. oryzae* was greatly influenced by the material of the storage containers. It is evident from the results that there were significant differences in grain weight loss among the germplasms as well as the different storage material/ structures. Greatest grain weight loss due to the weevils was registered from the cloth bags followed by gunny bags, polythene coated cloth bags, earthen pots and the lowest percent weight loss was recorded from the polythene bags.

These were observed in the years at 30, 60 and 90 DAS and their pooled mean. The corresponding values of % grain weight loss in respect of cloth bags, gunny bags, polythene coated cloth bags, earthen pots and polythene bags at 90 DAS were 32.00%, 27.59%, 26.27%, 23.98% and 21.16% respectively (pool mean values). From the results it was also observed that Mohanbhog recorded the highest percent of weight loss (28.79%) at 90 DAS while Seshphal followed thereafter (25.80%) and Jhagarikartik had the lowest percent of weight loss (24.00%) at 90 DAS (pooled mean). Overall, the Mohanbhog rice grains stored in cloth bags suffered the greatest with the highest percent of grains weight loss while Jhagarikartik rice grains stored in polythene bags registered the lowest percent of grains weight loss as per table no. 2.

Last but not the least, results presented in table no. 3 exhibit that adult population of *S. oryzae* was significantly influenced due to the germplasm as well as storage materials. This was observed at 30, 60 and 90 DAS in both the years of study and pooled mean data as well. The highest number of adults was produced (402.37) in Mohanbhog followed by Seshphal (382.37) and the lowest population was obtained from the germplasm Jhagarikartik (335.77) (pooled mean data).

It is also noticed from the results that among the storage materials used, highest population was registered from the cloth bags (435.89 adults) which was followed by gunny bags (408.44), polythene coated cloth bags (381.28), earthen pots (338.89) while the lowest population was noted from the polythene bags (303.00 adults) (pooled mean data) at 90 DAS.

When the germplasms and the storage materials were taken together, it was observed that the *S. oryzae* reared in Mohanbhog in cloth bags suffered the most with the highest weevil population while the grains of Jhagarikartik stored in polythene bags had the lowest weevil population.

Results of the effect of different storage material *viz.*, polythene coated cloth bags, gunny bags, polythene bags, cloth bags and earthen pots on the infestation of rice grains due to *S. oryzae* revealed that the cloth bags experienced the highest infestation and adult population followed by gunny bags at 30, 60 and 90 DAS. These were followed by polythene coated cloth bags and earthen pots while the least effect was observed in polythene bags.

Postharvest products are high value commodities and are subject to attack by a number of stored pests. These commodities are stored in various ways in large scale and in domestic purposes. Various storage containers/ materials have been tested for their suitability to protect the stored grains from the insect penetration and damage. The ultimate object of storage is that there should not be any damage of the commodity and no trace of any insect part or whole body.

Table.1 Effect of storage material on the percent of rice grains infested due to *Sitophilus oryzae*

