Studies on the varietal preference of rice weevil, *Sitophilus oryzae* L. and its management in stored wheat

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By

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Dated: 06/07/2010

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This is to certify that the thesis entitled **"Studies on the varietal preference of rice weevil, *Sitophilus oryzae* L. and its management in stored wheat"** submitted for the degree of **Master of Science in Agriculture** in the subject of **Entomology**, embodies bonafide research work carried out by **Mr. Ashok Kumar** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of this thesis was also approved by the advisory committee on **30/06/2010**.

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1. INTRODUCTION

In the sixties our country has celebrated the green revolution and since then continuous efforts are under way to increase wheat production. Wheat, *Triticum spp.,* is one of the most important crops in Indian agriculture. Wheat production in India for 2008-09 has been estimated at 78.4 million tones, which is 2.6 million tones (3%) more than that in the previous year. Accordingly, the yield per hectare was recorded as 2.8 tones, registering a 3 percent increase over the previous year. The estimated area under wheat is 28 million hectares and has recorded no changes (World-Agricultural-**Production**-August-2008). Phenomenal increase in its production and productivity have been achieved during the last decade with the advent of new high yielding improved varieties. One of the important reasons for this success has been the relative pest free status of wheat under field conditions (Singh, 1998). The nourishment offered by wheat is abundant. It provides carbohydrates, proteins, fats, mineral matter and certain vitamins. Wheat production in the country has increased by more than four times during the period of past two and half decades. Despite this spectacular increase there is an urgent need for further improvement in the production with storage techniques of wheat to meet out ever increasing demand. Wheat is stored at various levels by farmers, traders, government & semi-government agencies and consumers to meet out the long and short term consumption requirement and also to regulate the market availability and to provide seeds for next season. The grains in the storage are spoiled by both extrinsic and intrinsic factors, living organisms such as insects, mites and rodents causing heavy losses to the stored products (Pruthi and Singh, 1950). Insects are known to be one of the major limiting factors influencing the stored grain. A world survey by FAO showed about 5 per cent loss in storage to cereals each year (Herford, 1952). In India over all post harvest loss due to storage and handling has been estimated about 9.33 percent (Agarwal, 1968).

Although, more than a dozen stored grain pests have been recorded infesting wheat and other cereals in storage. Among them, the rice weevil, *Sitophilus oryzae,* Linn. (Curculionidae: Coleoptera) is a pest of international importance of a variety of stored grains *viz.* wheat, maize, rice and jowar. Larvae

and adults are internal feeder and cause a serious loss to cereals affecting the quality as well as quantity of the grains. In case of severe infestation even cent per cent grains may be damaged.

It is well known fact that food constituents play a vital role in the survival and reproduction potential of the insects. The grain characters, which also interfere the normal physiology or feeding of the insect, affect adversely the biology of the pest and these make a variety, resistant to insect attack. Although grains of almost all the varieties of wheat grown in the country are infested by stored grain pests but the extent of damage is influenced by the physio-chemical characters of the variety. The damage potential of this pest has been the subject of considerable research mainly on the relative preference in different stored products and among the varieties of the same product. Keeping this in view an attempt has been made to study the growth and development of this pest on some promising wheat varieties.

Efforts are being constantly made to achieve a break through in food grain production to overcome the problem of food scarcity. However, growing of food crops alone is not enough but efforts should be made to reduce the storage losses through eco-safe management techniques, which are suitable to the friendly economy of poor farmers at the same time utilizing the available natural resources in a compatible manner. Among the available natural resources plant and other inert materials possess same desirable qualities as grain protectants, which had been in practice in rural areas to protect stored grains from insect infestation. As the botanicals and inert materials are more easily available, cheaper, less persistent as compared to existing chemicals, besides, preventing quantitative and qualitative losses, they do not leave toxic residues in food grains. Under the present investigations, therefore, botanicals and other inert materials have been evaluated to find out their effectiveness against this pest.

Scope of the investigation:

The above facts have prompted to undertake the present investigations in order to find out answers to some of the outstanding problems with the following objectives in views.

(i) To investigate the varietal preference of *Sitophilus oryzae* L. on different

wheat varieties.

(ii) To study the life cycle of *Sitophilus oryzae* L.

