VARIETAL SCREENING OF RICE GENOTYPES FOR THE RICE WEEVIL, *Sitophilus oryzae* (Linnaeus) (Curculionidae: Coleoptera) At Laboratory Condition

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ABSTRACT

The rice weevil, Sitophilus oryzae (Linnaeus) *is a major pest of rice at storage condition in Nepal. A lab experiment was conducted for varietal screening of rice genotypes against S. oryzae at the National Rice Research Program, Hardinath, Dhanusha, Nepal in 2020. The study was carried out in Completely Randomized Design (CRD) in a three replicates. Fifty gram of each seven popular rice genotypes i.e Sambha Mansuli Sub-1, Ramdhan, Radha-11, Bahuguni-1, Bahuguni-2, Hardinath-2 and Lalka Basmati were used to screen the potential weevil resistant rice cultivars. Ten pairs of newly emerged adult S. oryzae of uniform age obtained from stock culture were released in each plastic jar in no-choice tests, while twenty five pairs of S. oryzae were released in the center, in choice tests. Results were evaluated based on the grain damage percent, weight loss percent, and total live weevil population for 90 days from the date of experiment. The result demonstrated that Lalka Basmati was the least damaged rice cultivar followed by Bahuguni-2. The highest weevil population over 90 days was recorded in Sambha Mansuli Sub-1 followed by Hardinath-2 and the least weevil population was found on Lalka Basmati followed by Bahuguni -2 in both test conditions. Lowest to highest damage ranking of rice genotypes was: Lalka Basmati<Bahuguni-2<Bahuguni-1<Radha-11<Ramdhan<Hardinath-2<Sambha Mansuli Sub-1. Thus, promotion of Lalka Basmati & Bahuguni-2 varieties is recommended to reduce the infestation of rice weevil in the storehouse condition. This information is useful for host plant resistant breeding program for the plant breeder.*

Key words: Genotypes, grain, rice weevil, storage, varietal screening

INTRODUCTION

Rice is the major cereal crop of Nepal which is cultivated in diverse agro-climatic regions of the country. This crop has the highest share (46%) and fulfills around 53% of the total edible grain requirement (MoAD, 2015) followed by maize (25-29%) and wheat (23-27%), respectively in Nepal. Rice is solely responsible for 20% AGDP & 7% GDP in Nepal (CBS, 2016/17). In 2018/19 AD, the area under rice cultivation was 14,91,744ha, with total production of 56,10,011 mt and productivity of 3.96 mt/ha (MoALD, 2018/19). In the

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Nepalese diet, the rice supplies about 39% energy, 29% protein, and 7% fat (Basnet, 2008). The grain of rough rice consists of the hull or husk (18-28%) and the caryopsis or brown rice (72-82%) and the brown rice consists of an outer layer (pericarp, tegmen, and aleurone layers) called bran (6-7%), the embryo (2-3%), and the edible portion (endosperm 89-94%) (Chen *et al*., 1998).

Most insect damage to the grain in the storage condition is caused by five primary storage insects *viz*, granary weevil (*Sitophilus granarius* L.), rice weevil (*Sitophilus oryzae* L.), maize weevil (*Sitophilus zeamais* L.), lesser grain borer (*Rhyzopertha dominica* F.) and Angoumois grain moth (*Sitotroga cerealella* Olivier) (USDA, 2015). Among these, rice weevil (*S. oryzae*) is one of the severe damaging pests of cereal grains like rice, sorghum, wheat, barley and maize, and also for their products (Baloch, 1992; Grenier *et al*., 1997; Neupane, 1995). In general, the losses (pre- and post-harvest) due to pests have been estimated to be 15-20% (Neupane, 1995). Even 1% loss of rice grain during storage accounts for 56000 mt annual loss of rice which can feed 3,36,000 persons per year in Nepal (MoALD, 2018/19). Minimization of post-harvest loss can be more economical than to increase the yield. With the increasing yield of high yielding varieties (HYV) of rice, storage loss is always neglected in Nepal.