		30 days			60 days			90 days		
		1st yr	**2nd yr**	**Pooled**	**1st yr**	**2nd yr**	**Pooled**	**1st yr**	**2nd yr**	**Pooled**
Genotype	**A**	8.91 (3.03)c	9.71 (3.12)c	9.31 (3.07)c	19.93 (4.49)b	20.74 (4.55)c	20.33 (4.52)c	30.33 (33.32)c	30.63 (33.40)c	30.48 (33.36)c
	B	11.52 (3.46)a	10.18 (3.25)b	10.85 (3.35)b	25.23 (5.06)a	23.34 (4.86)b	24.28 (4.96)b	37.88 (37.94)b	36.10 (36.88)b	36.99 (37.41)b
	C	11.09 (3.40)b	11.93 (3.52)a	11.51 (3.46)a	24.93 (5.04)a	25.56 (5.10)a	25.24 (5.07)a	40.80 (39.65)a	39.92 (39.14)a	40.36 (39.40)a
	SEm(±)	0.0203	0.0242	0.0158	0.0259	0.0301	0.0198	0.2203	0.2564	0.1692
	CD	0.058	0.070	0.045	0.075	0.087	0.056	0.636	0.740	0.479
	CV(%)	2.38	2.85	2.62	2.07	2.41	2.24	2.31	2.72	2.52
Storage	**PCB**	10.25 (3.26)bc	12.48 (3.60)a	11.36 (3.43)b	23.20 (4.86)b	25.00 (5.04)b	24.1 (4.95)b	37.11 (37.49)c	35.64 (36.64)c	36.38 (37.06)c
	GB	10.61 (3.33)b	10.52 (3.31)b	10.56 (3.32)c	23.99 (4.95)b	24.03 (4.95)b	24.1 (4.95)b	40.08 (39.26)b	40.14 (39.30)b	40.11 (39.28)b
	PB	8.75 (3.01)d	7.48 (2.78)d	8.12 (2.89)e	19.17 (4.41)d	17.48 (4.20)d	18.33 (4.31)d	28.18 (32.00)e	27.28 (31.34)e	27.73 (31.67)e
	CB	12.65 (3.62)a	13.06 (3.68)a	12.85 (3.65)a	28.68 (5.40)a	29.24 (5.45)a	28.96 (5.43)a	44.08 (41.59)a	44.73 (41.97)a	44.41 (41.78)a
	EP	10.27 (3.25c	9.50 (3.13)c	9.88 (3.19)d	21.77 (4.69)c	20.29 (4.54)c	21.03 (4.61)c	32.22 (34.51)d	29.95 (33.11)d	31.09 (33.81)d
	SEm (±)	0.0261	0.0313	0.0204	0.0335	0.0388	0.0256	0.2844	0.3310	0.2184
	CD	0.076	0.090	0.058	0.097	0.112	0.072	0.821	0.956	0.618
Geno × Storage	**SEm(±)**	0.0453	0.0542	0.0353	0.0580	0.0672	0.0443	0.4926	0.5733	0.3783
	CD	0.131	0.156	0.100	0.167	0.194	0.125	1.423	1.656	1.070

*Figures in the parenthesis are square root and angular transformed values. PCB- Polythene coated cloth bags, PB- Polythene bags, EP- Earthen pots, CB- Cloth bags, GB- Gunny bags, A-Jhagarikarti, B-Seshphal and C-Mohanbhog

Table.2 Effect of storage material on the percent of weight loss of rice grains due to *Sitophilus oryzae*

		30 days			60 days			90 days		
		1st yr	2nd yr	Pooled	1st yr	2nd yr	Pooled	1st yr	2nd yr	Pooled
Genotypes	A	13.87c	15.03c	14.45c	18.37c	20.29c	19.33c	23.18c	24.83c	24.00c
	B	13.58b	13.89b	13.73b	20.18b	19.10b	19.64b	26.03b	25.56b	25.8b0
	C	15.33a	15.42a	15.38a	23.72a	23.42a	23.57a	28.99a	28.59a	28.79a
	SEm(±)	0.107	0.128	0.118	0.101	0.112	0.107	0.134	0.104	0.120
	CD	0.310	0.369	0.341	0.292	0.324	0.309	0.387	0.300	0.346
	CV(%)	2.91	3.35	3.14	1.89	2.07	1.98	1.99	1.53	1.77
Storage	PCB	14.50c	15.49b	15.00b	21.68c	21.68b	21.68c	25.97c	26.57c	26.27c
	GB	14.91b	15.14b	15.03b	22.37b	21.91b	22.14b	27.69b	27.48b	27.59b
	PB	11.91e	12.72d	12.31d	16.85e	17.93d	17.39e	20.62e	21.69e	21.16e
	CB	16.89a	17.14a	17.01a	24.46a	24.25a	24.36a	32.28a	31.71a	32.00a
	EP	13.10d	13.41c	13.26c	18.43d	18.93c	18.68d	23.78d	24.19d	23.98d
	SEm(±)	0.138	0.165	0.152	0.131	0.145	0.138	0.173	0.134	0.155
	CD	0.400	0.476	0.440	0.377	0.418	0.398	0.499	0.387	0.447
Geno × Storage	SEm(±)	0.240	0.286	0.264	0.226	0.251	0.239	0.300	0.232	0.268
	CD	0.692	0.825	0.762	0.653	0.724	0.690	0.865	0.670	0.774

PCB- Polythene coated cloth bags, PB- Polythene bags, EP- Earthen pots, CB- Cloth bags, GB- Gunny bags, A-Jhagarikarti, B-Seshphal and C-Mohanbhog