(iii) To achieve eco-safe management of the *Sitophilus oryzae* L. in stored wheat.

2. REVIEW OF LITERATURE

Work on the varietal susceptibility is being carried out in different parts of the World as a part of IPM. However, *S. oryzae* which has emerged as a serious problematic pest of wheat in the world and specially in high humidity and temperature, in India it is a matter of great concern. Various workers have tested different varieties of wheat against this pest and found varying degree of preference/susceptibility.

2.1 Varietal Susceptibility:

Singh *et al*. (1968) tested 29 wheat varieties for resistance against *S. oryzae* on the basis of number of insects emerged. They found that three maxican varieties *viz.*, S-308, PV-18 and Sonara 64 and eleven NP varieties *viz.*, NP-1132A, NP-1132B NP-727, NP-164-4, NP-728, NP-125, NP-100, NP-731, Np-785, NP-781 and NP-52 were comparatively resistant. They attributed the hardness of grain as the probable factor for resistance.

Bhatia and Gupta (1969) studied the relative susceptibility of nine high yielding dwarf wheat varieties *viz*., Sonara 64, Sharbati Sonara, Lerma Roja 64A, S 307, S 331, Sonalika S 308, S 227, Kalyansona, HD 1593 and Triple Dwarf HD 1634 in the laboratory and reported varieties Sonara 64, Kalyansona, HD 1593 and Sonalika S 308 were significantly less susceptibile than the remaining six.

Gupta and Kadyan (1971) tested 11 vrieties of wheat and found C-281 and HD-44 were comparatively resistant to *S. oryzae* and S-306, HD-49 and HD-41 among the most susceptible varieties.

Puttarudrappa *et al.* (1971) evaluated five Mexican wheat varieties with an indigenous variety Bijaga Yellow and reported that indigenous variety recorded significantly low insect population (13.12) with least percentage of infestation, might be due to hardness of grains. Variety Lerma Roja has got maximum insect population compared to other varieties.

Chahal and Singh (1974) found that varieties WL-218, Wl-221 and WL-242 proved to be relatively resistance to *S. oryzae* and *R. dominica* pests, whereas, Lerma Roja, WL-237 and K-69-508 were found susceptible.

Varieties HD-7747, CC-522 and Kalyansona were moderately resistant, while HD-1982, K-65, K-68 and C-306 existed medium susceptible and UPT-72294, TL-174, JNK-6T-206 A-1 and HD-2009 proved susceptible. The influence of varieties on *S. oryzae* was studied on the basis of adult (male and female) weight and length of *S. oryzae* (Sudhakar and Pandey, 1982).

Sharma (1984) reported few wheat varieties *viz*., Kalyansona, NP-880, Shera Pusa Lerma and Sonalika were considered highly susceptible against *S. oryzae*. However, Pusa Lerma had significantly lower adult emergence than the other varieties.

Singh and Thapar (1998) observed that the weevil took significantly more time (41-42 days) to develop on grains and also fewer number of adults emerged in case of Jaya and IR-8 as compared to other varieties, i.e. PR-103, PR-106, PR-108 and PR-109.

On the basis of mean adult emergence, K-65, K-136, K-143, K-147, K-153, K-156, K-167, K-168 and K-171 were found tolerant to *S. oryzae* (4.33-5.33). While Sonalika, UP-2338, UP-2382, UP-2425 and PBW-396 were found highly susceptible, (Tiwari and Sharma 2002).

Rao and Sharma (2003) evaluated 53 wheat varieties out of which, least susceptible ones were KDH, HW 72, WH 147 and UAS-2021 with a mean progeny weevil emergence ranged from 7.6 to 12.0. Most susceptible response was recorded from the varieties *viz.*, Lok Bold, MACS-3347, DT-133, HW-2046, WTN-64, HD-2329, RNB-78, HW-2006 and PDW-287 (21.3-28.0). The grain size was positively correlated and significant with mean progeny weevil emergence.

Uttam *et al*. (2004) tested different barley varieties on growth and development of *S. oryzae* and found that none of the barley varieties was immune though, Amber, DL-88, Jyoti, Kedar, Lakhan and Azad varieties showed tolerance, whereas, Manjula, K-341, Karan-265 and Karan-4 were found most susceptible.

