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Feeding Preference and Developmental Period of Some Storage Insect Species in Rice Products

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Abstract.- Relative food preference (free choice) and developmental period of *Tribolium castaneum* (Herbst), *Rhyzopertha dominica* (F.) and *Trogoderma granarium* Everts were studied on paddy, brown and milled rice of varieties IR-6, NIAB-IRRI-9, Basmati-370 and DM-25 under laboratory conditions. Rice varieties responded differentially to the three insect species for feeding preference, development and grain weight loss. Feeding preference, oviposition and subsequent developmental period of the beetles varied significantly in different rice products. *T. castaneum* and *T. granarium* beetles preferred paddy to brown and milled rice for oviposition. However, *R. dominica* preferred brown rice to milled rice and paddy for feeding. *T. castaneum* larvae developed to adults only in brown rice, *T. granarium* in brown and milled rice, whereas, *R. dominica* in paddy and brown rice. The results also showed that highest grain weight loss was inflicted in brown rice, followed by white rice and paddy. The overall results manifested that DM-25 suffered lowest damage, followed by IR-6, Basmati-370 and NIAB-IRRI-9. Different factors pertaining to development of storage insects in rice products/varieties are discussed.

Key words: Rice varieties, rice products, storage insects, feeding preference.

INTRODUCTION

Rice (*Oryza sativa* L.) is the largest exportable commodity in Pakistan, after cotton. About one third of its total production is exported annually while the rest is consumed in the country. During 2007-2008 rice was grown on 2.5 million hectares with the production of 5.5 million tones (Anonymous, 2008). After harvesting, the paddy is processed as brown, parboiled and white or polished rice. The tough siliceous hull of paddy renders it unsuitable for human consumption and less prone to attack by storage insects. Other eatable rice products vary in nutritional quality and susceptibility to insect attack (Pomeranz, 1987). It is estimated that 5-10% of world's grain production is lost due to ravages of insect pests. These losses reach 50% in tropical countries where summer is hot and humid and storage facilities are improper and inadequate (Maqsood *et al*., 1988). Insect infestations deteriorate rice quality and decrease its demand and price in local and international market. Several insect species destroy rice grain during post harvest storage. For example Angoumois grain moth, *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae); lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae); weevils complex, *Sitophilus* spp. (Coleoptera: Curculionidae); red and confused flour beetle, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae); saw toothed grain beetle, *Oryzaephilus surinamensis* (L.) (Coleoptera: Curculionidae) and khapra beetle, *Trogoderma granarium* Everts (Coleoptera: Dermestidae) are very serious pests of stored grains (Lindgren *et al*., 1955; Cogburn, 1985; Shafique and Ahmad, 2003; Shafique *et al*., 2006; Shafique and Chaudry, 2007).

The present study describes feeding preference and developmental period of three storage insect pest species on paddy, brown and milled rice of four local genotypes under laboratory conditions.

MATERIALS AND METHODS

Paddy, brown rice and milled rice of four genotypes *viz*., IR-6, NIAB-IRRI-9, Basmati-370 and DM-25 were supplied by Plant Breeding and Genetic Division, NIAB, Faisalabad. Biological traits like feeding and oviposition preference, larval developmental period and weight loss caused due to larval feeding of three storage insect species, *T. castaneum*; *R. dominica* and *T. granarium* to various products of rice were tested under controlled

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laboratory conditions. Samples were pre-conditioned at 5°C for two weeks. Two factorial experiments were performed in a completely randomized design with three replicates.

Food preference tests

T. castaneum

Samples of paddy, brown and milled rice (10 g) from each genotype were placed closely in an octagonal Perspex free choice chamber, covered with a lid from the top. Newly emerged adults of *T. castaneum* (120 individuals) were released into the chamber from a top hole with the help of a glass funnel. The chamber was also covered with black cloth and kept for 24 hours to allow the insects to settle in various products of rice genotypes. The next day, numbers of adult beetles in each product were observed and recorded.

R. dominica *and* T. granarium

Young adults of 200 in number from each of the two insect species were used in the tests, following the same technique mentioned above. Adult beetles were allowed to oviposit in the samples for one week. Then, the beetles taken out and their counts were recorded.