Table.3 Effect of storage material on the population of *Sitophilus oryzae* after 90 days of storage

		90 days after storage		
		1st yr	2nd yr	pooled
Genotype	Jhagarikartik	333.40 (18.24)c	338.13 (18.35)c	335.77 (18.30)c
	Seshphal	386.33 (19.63)b	378.40 (19.43)b	382.37 (19.53)b
	Mohanbhog	403.47 (20.06)a	401.27 (20.00)a	402.37 (20.03)a
	SEm(±)	0.0209	0.0331	0.0196
	CD	0.060	0.096	0.055
	CV(%)	0.42	0.67	0.56
Storage	PCB	384.11 (19.60)c	378.44 (19.46)c	381.28 (19.53)c
	GB	409.22 (20.23)b	407.67 (20.19)b	408.44 (20.21)b
	PB	302.56 (17.39)e	303.44 (17.41)e	303 (17.40)e
	CB	434.56 (20.83)a	437.22 (20.90)a	435.89 (20.87)a
	EP	341.56 (18.48)d	336.22 (18.34)d	338.89 (18.41)d
	SEm(±)	0.0269	0.0428	0.0253
	CD	0.078	0.124	0.071
Geno × storage	SEm(±)	0.0466	0.0741	0.0438
	CD	0.135	0.214	0.124

*Figures in the parenthesis are square root transformed values. PCB- Polythene coated cloth bags, PB- Polythene bags, EP- Earthen pots, CB- Cloth bags, GB- Gunny bags, A-Jhagarikarti, B-Seshphal and C-Mohanbhog

There are several works on the use of various storage containers and/or materials. In an experiment in Bangladesh, among four containers namely tin kouta, earthen pot, plastic container and gunny bags, Ali *et al.,* (2009) observed least infestation in wheat from rice weevil when plastic container was used, whereas gunny bags had the greatest damage.

They reported lower efficacy of gunny bags for protecting the stored wheat from rice weevil as highest number of adults were noted. In the present study highest percent of weight loss, grain damage and number of adults in cloth bags followed by gunny bags indicate that they are not suitable for storage against the attack of rice weevil. Earlier studies of Baloch *et al.,* (1994) indicated that jute bag increased the risk of insect infestation. High level of infestation was also observed in stored wheat when preserved in gunny bags (Singh, 2001). Gunny bags caused better aeration for the stored insects due to its high porosity, which increased moisture content of the grains and thereby higher infestation (Ali *et al.,* 2009; Prakash, 1982). Thus the present findings of higher infestation and adult population in cloth bags and gunny bags are well explained and supported from the above. Besides, least infestation in polythene bag and polythene coated cloth bags lends support from Ali *et al.,* (2009) and Kabir *et al.,* (2003). In polythene bag and polythene coated cloth bag, aeration might have been prevented which in turn maintained the moisture percent of grains to a static level and arrested the development and growth of rice weevils as Ali *et al.,* (2009) and Kabir *et al.,* (2003) reported that tin kouta and plastic container and gunny bag with polythene reduced the insect infestation.

Greater infestation of grains and adult population of rice weevils in cloth bags and gunny bags may be well explained from the findings Manueke *et al.,* (2015) who reported that the highest infestation of *S. oryzae* was registered from the gunny sacks while the lowest from the plastic bags. They narrated that there was lack of or lesser air circulation in gunny bags in comparison to other storage structures and the gunny bags absorb heat when the air around the bags become hotter and will make the grains hot, and when the air become cooler, the water vapour will be formed inside the gunny bags which will be absorbed by the grains inside the gunny bags leading to increased water content of the grains. Besides, the gunny bags absorb water from the adjoining air and the grains inside will be moist/ damped due to higher moisture content and will provide ideal conditions for the development of *S. oryzae.* Similar reason might be applicable for the cloth bags since the cloths also have the potential to absorb the heat or the air around them.

The least preference of the rice weevils for the polythene bags in the present studies may be justified by the result of Manueke *et al.,* (2015) who explains that aeration in plastic bag is prevented leading to moisture content of grains unchanged and reduction in the population of the adults (Ali *et al.,* 2009) than other storage materials as the plastic material is thinner than the others.

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