Lasker and Ghosh (2005) evaluated ten wheat cultivars *viz.*, PBW-373, HP-1633, HD-2643, PBW-343, Sonalika, NW-1014, HP-1731, PBW-499, HD-2285 and NW-1012 for their relative susceptibility to *S. oryzae* and found that

infestation was lowest in HP-1731 (14.0%) and highest in HD-2285 (47.67%). The percentage of weight loss after infestation was highest in PBW-499 (13.50%) and lowest in HP-1731 (6.33%).

To determine susceptibility and tolerance of wheat cultivars to *S. oryzae* variety DBW-14 suffered the highest damage of approximately 80 percent, while, NW-2026 had the least damage of 41.67%. NW-2026, WH-736, HD=2643 and KL-9107 were relatively less susceptibility to damage than DBW-14, HUW-543, HP-1731, UP-262 and NW-1014 (Paul *et al*., 2005).

Sharma *et al*. (2005) studied the susceptibility of seventeen cultivars of wheat against *S. oryzae viz.*, HUW-543, HUW-468, HP-1731, HP-1733, HP-1744, UP-262, UP-2425, WR-252, DBW-14, NW-2036, NW-2026, PBW-343, WH-736, NW-1014, HD-2643, K-9107 and HW-2045 at 28º C temperature and 70% R.H. showed the percent weight loss of grain was maximum in HP-1731 (9.25%) followed by HUW-468 (9.11%) and UP-262 (8.38%) after 20 days of inoculation. The minimum percent weight loss was observed in K-9107 (3.15%) followed by HD-2643 (3.28%), NW-2026 (3.58%) and NW-1014 (3.89%).

Bamaiyi *et al*. (2007) screened 36 sorghum cultivars for their relative susceptibility to *S. oryzae*. BES, ICSV 111, ICSV 247, ICSV 1079BF and ICSV 89009NG identified as low index of susceptibility and were graded as resistant. SINGE-2, SK5912, ICSV902NG, KSV8, 18395 and ICSV210 were regarded as highly susceptible. They concluded that grain hardness was the overall factor responsible for resistance to *S. oryzae*.

2.2 Life cycle of *Sitophilus oryzae* L.

Eggs are laid at temperature between 15 to 35ºC (with an optimum around 25º C) and grain moisture contents over 10 percent; however, rate of oviposition is very low below 20 º C or above 32 º C and below 12 per cent moisture content (Birch, 1944)

Upon hatching, the larva begins to feed inside the grain, There are four larval instars at 25 ºC and 70 per cent R.H., pupation takes place after 25 days,

although development periods are extremely protracted at low temperatures (i.e. 98 days at 18 º C and 70 per cent R.H.). Pupation takes place within the grain and newly developed adult chews its way out, leaving a large characteristic emergence hole. Total development periods take about 35 days under optimal conditions to 110 days in unfavorable conditions. The actual length of the life cycle depends upon the type and quality of grain. (Birch, 1944; Howe, 1952)

The eggs are laid individually in small cavities chewed into cereal grains by the female; each cavity is sealed, thus protecting the egg, by waxy secretion produced by the female. The incubation period is about 6 days at 25ºC (Howe, 1952).

Teotia and Singh (1968) studied the ovipositional behaviour and development of *S. oryzae* on various natural foods and observed that the oviposition was high on rice and wheat grains and low on Jowar, un-husked barley and maize. The growth index were in the following order: rice 2.96, barley (husked) 2.20, wheat 2.13, maize 1.69, Jowar 1.65, barley (un-husked) 1.20, oats (husked) 1.22 and oats (un-husked) 1.20. It was concluded that rice was the most preferred, whereas, un-husked oats was least preferred for oviposition and development of *S. oryzae*.

Rice weevil, *Sitophilus oryzae* L. is universally regarded as one of the most destructive primary pests of stored cereals such as barley, maize, rice and wheat. It does not often breed in non-cereal foods, although a few strains of S. *oryzae* have been found which can develop on grain legumes (Coombs *et al.*, 1977).

Longstaff (1981) reviewed the biology of *S. oryzae* L. and observed that adults are long lived (several months to one year). Eggs are laid through out most of the adult life, although 50% per cent may be laid in the first 4-5 weeks and each female may lays up to 150 eggs.

