Research Article

RICE WEEVIL (*Sitophilus oryzae* L.) HOST PREFERENCE OF SELECTED STORED GRAINS IN CHITWAN NEPAL

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ABSTRACT

A host preference experiment was carried out at the Entomology Laboratory, Institute of Agriculture and Animal Science, Rampur, Chitwan in 2008 to estimate the comparative storage losses in different host crops due to rice weevil, *Sitophilus oryzae* L. under both free, and no-choice conditions. A completely randomized design (CRD) was used with five treatments (T1 = polished rice, T2 = unpolished (rough) rice, T3 = wheat, T4 = maize, and T5 = barley), each replicated four times. The assessed parameters were percent grain damage, percent weight loss, and number of F1 progeny produced in both no-choice and free-choice conditions. Polished rice was the most preferred host in free-choice testing, with 18.75% grain damage, 14.11% grain weight loss, and 138.8 adult F1 progeny. Wheat was the most preferred host under no-choice conditions, and was followed by polished rice in the same regard. Percent weight loss (17.72%) and F1 progeny (122.5 adult weevils) were highest in wheat. Rough rice was the least preferred host under both conditions. *S. oryzae* thus preferred polished rice under free-choice and wheat under no-choice. This information could be critical in formulating management tactics.

Keywords: *Sitophilus oryzae* L., free choice, no choice, CRD, F1 progeny.

INTRODUCTION

Storage grain losses of major cereal crops can be attributed primarily to attack by rice insect pests, diseases, and rodents (Rana and K.C., 1977). It is generally believed that half of the storage losses are usually caused by insects (FAO, 1968). In Nepal, *Sitotroga cerealella* L., *Sitophilus* spp., and *Rhyzopertha dominica* L. are among the major pests of stored rice grains (Neupane, 2002). Storage grain loss is 7-10% in Nepal (RSGP, 1992). Of these pests, *Sitophilus oryzae* L. is the most cosmopolitan in nature, and causes severe losses in rice, maize, barley, wheat, and other crops (Bhatia *et. al.*, 1975; Singh, *et. al*, 1980; Neupane, 1995). While the hot, humid climate of Southeast Asia is quite suitable for rice cultivation, it is equally suitable for rapid stored-product insect development which can result in explosive outbreaks, potentially causing devastating post-harvest rice grain damage.

Most farmers in rural Nepal lack the technology or skills needed to implement adequate long-term seed or food grain storage systems. In fact, most grain storage systems used in rural Nepal for long- or short-term use are rudimentary and poor at best. Storage management is a neglected aspect of farming in Nepal. The majority of farmers and organizations tend to concentrate their efforts on the production aspect. While focusing on production, farmers tend to ignore the need for post-harvest loss minimization. Additionally, little applicable extension work has been organized to encourage adoption of improved practices, including modern technologies such as advanced storage systems, use of effective eco-friendly pesticides, or even resistant varieties. Increasing global agricultural demand continues to necessitate the research and development of more efficient and ecologically sound agricultural production, storage, and pest management practices, and with respect to grain crops, characterization of *S. oryzae* severity in various host crops for use in management strategy formulation. Thus, the objectives of this study are to estimate relative losses in different host crops and to determine the relative rice weevil host preference in said crops under both free- and no-choice storage conditions.

MATERIALS AND METHODS

An evaluation of rice weevil host preference (*S. oryzae*) was conducted at the Entomology Laboratory, Department of Entomology, Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan during the period from 4^{th} March to 4^{th} June 2008.

Rice weevil (*Sitophilus oryzae* L.) mass rearing

Rice weevils, *S. oryzae*, were reared at the Entomology Laboratory, Department of Entomology, IAAS, Rampur, Chitwan. The live specimen culture was obtained from rice storage and accurately identified based upon distinct characteristics. The rice weevil (*S. oryzae*) possesses two red ochre -colored spots on each elytron, while the maize weevil (*S. zeamais*) bears two red ochre-colored, short, longitudinal stripes on each elytron. In general, maize weevils appear larger than the rice weevil. Mass rearing was carried out in 25cm×15cm×5cm cloth bags using the rice variety, 'Sava Mansuli'.