Most of the newly released rice varieties and hybrids are highly susceptible to the attack of insect pests either in storage or field conditions (Gimma *et al*., 2008). So, farmers are not getting much benefit from the increased productivity potential of newly released varieties and hybrids. The yield-oriented research of Nepalese scientists concentrated their efforts to release high yielding fine & aromatic rice varieties. A chemical composition like carbohydrate, protein & amylose content of grains determines the choice of food as well as the behavioral process of insects (Belloa *et al*., 2000). The susceptibility of rice weevil is negatively correlated with the hardness of grain and crude fiber content which leads to reduce the damage of paddy (Singh, 2002). Similarly, limited information is available on post-harvest/storage insect pests of improved varieties of rice in Nepal. Therefore, there is a need to evaluate the varietal preference of storage insect pests for popular rice varieties.

MATERIALS AND METHODS

The research was conducted at the Entomology Laboratory in the National Rice Research Program (NRRP), Hardinath, Dhanusha, Nepal from January to June 2020. The research station is located at a latitude 26^{0}47'46.5"N and longitude 85^{0}57'49.35"E and an altitude of 93.0 meters from the sea level. The experiment was laid out in a Completely Randomized Design (CRD) with three replicates. Total seven popular rice genotypes popular in Terai region of Nepal are listed in Table 1 and genotype details are given in Table 2. The genotypes were selected as these are commercially grown by the farmers in the periphery of research area.

Newly emerged 10 pairs of male and female fresh adult weevils were used in each plastic jar for no-choice test while 25 pairs weevil were released in the center for choice test.

Table 1: Detail of treatments on the varietal screening of rice genotypes against rice weevil

Rice genotypes	No choice test		Choice test	
	Grain wt. (gm.)	No. of weevils (pairs)	Grain wt. (gm.)	No. of weevils (pairs)
Sambha Mansuli Sub-1	50	10	50	25 pairs in center
Ramdhan	50	10	50	
Radha-11	50	10	50	
Bahuguni-1	50	10	50	
Bahuguni-2	50	10	50	
Hardinath-2	50	10	50	
Lalka Basmati	50	10	50	

Table 2: Characteristics of rice genotypes used in experiments

	Sambha Mansuli Sub-1	Ramdhan	Radha-11	Bahuguni-1	Bahuguni-2	Hardinath-2	Lalka Basmati
Origin	IRRI	India	India	Nepal	Nepal	Nepal	Nepal
Released year	2011	2006	1995	2018	2018	2010	2010
Production season	Summer (Rainy)	Summer (Rainy)	Summer (Rainy)	Summer (Rainy)	Summer (Rainy)	Summer (Rainy)	Summer (Rainy)
Maturity days	145-150	130-137	145-150	135	142	125	150
Yield potential	3.5-4	4-7.2	4	5.5	5.8	3.1-4.2	2.5-3.5
Recommended domain	Terai & Inner Terai (upto 500 m of mid hill) Irrigated and Swampy Land	Terai& inner terai (Valley, Makawanpur, Chitwan & Nawalpur)	Central Terai (Parsa, Bara, Rautahat, Sarlahi, Mahottari & Dhanusha)	Terai (upto 700 masl)	Terai (upto 700 masl)	Terai & Inner terai	Mid & Eastern Terai

Awn	Absent	Absent	Absent	Absent	Absent	Absent	Present
Husk color	Light brown	Light brown	Brown	Light brown	Brown	Brown	Red
Grain shape	Short and fine grain	Long and fine grain	Long grain	Long grain	Long grain	Long & thick grain	Long grain
Remarks	TGW:19gm Protein:10.3%	TGW:21gm Protein: 6.05% Amylose:22.08%	TGW:21.8gm Protein:7.24% Amylose: 22.5%	TGW:22gm Protein: 7.3 % Amylose:22.4%	TGW:23.5gm Protein: 7.43% Amylose:24.3%	TGW: 25.8gm Protein:8.1%	TGW:18.33gm Protein:8 % Amylose:23.4%

Source: (MoALD, 2018/19; SQCC, 2017)

NO-CHOICE TEST

A total of 21 plastic jars (15.0 cm x 9.0 cm) with a screened hole on their lids were taken in no-choice test for 7 rice genotypes that was replicated thrice for each genotype. Fifty gram (50 gm) sample of sterilized rough rice was taken for each rice genotype that was kept in individual plastic jar. Then, 10 newly hatched matured pairs (10 male & 10 female) of fresh weevils from the stock culture were released in each jar with tightly covered ventilated lid. All jars were placed in the laboratory at room temperature of 31.3 ± 1.5 ^{0}C.