Schwartz and Burkholder (1991) studied the developmental period and adult emergence of *S. granaries* on barley, corn, oats, rice and wheat and observed that development was slowest on corn and fastest on rice. Progeny production was highest on barley and wheat followed by corn, rice and oats. They also reported that the development was slowest at 15°C and fastest at 30°C.

Jacob (1992) reported that the adults were provided with raw rice, parboiled rice, wheat and paddy for oviposition in laboratory and the grains were observed for emergence of the next generation. More adults were emerged from the wheat than rice. The development period was shorter and the emerged adult weights were higher on wheat.

Rice weevil, *sitophilus oryzae* L. was first described by Linnaeus in 1798 as *Curculio oryzae* and was later revised by De Clairville and Scheltenburg in 1798 as *Calandra oryzae*, which uses the commonest generic synonym for *Sitophilus* (CABI, 2001).

Barbhuiya and Devashish (2002) studied the biology of *Sitophilus oryzae* and reported that the total number of eggs laid by rice weevil during its life span on wheat, Jowar, maize and rice were 225, 160, 115, 54, respectively. The developmental period of rice weevil was short in wheat (35 days) followed by rice (38 days), Jowar (41.25 days) and long in maize (46.5 days). The incubation period varied from 5-7 days. The survival period of adult (both sexes) was more on wheat (41 days) followed by Jowar (37 days), maize (32 days) and less on rice (27 days).

2.3 Management of *Sitophilus oryzae* L.

Bowry *et al*. (1984) tested powder of neem, linseed, mustard, castor and mahua cakes for their effect on the egg laying, infestation and its repellent action against *S. oryzae*. The results showed that the powder of neem cake was most effective in reducing the egg laying and minimizing the damage followed by linseed, mustard, mahua and castor cakes. The repellent properties were maximum in neem and linseed cake powder followed by mustard, castor and mahua, respectively.

Mathur *et a*l. (1985) evaluated the efficacy of black pepper, neem kernel powder, ash, turmeric, sonth and adhatoda in comparison to malathion as against *C chinensis* infesting black gram grain. Among plant products, black pepper was most toxic, followed by neem kernel powder and ash, which were at par with malathion without advesely affecting viability of the seeds, whereas adhatoda was found least effective.

Sharma *et al*. (1989) determined the effectiveness of neem kernel powder for the control of *R. dominica* and *S. oryzae*. The neem powder mixed with wheat grain at the dose 3.0, 2.0, 1.0 and 0.5g per 100g of grain. More than 70 per cent mortality of *R. dominica* was observed at the minimum dose of 0.5g neem kernel powder per 100g of grains, whereas, in case of *S. oryzae* only 64.0 per cent mortality could be obtained at this dose. However, the highest dose tested i.e. 3.0 gram per 100 gram grain caused 100per cent mortality in both test insects after one month of treatment. There was no fresh emergence of insect from the treated grain up to 3 months after treatment.

Chiranjeevi (1991) tested the efficacy of seed powder of neem and leaf powder of neem, apamagra, kesarachetha, lantana, rhizome powder of sweet flag and ash of cow dung, acacia wood, neem wood and *Casuarina* against *C. chinensis* on the basis of percent grain damage, per cent protection over control and viability of treated seeds. He concluded that cow dung ash was most effective in reducing percent grain damage followed by neem seed kernel powder, sweet flag rhizome powder and neem leaf powder.

Singh and Mall (1991) studied the comparative efficacy of oil and cakes of castor, neem, mustard, linseed and powder of *Ipomea carnea*, *Melia azadirachta* as grain protectant against *S. oryzae* infesting stored wheat under laboratory conditions. Significantly less number of beetles were obtained in grains treated with neem oil (7.66), followed by powders of *I. carnea* & *M. azadirachta* and neem cake being 14.33, 16.06 and 17.33, respectively. The grain damage as well as loss in weight were minimum in neem oil treated grains.

Of several plant products tested against *S. oryzae* on wheat seeds, custard apple seed powder and neem seed powder were found most effective with regard to percentage damage grain, percentage grain weight loss and average adult population (Mishra *et al*. 1992).