Treatment details

S. oryzae relative host preference was studied under both no-choice and free-choice storage conditions at the laboratory in a completely randomized design (CRD) experiment with five treatments (T1 = polished rice, T2 = unpolished (rough) rice, T3 = wheat, T4 = maize and T5 = barley) and four replications. Collected test grain moisture contents, assessed via Wile Digital Moisture Meter (URL: info(at)farmcomp.fi), were standardized to 13% by sun-drying collected test grains. Tiny punctures were made in the lids of small plastic containers into which exactly 100 grains from each material sample were placed. Each container was infested with 15 male-female pairs of two-week-old adult rice weevils. Weevil sex was determined by rostra length and rostra pit discrimination, as is described in Reddy (1951), and by abdominal tip shape, as is described in Qureshi (1963).

After one week, released adults were separated from test materials via a #10 sieve and discarded, after which samples were replaced in their respective containers. Each container was carefully observed on a daily basis, beginning on the 30th day following removal. Emerging F1 progeny in each container were separated from the sample grain daily via #10 sieve, counted, and then discarded. This process continued daily until F1 progeny emergence reached zero in all containers.

Observation and calculation

Relative rice weevil host preference assessment parameters included: percent grain damage, percent weight loss, and number of F1 progeny produced in both no-choice and free-choice conditions. Average F1 developmental period was calculated for each container. Upon experiment conclusion, percent weight loss was calculated using grain weight measurements from treatment inception to conclusion (encompassed a 60-day period). Damaged grains from the 100-grain samples in each container were separated manually from undamaged grains using a magnifying glass. Damaged and undamaged grains were independently weighed. Weighing was performed at 15, 30, 45, and 60 days from treatment inception for free choice while it was taken at 15, 30 and 60 days from treatment inception for no choice. Percent grain damage was computed using the following formula:

Grain damage (%) = (number of damaged grains / total number of grains) × 100

Daily temperature and humidity minimums and maximums were recorded throughout the experiment via BEURER, HM11 Art-Nr.:678.01 CE digital instruments.

Data analysis

Primary data from observations of all three experiments were recorded and calculated using Microsoft Office Excel®. Percentage data were processed by arcsine and square root transformation. Final graphs and tables were also prepared using Microsoft Office Excel®. These processed values were subjected to an Analysis of Variance (ANOVA) test at 1% and 5% significance levels using MSTAT-C software. The mean separation for treatments was done using Duncan's Multiple Range Test (DMRT) with MSTAT-C.

RESULTS

1. Free-choice test

Weight loss

Of the five treatments, *S. oryzae* caused the greatest weight loss to polished rice (14.11%), followed by wheat (11.86%), barley (8.80%), and maize (5.43%). All treatments differed significantly in the final weights (Table 1).

Table 1. The weight loss and F1 progeny in different host crops due to *S. oryzae* infestation under free choice condition at IAAS, Rampur, Nepal, 2008

Treatment	Grain weight (gm) (Mean±SE)*	Weight loss (%) (Mean±SE)*	F1 progeny (No.) (Mean±SE)*
Polished Rice	85.89e	14.11a ± 0.12	138.8a
Rough Rice	97.06a	2.95e ± 0.17	16.25c
Wheat	88.14d	11.86b ± 0.44	130.3a
Maize	94.57b	5.43d ± 0.50	30.00b
Barley	91.21c	8.80c ± 0.39	27.25b

*Values with the same letters in a column are not significantly different (P=0.05) by DMRT (MSTAT-C, 2002)

F1 progeny

The number of F1 progeny produced was numerically greatest in polished rice (138.8 adults), followed by wheat (130.3 adults); however, the differences were not statistically significant (Table 1). Maize (30.0 adults) and barley (27.25 adults) were relatively similar and did not differ statistically. The lowest number of *S. oryzae* F1 progeny was recorded in rough rice (16.25 adults), a number significantly lower than progeny values recorded for other treatments.