Insect development and sample weight loss

T. castaneum

Fresh sample of each rice genotype product (10 g) was kept in 150 g capacity glass jars, covered with finely perforated tin lids. Fifty neonates of *T. castaneum* larvae from laboratory reared culture were placed in each jar and covered with a lid. The larvae were allowed to feed and develop in each rice genotype at 27±2◦C and 60±5% R.H. When adults emerged, number of the beetles was recorded twice a week for 90 days. Percent weight loss in each infested sample was determined and compared with the control.

R. dominica *and* T. granarium

Samples having eggs/larvae of *R. dominica* and *T. gramarium* were used for estimating developmental periods of these insects. Samples were kept in 150 g capacity glass jars covered with finely perforated tin lids. The samples infested with *R. dominica* were kept at 27±2°C and 60±5% R.H. The larvae of *T. granarium* were kept at 33±2°C and 60±5% R.H., counted and recorded (20 days post oviposition) during the developmental period. When adults emerged, number of the beetles was recorded twice a week for 90 days. Percentage weight loss in each of the infested sample with *R. dominica* and *T. granarium* was determined compared with the control.

Statistical analysis

The data were subjected to statistical analysis by using MSTATC software programme and ANOVA, followed by Duncan's new multiple range test for multiple comparison of paired means (Steel *et al*., 1997).

RESULTS

T. castaneum

Feeding preference, developmental period of larvae and grain weight loss in different products of the rice genotypes varied significantly (Table I). Significantly high number of beetles preferred paddy (20.4) for feeding, oviposition or hiding when compared with brown or milled rice. Preference was also significantly high in NIAB-IRRI-9 (10.7) among the varieties. Larvae of *T. castaneum* developed to adults only in brown rice (23.0 days) while no larvae could develop in paddy or milled rice. Significantly high number of adults developed in Basmati-370 (10.3 days), followed by DM-25, NIAB-IRRI-9 and IR-6. Developed larvae caused significantly high grain weight loss in brown rice (8.6%), followed by milled rice (6.7%) and paddy (3.8%). However, grain weight loss was significantly high in IR-6 and NIAB-IRRI-9, followed by DM-25 and Basmati-370. The interactions of beetle's preference, larval developmental period and grain weight loss in rice products *vs*. varieties were highly significant.

R. dominica

Feeding/oviposition preference by *R. dominica* beetles, developmental period and weight loss in different products of rice cultivars varied significantly (P <0.05) (Table II). The beetle's feeding preference and oviposition was significantly high (18.0) for the brown rice, followed by milled

Table I.- Feeding preference, and weight loss developmental period of *T. castaneum* larvae in products of some rice varieties.

Varieties	Paddy	Brown rice	Milled	Over all mean
Adults (Attracted)				
IR-6	19.3±1.2b	2.7±0.3 de	3.0±0.6 de	8.3±2.77 b
NIAB-IRRI-9	27.3±0.9 a	3.0±0.6 de	1.7±0.3 de	10.7±4.18a
Basmati-370	20.3±1.5 b	2.3±0.3 de	1.0±0.0 de	7.9±3.14 b
DM-25	14.7±0.9 c	4.0±0.57 d	3.3±0.88de	7.3±1.87b
Over all mean	20.4±1.45a	3.0±0.27b	2.2±0.37b	-
Developmental period (Days)				
IR-6	0.0	18.0±0.6 d	0.0	6.0±0.57 d
NIAB-IRRI-9	0.0	20.0±0.6 c	0.0	6.6±0.57c
Basmati-370	0.0	31.0±0.6 a	0.0	10.3±0.57a
DM-25	0.0	23.0±0.6 b	0.0	7.6±0.57b
Over all mean	0.0	23.0±1.5 a	0.0	-
Weight loss (%)				
IR-6	4.0±0.08 g	8.3±0.03 b	7.3±0.17 c	6.6±0.65a
NIAB-IRRI-9	4.6±0.14 f	8.4±0.05 b	6.9±0.15 d	6.6±0.55 a
Basmati-370	2.9±0.14 i	8.9±1.90 a	5.9±0.20 e	5.9±0.86 c
DM-25	3.7±0.08 h	8.7±1.56ab	6.7±0.06 d	6.3±0.72b
Over all mean	3.8±0.19c	8.6±0.0 a	6.7±0.17b	-

Mean (±SE; n=3) sharing similar letters in each column do not differ significantly at $P < 0.05$.