Prakash *et al*. (1993) evaluated 20 plant products against *S. oryzae*, only 7 products significantly reduced adult populations and weight loss of grain. Neem seed oil was the most effective, followed by *Piper nigrum* seed powder, leaves of Vitex, leaves of *Andrographis paniculata*, dried mandarin fruit peel, rhizome powder of turmeric and seed powder of *Cassia fistula*, respectively.

Juneja and Patel (1994) indicated that the seed powder of custard apple and black pepper, leaves of mint (*Mentha piperata* L.) and peel of orange (*Citrus reticulata* Blanco) at 5 parts per 100 parts of green gram gave 100% adult mortality of the pulse beetle after 3 days of treatment and completely prevented the egg laying by female until 60 days after treatment and no population build up and grain damage were observed up to four months of storage, whereas, seed kernel powder of neem (*A. indica*) gave protection upto three months.

Shivanna *et al*. (1994) evaluated the efficacy of seed powder of neem (*A. indica*), ponge (*Pongamia glabra* [*P. pinnata*]), soapnut (*Acacia sinuate*), custard apple (*A. squamosa*), black pepper (*P. nigrum*), rhizome powder of turmeric (*Curcuma longa*) and sweet flag (*Acorus calamus*), leaf powder of tulsi (*Ocimum basilicum*) and *Eucalyptus*, each at 0.5, 1.5 and 2.5g per 50g of seeds of red gram (*C. cajan*) against *C. chinensis* on the basis of fecundity, adult emergence and per cent grain weight loss. Among the plant products, the sweet flag powder gave maximum protection against this bruchid, followed by custard apple, black pepper, turmeric and neem powder at the higher rate.

Imti and Zudir (1997) assessed the efficacy of neem leaf and kernel powders at 5 or 10g/kg rice seeds against *S. oryzae* in the laboratory and observed that neem kernel powder at the rate 10g/kg seed was found the most effective protectant, the infestation percentage being 12.34 percent as against 38 per cent in the untreated control.

Kumari and Singh (1998) concluded that Black pepper (*piper nigrum*) powder, neem (*Azadirachta indica*) leaf dust and mangraila (*Nigella sativa*) powder were equally effective in respect of number of eggs laid, number of adults emerged and reduced damage to grains by *C. chinensis* in mungbean

Rao and Sarangi (1998) evaluated the efficacy of grain protectants *viz*., sweet flag rhizome powder, turmeric powder, neem kernel powder, bael leaf powder and lantana leaf powder against rice weevil (*S. oryzae*) at 3 and 5g/kg grain. The mortality percent steadily increased with an increase in exposure period from 24 to 96 hours. Sweet flag rhizome powder at 5g/kg seed was found to be the most effective grain protectant even up to 45 days after treatment in resulting 100% mortality after 90 days of treatment.

Sharma (1999) suggested neem leaf powder at 5% protected the maize grains against *Sitophilus oryzae, Sitotroga cerealella, Rhizopertha dominica* and *Trogoderma granarium.*

Ulrichs and Mewis (2000) tested diatomaceous earth (Diatomite) Fossil Sheild R and the neem product Neem Azal- T/S R as single treatment and in combination for the control of *Sitophilus oryzae* and *Tribolium castaneum*. DE applied in concentrations of 0.5, 1.0 and 2.0g/kg rice reduced number of surviving beetles significantly. A single treatment with the neem product, in concentrations of 0.01, 0.1, 0.2 and 1.0 g azadirachtin/kg rice increased the mortality rate for both species significantly. The combination of neem and diatomaceous earth (1.0 g DE with 0.2 or 1.0 g azadirachtin) was more effective than the single treatment in reducing the numbers of beetles.

Khajuria *et al*. (2003) tested dry leaves (crushed) of six plants *viz.*, neem, eucalyptus, tulsi, melia, mint and chrysenthamum at 1 and 2g per 25g of sterilized rice against *S. oryzae*. Results revealed that all the treatments were significantly superior to control. Mortality of the *S. oryzae* @ 2g/25g rice was 100% in mint leaves in one day followed by neem, melia, tulsi, eucalyptus and chrysanthamum leaves.