CHOICE TEST

In choice test, 50 gm rough rice of different rice genotypes was kept in each plastic jar (15.0 cm x 9.0 cm). The plastic jar was circularly arranged in large and circular (40 cm x 45 cm) paper cartoon and it was replicated thrice. The distance between one plastic jar to another plastic jar in a cartoon was approx.10.0 cm. In each replication, seven plastic jars having sterilized rough rice were kept in a circular manner where 25 pairs of rice weevils were released in the center of the paper cartoon. In the choice test, the lid of each jar was opened to allow free movement of weevils towards their preferred genotypes. Four circular holes were made on sides of the jar to allow free movement of weevils. The cartoon was tightly covered by plastic tape to prevent escape of rice weevil and a large hole that covered with fine net was made on the cartoon to allow free movement of air.

DATA RECORDED

- Thousand-grain weight: Thousand-grain weights of all the treatments and replications were taken before the experimental setup and during each time of data recording.
- The moisture content of grains: Moisture content of all the genotypes of rice was recorded before the experimental setup and during each time of data recording with the 55 Wile-moisture meter devices.

- The number of damaged and undamaged grains: The number of damaged and undamaged grains was examined by taking a 10 gm random sample from each treatment.
- Weight of damaged and undamaged grains: The weight of damaged and undamaged grains was taken with the help of a digital weighing balance- Electronic Compact scale (SF-400A) of CE Company.
- Percentage of damaged and undamaged grains:The percentage of damaged and undamaged grain was taken by the following formulae.

$$\text{Damage (\%)} = \frac{Nd}{Tn} \times 100$$

$$\text{Undamage (\%)} = \frac{Nu}{Tn} \times 100$$

(Enbakhare and Lawogbomo, 2020)

Where,

Nd: No. of damaged grains
Nu: No. of undamaged grains
Tn: Total number of grains

- Weight loss percentage: The weight loss percentage of grains was calculated by using the count and weight method using the following formula,

$$\text{Weight loss (\%)} = \left[\frac{UNd \quad DNu}{\{U(Nd + Nu)\}} \right] \times 100$$

(Lal, 1998)

Where,

D: Weight of damaged seeds
U: Weight of undamaged seeds
Nd: No. of damaged seeds
Nu: No. of undamaged seeds

- The weevil population: The number of both live and dead weevils in all the treatments was counted during each time of data recording.
- Room temperature and relative humidity: The temperature and relative humidity of the laboratory was recorded using digital Thermo-Hygrometer device (HTC-2).

Weevil multiplication in the plastic jars was observed at 15 days interval up to 90 days from the first count. The weevil population number and grain damage was recorded by counting the number of adults (from 50 gm grain) and damaged & undamaged grains (from 10 gm grain) respectively.

The data were tabulated in MS Excel, analyzed by using RStudio software, and mean comparisons was done by using Duncan's Multiple Range Test (DMRT) at 5% level of significance (Gomez and Gomez, 1984).

RESULT AND DISCUSSION

CHOICE TEST

Effect of weevil on mean grain damage percentage (number basis)

The mean grain damage percent (number basis) was significantly different (p<0.05) among rice varieties over 90 days of experiment. The highest grain damage percent was in Sambha Mansuli Sub-1 (1.68%) and the lowest in Lalka Basmati (0.78%). Damage in Sambha Mansuli Sub-1 was statically at par with Hardinath-2 (1.48%) while Lalka Basmati was at par with Bahuguni-2 (0.79%) (Table 3). However, the numbers of grains damage was not high.

Effect of weevil on mean grain damage percentage (weight basis)

The mean grain damage percent (weight basis) was also observed in similar trend as on the number basis. The highest grain damage percent was in Sambha Mansuli Sub-1 (1.81%) and the lowest in Lalka Basmati (0.76%). Damage in Sambha Mansuli Sub-1 was statically at par with Hardinath-2 (1.51%) while Lalka Basmati was at par with Bahuguni-2 (0.78%) and the remaining varieties shown intermediate effects (Table 3).