Table II.- Feeding preference, and weight loss developmental period of *R. dominica* in products of some rice varieties.

Varieties	Paddy	Brown	Milled	Over all mean
Adults (Attracted)				
IR-6	13.6±0.66d	14.0±1.15d	19.6±0.88b	15.8±1.07b
NIAB-IRRI-9	15.0±0.57cd	26.6±0.88a	20.0±0.57b	20.6±1.72a
Basmati-370	10.0±0.57e	17.0±0.57c	10.3±2.27c	12.4±1.19c
DM-25	7.0±0.57f	14.6±2.51cd	14.3±2.40cd	12.0±1.38c
Over all mean	11.4±0.98c	18.0±1.58a	16.1±1.30b	-
Developmental period (Days)				
IR-6	35.3±2.02b	25.7±1.76c	0.0	20.3±2.48b
NIAB-IRRI-9	83.3±3.18a	13.0±1.15d	0.0	32.1±15.86a
Basmati-370	34.3±2.02b	35.3±2.60b	0.0	23.2±1.49b
DM-25	17.7±1.76d	25.0±2.64c	0.0	14.2±2.17c
Over all mean	42.7±6.75a	24.7±2.55 b	0.0	-
Weight loss (%)				
IR-6	7.2±0.26b	5.9±0.27c	2.4±0.20e	5.2±0.73b
NIAB-IRRI-9	12.5±0.26a	3.0±0.08e	2.6±0.17e	6.0±1.61a
Basmati-370	6.8±0.40b	6.9±0.08b	2.7±0.05e	5.4±0.70b
DM-25	4.6±0.08d	5.8±0.15c	2.4±0.14e	4.3±0.49c
Over all mean	7.8±0.08a	5.4±0.44b	2.5±0.0 c	-

Mean (±SE; n=3) sharing similar letters in each column do not differ significantly at $P < 0.05$.

(16.1) and then by paddy rice (11.4). Beetle's preference was also significantly high for NIAB-IRRI-9 (20.6), followed by IR-6, while it was comparable in Basmati-370 and DM-25. However, significantly high *R. dominica* adults developed in paddy (42.7), followed by brown rice, while no larva could develop to imago in milled rice. The number of developed adults was recorded significantly high in NIAB-IRRI-9 (32.1), at par in Basmati-370 and IR-6 and low in DM-25 (14.2). The grain weight loss (%) caused by *R. dominica* was significantly high in paddy (7.8), followed by brown (5.4) and then by milled rice (2.6). Among varieties, grain weight loss was significantly high in NIAB-IRRI-9 (6.1), at par in Basmati-370 and IR-6 and significantly low in DM-25 (4.3). The interaction of beetle's preference for oviposition, recovery of adults and grain weight loss in rice products *vs*. varieties was highly significant.

T. granarium

Preference of *T. granarium* beetles for oviposition, number of hatched larvae, adults and grain weight loss in different products of rice genotypes were summarized in Table III. The beetles preferred paddy (12.6) for oviposition to brown (10.0) and milled rice (7.6). The preference was high for IR-6 (11.0) followed by DM-25 (10.8), NIAB-IRRI-9 (9.8) and Basmati-370 (8.7). However, significantly high number of hatched larvae were found in milled rice (58.3), followed by brown rice (54.8) and then paddy (14.2). Number of hatched larvae in Basmati-370 (47.1), DM-25 (45.0) and NIAB-IRRI-9 (44.4) was almost similar; however, it was significantly low in IR-6 (33.3). Significantly high number of *T. granarium* adults developed in brown rice (52.9), followed by milled rice (28.0), while no larvae could develop to adults

Table III.- Preference for oviposition, hatched larvae, developmental period and weight loss of *T. granarium* in products of some rice varieties.