Athanassiou *et al*. (2004) assessed the effect of the diatomaceous earth (DE) formulations Insecto, SilicoSec and PyriSec on stored Oat, Rye and Triticale against adults of *Sitophilus oryzae* and *Tribolium confusum* at three dose i.e. 0.75, 1.0 and 1.5g /kg grain. They recorded 100 percent mortality in *S. oryzae* adults after 7 days of exposure in all three types of grains All formulations were equally effective after 7 days of exposure against *S. oryzae*, but at 48 hours of exposure, PyriSec caused significantly higher mortality than the other two formulations. No progeny were recorded in the Triticale of *S. oryzae*.

Patel *et al*. (2004) tested neem, bergera, aak, ipomoea, garlic, chilli, turmeric, mango ginger and mustard powders at three doses (1, 3 and 5g/kg grain) for their efficacy against *Sitophilus oryzae*. The mango ginger rhizome powder was found the most effective treatment.

Kumar *et al.* (2005) evaluated botanical powders against rice weevil (*Sitophilus oryzae*) in stored *Sorghum* with Malathion (control). The least number

of weevil adults were observed in malathion and sweet flag treatments. Among the botanicals, powders form of sweet flag rhizome and custard apple seed recorded the lowest seed damage followed by neem seed, neem leaf, eucalyptus leaf, clerodendron leaf and vitex leaf.

Athanassiou (2006) evaluated the insecticidal effect of beta cyfluthrin applied to wheat with or without the adition of the diatomaceous earth (DE), against adults of *Sitophilus oryzae* and *Tribolium cofusum* at three doses 0.125, 0.25 and 0.75 ppm of beta cyfluthrin and the diatomaceous earth doses was 250 ppm, adults mortality was assessed after 24, 48 hours, 7 and 14 days of exposure to the treated substrate. For *S. oryzae*, the presence of DE increased the insecticidal effect of beta cyfluthrin at 0.125 and 0.25 ppm, adults mortality ranged between 64% and 100% after 14 days of exposure.

Patel (2006) used Neem leaves and Mango ginger rhizome powders to test their efficacy against *Sitophilus oryzae* at three doses (1, 3 and 5g/kg grain) under free choice and no choice test and found that both botanicals were effective but mango ginger rhizome powder was more effective and decreased the emergence of the adult beetles.

Tewari and Tiwari (2008) studied the bio-efficacy of Diatomaceous earth formulation against five major insect pests of stored cereals *viz., R. dominica, S. oryzae, T. castaneum, S. cerealella and C. cephalonica* at 0.01, 0.02, 0.05, 0.10 and 0.20 per cent (w/w) and observed that 0.02 per cent checked 93.8, 98.1, 100.0, 100.0, 100.0 percent progeny of *R. dominica, S. oryzae, T. castaneum, S. cerealella and C. cephalonica* respectively.

Matti and Awaknavar (2009) evaluated the insecticidal effect of the diatomaceous earth formulation “Protect” at 0.025, 0.05 0.10, 0.15, 0.25 and 0.30 per cent against adults of rice weevil in stored Jowar seeds and found cent per cent mortality at 0.30, 0.25, and 0.15 per cent. However, no mortality was recorded in control during storage period of two months.

3. MATERIALS AND METHODS

The experiment was carried out in the Storage Entomology Laboratory, Department of Entomology, Rajasthan College of Agriculture, Udaipur in a complete randomized design in four replications. The details of the treatments, materials used, techniques followed and criteria adopted for treatment evaluation during the course of present investigations are described in the following text.

3.1 Maintenance of stock culture of Rice weevil:

Rice weevil, *Sitophilus oryzae* L., the test insect was reared in laboratory at 27 ± 2°C temperature and 65 ± 5 percent relative humidity measured with hygrometer. Wheat grains were used as culture media for rearing the insect. Sufficient quantity of media was freezed at minus 15°C for one week to make it free from mites and insects infestation. After removing the media from freezer, the container was sealed with masking top to protect it from further insect infestation before starting the culture. Moisture content of the media was checked with a grain moisture meter and the media was tempered to 13 percent moisture content by adding quantity of water. The media was then kept in the sealed container at

the room temperature for 7 days to homogenize the grain moisture content. The required amount of water was calculated by the following formula (Heinreches *et al*., 1985):

$$\text{Weight of water} = \frac{\text{Desired moisture (\%)} - \text{Moisture (\%)}}{100 - \text{Desired moisture (\%)}} \times \text{Weight of wheat grain}$$

Nucleus culture of rice weevil was obtained from Division of Entomology, Indian Agriculture research Institute, New Delhi and placed in the medium to produce progeny to serve as stock culture to start the rearing program. After one week of oviposition, the adults were removed from the medium by sieving them with number 10 mesh sieve. The adults were discarded and the media was transferred to the respective jar and kept in the rearing room till adult weevils emerged (about 5 to 6 weeks). The newly emerged adults thus obtained were used as the stock culture in the mass-rearing program.