Effect of weevil on mean weight loss percentage

The mean weight loss percent was significantly different (p < 0.05) among rice varieties over 90 days after treatment. The highest weight loss percent was in Sambha Mansuli Sub-1 (1.07%) and the lowest in Bahuguni-2 (0.57%). Damage in Bahuguni-2 was at par with Lalka Basmati (0.59%) and Radha-11 (0.62%) (Table 3). Weight loss of grains was fluctuated with the weight of damaged and undamaged grains.

Effect of genotypes on mean number of live weevils

The mean number of live weevils was significantly different (p < 0.05) among rice varieties over 90 days after treatment. The highest number was in Sambha Mansuli Sub-1 (4.10%) and the lowest in Lalka Basmati (1.01%). The damage of Lalka Basmati was at par with Bahuguni-2 (1.25%) (Table 3).

Table 3: Effects of rice weevil on selected parameters over 90 days under choice condition

Rice varieties	Mean grain damage % (number basis)	Mean grain damage % (weight basis)	Mean weight loss %	Mean number of live weevils
Sambha Mansuli Sub-1	1.68^{a}	1.81^{a}	1.07^{a}	4.10^{a}
Ramdhan	1.19^{b}	1.13^{c}	0.78^{b}	2.13^{d}
Radha-11	1.16^{b}	1.16^{c}	0.62^{cd}	2.73^{c}
Bahuguni-1	1.27^{b}	1.21^{bc}	0.81^{b}	1.58^{e}
Bahuguni-2	0.79^{c}	0.78^{d}	0.57^{d}	1.25^{ef}
Hardinath-2	1.48^{ab}	1.51^{ab}	0.76^{bc}	3.27^{b}
Lalka Basmati	0.78^{c}	0.76^{d}	0.59^{d}	1.01^{f}

SEm (±)	0.081	0.091	0.042	0.241
CV (%)	16.3	16.00	11.2	12.90
p- value	<0.001	<0.001	<0.001	<0.001
Significance	s	s	s	s

NO- CHOICE TEST

Effect of rice weevil on mean grain damage (number basis)

The mean grain damage percentage (number basis) was significantly different ($p < 0.05$) in various rice varieties over 90 days after treatment. The highest grain damage percent was in Sambha Mansuli Sub-1 (1.69%) and the lowest in Lalka Basmati (0.63%). The damage of Sambha Mansuli Sub-1 was statically at par with Hardinath-2 (1.39%) while Lalka Basmati was at par with Bahuguni-2 (0.76%), Bahuguni-1 (0.86%) & Radha-11 (0.96%) (Table 4).

Effect of rice weevil on mean grain damage percentage (weight basis)

Similarly, mean grain damage percent (weight basis) was significantly different ($p < 0.05$) in various rice varieties over 90 days after treatment. The highest grain damage percent was in Sambha Mansuli Sub-1 (1.86%) and the lowest in Lalka Basmati (0.64%). The damage of Sambha Mansuli Sub-1 was statically at par with Hardinath-2 (1.85%) while Lalka Basmati was at par with Bahuguni-2 (0.76%), Bahuguni-1 (0.84 %) & Radha-11 (0.95%) (Table4).

Effect of rice weevil on mean weight loss percentage

The mean weight loss percent was significantly different ($p < 0.05$) among various rice varieties over 90 days after treatment. The highest weight loss percent was in Sambha Mansuli Sub-1 (1.15%) and the lowest in Lalka Basmati (0.50%). The damage of Lalka Basmati was at par with Bahuguni-2 (0.55%) and other varieties had intermediate weight loss (Table 4).

Effect of genotypes on mean number of live weevils

Counting of live weevil population was significantly different ($p < 0.05$) among various rice varieties over 90 days after treatment. The highest number was in Sambha Mansuli Sub-1 (6.60%) and the lowest in Lalka Basmati (3.19%) (Table 4). Fluctuation of live weevil's population was in the intermediate range in other remaining varieties.