Grain damage

In the free choice test, the percent grain damage in polished rice was found to be numerically the highest on all four observation dates, yet wheat grain damage did not differ statistically from polished rice on the 15, 30 and 45 day inspections (Table 2). For instance, on the 15 day inspection, polished rice exhibited the highest level of grain damage at 9.50%, a value shared by wheat, and followed by barley (3.0%), rough rice (2.75%), and maize (2.75%). The three lower damage percentages did not differ significantly from each other. With the exception of rough rice, the grain damage had increased when observed at 30 days. This was evident in polished rice, wheat, maize, and barley. At 30 days, the maximum grain damage was observed in polished rice (11.50%), and was numerically followed by wheat (10.00%). At 45 days in this free-choice test, polished rice began to emerge (potentially) as the most susceptible host with a grain loss of 13.50%, though this value was, statistically speaking, not significantly dissimilar to that of wheat (12.0%). Barley (6.25%) and maize (5.50%) failed to demonstrate a significant relationship in terms of grain damage, while the lowest level of grain damage occurred in rough rice (3.25%) (Table 2).

The highest grain loss level (18.75%) was evident in polished rice at 60 days. This level was much higher than those recorded from other hosts, all of which differed statistically from polished rice and also each other. Rough rice incurred 4.50% damage while wheat, barley, and maize incurred 16.25%, 8.50%, and 6.25% grain loss, respectively (Table 2).

Table 2. The grain damage of different host crops due to *S. oryzae* under free choice condition at IAAS, Rampur, Nepal, 2008

Treatment	Grain damage (%)(Mean±SE)*			
	15day	30day	45day	60day
Polished Rice	9.50a ± 0.29	11.50a ± 0.29	13.50a ± 0.87	18.75a ± 0.75
Rough Rice	2.75b ± 0.48	2.75b ± 0.25	3.25c ± 0.48	4.50e ± 0.29
Wheat	9.50a ± 0.96	10.00a ± 1.47	12.00a ± 1.08	16.25b ± 0.63
Maize	2.75b ± 0.25	4.25b ± 0.48	5.50b ± 0.29	6.25d ± 0.48
Barley	3.00b ± 0.41	4.00b ± 0.41	6.25b ± 0.25	8.50c ± 0.29
CV (%)	19.64	22.65	16.72	9.59
LSD (P=0.05)	1.627	2.219	2.041	1.568
SEm ±	0.539	0.736	0.676	0.520

*Values with the same letters in a column are not significantly different (P=0.05) by DMRT (MSTAT-C, 2002)

2. No-choice test

Weight loss

Based on the percentage of weight loss, wheat (17.72%) appeared to be the most preferred host for *S. oryzae* followed by polished rice (11.57%), a significant difference as seen in Table (3). The lowest weight loss was seen in rough rice (3.40%). Maize (7.18%) and barley (9.18%) also differed significantly from one another in the weight loss assessment resulting in the values for all treatments differing significantly in terms of grain weight loss.

Table 3. The weight loss and F1 progeny in different host crops due to *S. oryzae* infestation under no choice condition at IAAS, Rampur, Nepal, 2008

Treatment	Grain weight (gm) (Mean±SE)*	Wt loss (%) (Mean±SE)*	F1 progeny (No.) (Mean±SE)*
Polished Rice	88.43d	11.57b± 0.51	122.5a
Rough Rice	96.60a	3.40e ± 0.49	21.25c
Wheat	82.28e	17.72a ± 0.68	116.0a
Maize	92.82b	7.18d ± 0.69	33.00b
Barley	90.82c	9.18c ± 0.48	28.75bc

*Values with the same letters in a column are not significantly different (P=0.05) by DMRT (MSTAT-C, 2002)

F1 progeny

Table 3 shows that the number of F1 progeny produced in polished rice and wheat were statistically similar. The numbers of F1 progeny produced were 122.5 and 116.0 adults in polished rice and wheat, respectively. Similarly, barley (28.75 adults) produced a similar number of F1 progeny to that of maize (33.0 adults) and of rough rice (21.25 adults), but the values for rough rice and maize were significantly dissimilar to one another.

Grain damage

In the no-choice test, the greatest percentages of damaged grains were observed in polished rice, and are enumerated as follows: 7.5%, 9.75%, and 14.0% at 15, 30, and 60 days following treatment inception, respectively (Table 4). At 15 days, the damage found in wheat (5.25%) was significantly lower than that observed in polished rice. Grain damage values were statistically indistinguishable across rough rice (2.25%), maize (2.75%), and barley (3.0%) treatments at 15 days.