Varieties	Paddy	Brown	Milled	Over all mean
Adults (Attracted)				
IR-6	14.6±1.45a	10.3±1 cd	8.0±0.57 fg	11.0±0.4 a
NIAB-IRRI-9	12.0±1.2 bc	9.3±1 cdef	8.3±0.9 def	9.8±0.7 ab
Basmati-370	14.0±0.6 ab	5.3±0.9 g	7.0±0.6 fg	8.7±1.4 b
DM-25	10.0±0.6cde	15.0±0.6 a	7.3±0.9 efg	10.7±1.0 a
Over all mean	12.6±0.7 a	10.0±1.1 b	7.6±0.4 c	-
Hatched larvae (Nos.)				
IR-6	13.6±0.9 h	39.0±3.2 f	47.3±2.0 e	33.3±5.2 b
NIAB-IRRI-9	22.3±0.9 g	50.6±2.6 de	60.3±2.4 c	44.4±5.8 a
Basmati-370	7.0±0.6 i	78.6±3.5 a	55.6±2.6 cd	47.1±8.3 a
DM-25	14.0±0.6 h	51.0±2.3 de	70.0±3.5 b	45.0±8.3 a
Over all mean	14.2±1.7 c	54.8±4.6 b	58.3±2.7 a	-
Developmental period (Days)				
IR-6	0.0	36.3±2.10 c	26.0±2.3 d	21.0±2.8 c
NIAB-IRRI-9	0.0	49.3±7.5 b	34.3±2.0 c	27.8±3.7 b
Basmati-370	0.0	77.0±3.5 a	25.3±0.9 d	34.1±11.7 a
DM-25	0.0	49.0±2.0 b	25.6±1.8 d	24.8±5.4 b
Over all mean	0.0	52.9±4.6 a	28.0±1.4 b	-
Weight loss (%)				
IR-6	2.5±0.1 ef	9.1±0.5 b	5.4±0.47 d	5.6±0.10 b
NIAB-IRRI-9	3.5±0.7 e	9.5±0.6 b	7.7±0.5 c	6.9±0.9 a
Basmati-370	1.7±0.0 f	12.7±0.2 a	5.3±0.14 d	6.5±1.6 a
DM-25	2.1±0.0 f	9.7±0.4 b	5.80±0.2 d	5.5±1.1 b
Over all mean	2.4±0.2 c	10.2±0.5 a	6.0±0.3 b	-

Mean (±SE; n=3) sharing similar letters in each column do not differ significantly at $P < 0.05$.

in paddy. The developed adults were significantly high in Basmati-370 (34.1) at par in NIAB-IRRI-9 (27.8) and DM-25 (24.8) and low in IR-6 (21.0). The grain weight loss (%) inflicted by *T. granarium* larvae was significantly high in brown rice (10.2), followed by milled rice (6.0%) and then by paddy (2.4). The grain weight loss was higher in NIAB-IRRI-9 (6.9) and Basmati-370 (6.6) than IR-6 (5.7) and DM-25 (5.5). The interactions of rice products and varieties for different characters studied were highly significant.

DISCUSSION

Obtained results clearly indicated that the beetle's preference for feeding, oviposition or hiding and adult development varied in different rice products. *T. castaneum* and *T. granarium* beetles preferred paddy rice for oviposition or hiding to brown and milled rice. *T. castanium* larvae developed to adults only in brown rice, while 50 larvae (about 41%) died in paddy and milled rice during development. Significantly high number of *T. granarium* larvae developed to adults in brown rice, followed by milled rice and no larvae could develop to imago in paddy. These insect species are external feeders; therefore they could not feed on rice kernel by boring through the tough siliceous hull of paddy (Cogburn, 1985). As the brown rice was much preferred by *T. castaenium* and *T. granarium* for the adult development, Pomeranz (1987) reported that it is more prone to insect infestation and quality deterioration during storage which lessens its demand as food. *T. castaenium* larvae failed to develop in milled rice. One of the reasons could be that head rice (unbroken milled rice) was used in the experiments. Intact grains are stored much better against *T. castaneum* than damaged or ground grain (Li and Arbogast, 1991).

R. dominica preferred brown rice to milled rice and paddy for feeding, oviposition or hiding. However, significantly high number of adults developed in paddy, followed by brown rice. Cogburn (1977 and 1985) reported that larvae and adults of *R. dominica* were found more in rough or brown rice developed inside the grain and caused reduction in milling yield as well as weight loss of rough rice.