Table4. Effects of rice weevil on selected parameters over 90 days under no-choice condition

Rice varieties	Mean grain damage % (number basis)	Mean grain damage % (weight basis)	Mean weight loss %	Mean number of live weevils
Sambha Mansuli Sub-1	1.69^{a}	1.86^{a}	1.15^{a}	6.60^{a}
Ramdhan	1.07^{bc}	1.03^{c}	0.70^{bc}	4.25^{c}
Radha-11	0.96^{cd}	0.95^{cd}	0.69^{bc}	4.39^{c}
Bahuguni-1	0.86^{cd}	0.84^{cd}	0.62^{cd}	3.94^{d}
Bahuguni-2	0.76^{cd}	0.76^{cd}	0.55^{de}	3.50^{e}
Hardinath-2	1.39^{ab}	1.85^{a}	0.78^{b}	4.95^{b}
Lalka Basmati	0.63^{d}	0.64^{d}	0.50^{e}	3.19^{f}

SEm (±)	0.081	0.092	0.052	0.233
CV (%)	18.62	18.11	8.51	3.05
p- value	<0.001	<0.001	<0.001	<0.001
Significance	s	s	s	s

Rice weevil preferred Sambha Mansuli Sub-1, followed by Hardinath-2 while refused Lalka Basmati, followed by Bahuguni-2 varieties with respect to damage percent based on the number & weight of grains, weight loss percent, and live adult weevil count over the 90 days after experiment. The factors that confer resistance to the grains against the infestation of rice weevil are varied. Smith (2005) in his study reported that such variation in the resistance level of different rice varieties for rice weevil normally because of their morphological characters or the presence of allelochemicals in the rice grains. The presence of awn in the Lalka Basmati variety probably makes it least damaged to others as awn is a needle-like appendage of grains which hinders weevil from making oviposition hole on the grain (Grundbacher, 1963). Similarly, amylose content of Lalka Basmati (23.4%) & Bahuguni-2 (24.3%) is higher than others (less than 23%) which determine their resistance level and found to be more resistant than others. This is also supported by Abraham *et al*. (1972) who found that the most resistant variety had the highest amylose content. Additionally, less thousand-grain weight (TGW) of Lalka Basmati (18.33gm) may be the causes of least grain damage with minimum weevil count as Ahmad (2018) reported that the percentage of infestation of rice weevil decreases with the reduction of thousand-grain weight of varieties. This is because of fine sized grains of varieties having less TGW, which make weevils unfit for oviposition on grains as Ashamo (2006) mentioned that oviposition, development, and F1 adult emergence were favored by bigger grains. More number of weevil emergence on Sambha Mansuli Sub-1 & Hardinath-2 variety was recorded as their thin hull cover, compared to others which makes it easy to deposit their eggs inside the grains. These findings are somewhat in line with Regmi *et al*. (2017). Ajao *et al*. (2019) who observed that small seed size, tightness of it hull, and reddish caryopsis of a particular variety could explain why it was resistant to *S. oryzae* attacks. However, the infestation in all cases seems to be less because of the hull covering of grains in rough rice as hull comprises 18 to 25% of the rough rice. According to Brasse (1960) and Russell (1968), an intact and tight hull of grains contributes to resistance with rice weevil *S. oryzae* while imperfect glumes contributed to susceptibility. Therefore, rice varieties exhibit varying degrees of susceptibility to damage by insects. Varietal resistance against weevil can be developed as a major component of insect pest management which is comparable with other management tactics. It can be a major way for reducing postharvest losses of grains which may be useful for plant breeders to work for varietal resistance.

CONCLUSION

Rice weevil (*S. oryzae*) is the severe damaging pests of rice in the storage condition. Losses of agricultural commodities during the post-harvest period have been considered a major problem in Nepal. Lalka Basmati was a less susceptible variety followed by Bahuguni-2 while Sambha Mansuli Sub-1 was the most susceptible variety followed by Hardinath-2 concerning grain damage percent (number & weight basis), weight loss percent, and live adult weevil population for both no-choice & choice conditions, respectively. Therefore, this experiment concluded that cultivation of Lalka Basmati & Bahuguni-2 varieties is the way to save grains from the attack of storage insect pest, which minimizes the postharvest loss of stored rice.

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