On day 30, the highest percent grain damage was found in polished rice (9.75%), and was followed by wheat (8.50%), barley (4.75%), maize (4.0%), and rough rice (2.50%). Damage caused by *S. oryzae* was approximately equal in maize and rough rice, but was statistically lower than that seen in wheat or polished rice (Table 4). At 60 days, the damage levels in polished rice (14.0%) and wheat (12.50%) were statistically similar (Table 4).

Table 4. The grain damage of different host crops due to *S. oryzae* under no choice condition at IAAS, Rampur, Nepal, 2008

Treatment	Grain damage (%) (Mean±SE)*		
	15day	30day	60day
Polished Rice	7.50a ± 0.29	9.75a ± 0.48	14.00a ± 0.75
Rough Rice	2.25c ± 0.48	2.50d ± 0.29	2.50c ± 0.25
Wheat	5.25b ± 0.85	8.50b ± 0.29	12.50a ± 0.71
Maize	2.75c ± 0.25	4.00c ± 0.41	4.00bc ± 0.25
Barley	3.00c ± 0.41	4.75c ± 0.48	5.75b ± 0.25
CV (%)	24.30	13.49	9.52
LSD (P=0.05)	1.520	1.199	1.936
SEm ±	0.504	0.39	0.642

*Values with the same letters in a column are not significantly different (P=0.05) by DMRT (MSTAT-C, 2002)

3. Comparison between no-choice and free-choice conditions

Weight loss

Comparing grain weight loss between five different host crops, weight loss for polished rice was higher under free-choice (14.11%) than it was under no-choice (11.57%) (Figure1). Percent grain weight decrease in wheat was higher in the no-choice test (17.72%) than was seen in the free-choice test (11.87%). Percent weight decrease was higher in barley, maize, and rough rice under free-choice than under no-choice.

Grain damage

In Figure (2), it is seen that polished rice, grain damage at 60 days after treatment was numerically higher (21.25%) in free-choice than it was in the no-choice test (18.75%). Likewise, the damage was higher under free-choice than under no-choice in wheat. Grain damage was higher under no-choice in maize (6.25%) than was observed under free-choice (5.25%), and a similar trend was observed in barley and rough rice.