Like products, rice varieties also responded differentially to the three insect species for feeding/oviposition preference, insect development and grain weight loss. The results manifested that among the rice genotypes DM-25 suffered the lowest damage from tested insect species, followed by IR-6, Basmati-370 and NIAB-IRRI-9. Different reproduction rates of stored grain insect species in different varieties/products of rice were recorded (McGaughey, 1970; Cogburn *et al*., 1983 and Shafique and Ahmed, 2003). Varietals resistance to stored rice insects is relation to grain hardness, amylase content, non-chalkiness and phenolic content in the rice kernels. (Shibuya, 1984; Pomeranz, 1987; Ahmad *et al*., 1998).

CONCLUSIONS

Preference of storage insects for their feeding, oviposition or hiding and developmental period vary according to insect species, product and rice variety. Insect infestation and grain weight loss was higher in brown rice than milled rice and paddy. Knowledge of insect behaviour and physio-chemical characteristics of different rice products and varieties from present study might help alleviation of grain losses by storage insects.

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REFERENCES

AHMAD, M., AHMAD, T., SOOMRO, A.M. AND BALOCH, A.W., 1998. New insights into the physiochemical, cooking and eating characteristics of Pakistani rice. In: *New genetical approaches to crop improvement* (ed. S.S.M. Naqvi), pp. 297-313. Atomic Energy Agricultural Research Centre, Tandojam, Pakistan.

ANONYMOUS, 2008. *Economic survey of Pakistan*. Govt. Pakistan, Islamabad, pp., 21.

COGBURN, R.R., 1977. Susceptibility of varieties of stores rough rice to losses caused by storage insects. *J. stored Prod. Res*., **13**: 29-34.

COGBURN, R.R., BOLLICH, C.N. AND MEOLA, S., 1983. Factors that affect the relative resistance of rough rice to Angoumois grain moths and lesser grain broers. *Environ. Ent*., **12**: 936-942.

COGBURN, R.R., 1985. Rough rice storage. In: *Rice: chemistry and technology* (ed. B.O. Juliano). The American Association of Cereal Chemists, Inc. St. Paul, Minnesota, USA. pp. 265-287.

LI, AND ARBOGAST, R.T., 1991. The effect of grain breakage on fecundity, development, survival and population increase in maize of *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). *J. stored Prod. Res*., **27**: 87-94.

LINDGREN, D.L., VINCENT, L.E. AND KROHNE, H.E., 1955. The khapra beetle, *Trogoderma granarium* Everts. *Hilgardia*, **24**: 1-36.

MAQSOOD, L., KHATTAK, S.U., KHALIL, S.K. HUSSAIN, N. AND HAMED, M., 1988. Combined infestation and losses caused by three storage insects in Pak-81 wheat variety. *The Nucleus*, **25**: 23-26.

MCGAUGHEY, W.H., 1970. Effect of degree of milling and rice variety on insect development in milled rice. *J. econ. Ent.*, **63**: 375-376.

POMERANZ, Y., 1987. *Modern cereal science and technology*. VCH Publishers. Inc. New York.

SHAFIQUE, M. AND AHMAD, M., 2003. Susceptibility of milled rice genotypes to Angoumois grain moth, *Sitotraga cerealella,* (Oliv.) (Lepidoptera: Gelechiidae). *SAARC. J. Agric*., **1**: 193-197.

SHAFIQUE, M., AHMAD, M. AND CHAUDRY, M.A., 2006. Feeding preference and development of *Tribolium castaneum* (Herbst) in wheat products. *Pakistan J. Zool*., **38**: 27-31.

SHAFIQUE, M. AND CHAUDRY, M.A., 2007. Screening of rice genotypes for resistance to storage insects. *Pak. Ent.*, **29**: 19-21.

SHIBUYA, N., 1984. Phenolic acids and their carbohydrate esters in rice endosperm cell walls. *Phytochemistry*, **23**: 2233-2237.

STEEL, R.G.D., TORRIE, J.H. AND DICKEY, D.A., 1997. *Principles and procedures of statistics. A biometrical approach.* 3rd ed. McGraw Hill Inc., New York.

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