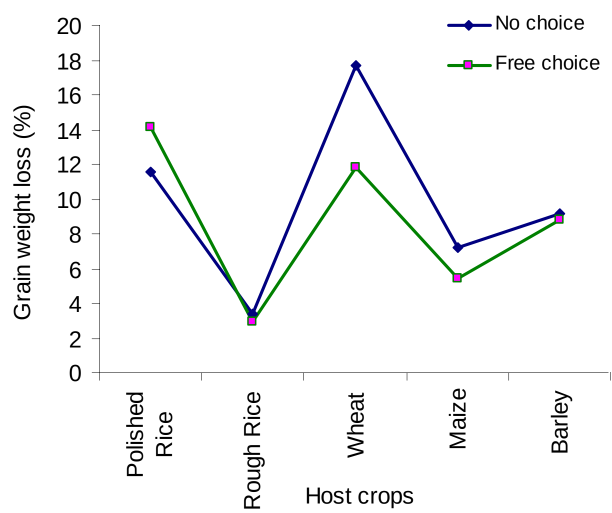

Figure 1. Grain weight loss due to *S. oryzae* in different host crops

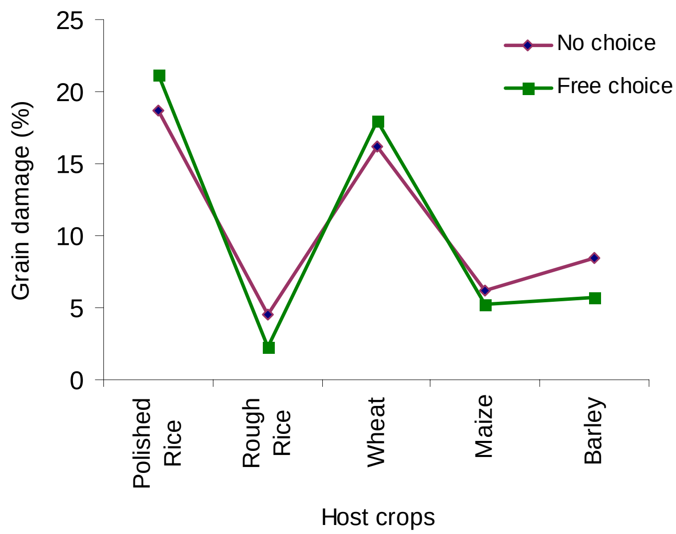

Figure 2: Grain damage due to *S. oryzae* in different host crops

DISCUSSION

S. oryzae L. is universally regarded as one of the most destructive primary pests of stored cereals such as barley, maize, rice, and wheat (Atwal and Dhaliwal, 2002). Annual grain loss in storage due to these insects approaches 15% (Joshi *et al.*, 1991). It is estimated that 20% of the total maize harvest is lost annually due to insect pest attack (Upadhyay *et al*., 2001). In one study, the maximum grain loss in wheat attributable to a single weevil was measured at 19%, and it was nearly 57% in rice (Banerjee and Nazimuddin, 1985).

Five host crops (polished rice, rough rice, wheat, maize, and barley) were tested to determine the host preference of *S. oryzae* under free- and no-choice conditions. Grain weight decrease, number of F1 progeny, and percent grain damage differed significantly among the various selected host grains. Grain weight loss was found to be the greatest in polished rice (14.11%) in the free-choice scenario, and it was the least in rough rice (2.95%). The greatest percentage of weight loss was observed in wheat in the no-choice test.

A similar finding was reported by Banerjee and Nazimuddin (1985), where the maximum single-kernel weight decrease attributable to an individual larva was 57 and 19 percent in rice and wheat, respectively. A similar result was also reported by Ansari (2003). Regarding individual insect consumption, it has been reported that *Sitophilus oryzae* and *Rizopertha domonica* can consume 0.49 mg and 1.5 mg (respectively) of grain daily and produce 11-12 mg and 54 mg (again, respectively) of waste products throughout their lives (Golebiowska, 1969 cited by Shivakoti and Manandhar, 2000).

Percent grain damage was assessed at 15, 30, 45, and 60 days following experiment inception. The greatest grain damage was observed in polished rice (18.75% for free-choice and 14.00% for no-choice) and was followed by wheat (16.25% for free-choice and 12.50% for no-choice). These values are not unexpected, considering that an exceedingly high level of damage (67.78%) was reported by Ansari (2003) in wheat, while the level was 40.97% in maize.

In this study, F1 progeny population (adults) was greatest in polished rice (138.8 in free-choice and 122.5 in no-choice). These values were followed by wheat, maize, barley, and rough rice. Teotia and Tewari (1977) studied the ovipositional behavior and development of *Sitophilus oryzae* L. on various natural foods, and observed that oviposition was higher in rice and wheat grains and lower in un-husked barley and maize. In fact, previous studies have revealed that rice (followed by wheat, jowar, barley, and maize) is the most preferred host in terms of oviposition (Ansari, 2003; Teotia and Tewari, 1977).

While polished rice did indeed appear to be the most preferred host in this study, Lucas and Riudavets (2000) reported a higher rate of increase in the number of *S. oryzae* progeny in brown rice. Lucas and Riudavets (2002) explained this occurrence as a result of the conventional polishing process (applied prior to infestation) causing reduced nutritional quality, consequently reducing the recorded number of weevil progeny and measured individual weevil weight. In contrast, Jacob (1992) observed greater *S. oryzae* adult emergence in wheat than was seen in raw rice, parboiled rice, and paddy rice. In addition, Jacob (1992) also reported shorter development and greater emergent adult weight in wheat than was observed in rice.

CONCLUSION

Findings of this study reveal that weevils prefer polished rice and wheat over other host crops when conditions favor infestation. Damage in both polished rice and wheat was measured at approximately 20 percent. Therefore, the level of damage severity is significant in these two host crops. This level can be used as an aide in determining location-specific economic threshold levels (ETL), economic injury levels (EIL), and population dynamics, all of which are important tools in implementing environmentally friendly and ecologically sustainable weevil management practices.

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