3.2 Mass rearing of rice weevil:

The mass rearing was done in two plastic jars of 1 kg capacity. Minute holes were made on the lids of the jars by inserting hot insect pins to facilitate proper aeration and ventilation. The medium was kept at the rate of 500g per jar and 5 cc (approximately-550 pairs) of newly emerged adults were released in each jar. The jars were closed with lids, labeled and placed in the rearing chamber.

After allowing the weevils to oviposit for one week then these weevils were removed from first set of jars using a number 10 mesh sieve. The medium was transferred to the respective jar and the adults were released to a second set of jars. After allowing these insect to oviposit for one week, they were again transferred to a third set of jars and were allowed to oviposit for one week. After removing them from the third set of jars, the adults were discarded.

Weevils which started to emerge from about 5 weeks after oviposition were used in the experiments and some of them were transferred to fresh medium and the process was repeated to maintain the culture.

3.3 Varietal preference of *Sitophilus oryzae* L. on different wheat varieties:

The following ten wheat varieties were obtained from Department of Agronomy, Rajasthan College of Agriculture, Udaipur for the purpose to studying the host preference of *S. oryzae*.

1. RAJ-3765
2. LOK-1
3. RAJ-3077
4. RAJ-3777
5. MP-1203
6. HI-8627
7. MPO-1215
8. RAJ-4161
9. MP-4010
10. RAJ-4164

The grains were freezed and their moisture content was adjusted to 13 percent as described earlier. After tempering the grains, 30 g of each test material was taken in small plastic containers.

The samples in all containers were infested with 15 pairs (Males and Females) of two weeks old adults obtained from the laboratory culture.

The released adults were removed by using 10 mesh sieve from the test material after 7 days and the samples were replaced in the respective containers.

Each container was carefully observed daily, starting at 30^{th} day after removal of the released adults. The F_1 progeny emerging in each container were separated daily from the grains by using a number 10 mesh sieve, counted and discarded. After sieving, the grains were replaced in the respective containers and the same process was repeated on the following days till the emergence of the F_1 progeny was completely stopped in all containers. The average developmental period taken by F_1 progeny in each container was calculated. Damaged and undamaged grains were separated and counted from each container under magnifying glass lens. The damaged and undamaged grains were weighed

separately on an electronic balance. The per cent weight loss was worked out by count and weight method (Dick, 1987).

$$\text{Per cent weight loss} = \frac{(UNd) - (DNu)}{U\,(Nd + Nu)} \times 100$$

Where,

U = Weight of undamaged grains

Nu = Number of undamaged grains

D = Weight of damaged grains

Nd = Number of damaged grains

3.4 Life cycle of *Sitophilus oryzae* L.:

Life cycle of rice weevil, *Sitophilus oryzae* L. was studied on wheat grains. In experimental procedure, healthy grains of wheat was disinfested and placed in each plastic container and the lids containing previously made minute holes were replaced. The experiment was replicated four times.

Four pairs of two weeks old adults obtained from stock culture were released in each container for 24 hours to get the eggs of same age only. After 24 hours the adults were removed and discarded from the containers.

One egg per seed was allowed to develop and the remaining eggs were scraped off with the help of razor blade. The procedure to keep one egg per seed give correct estimation for determining the percent adult emergence. The average developmental period was considered from the date of egg laying to the date of adult emergence. The total duration of life cycle was considered from the date of egg laying to the date of adult died. Following observations were recorded.

1. Hatching period (days)
2. Larval period (days)
3. Pupal period (days)
4. Adult emergence (per cent)
5. Growth index

6. Adult longivity of male and female (days)
7. Total life cycle of *S. oryzae* (days)

Growth index was computed as suggested by Singh and Bhattacharya, 2004.

$$\text{Growth index} = \frac{\text{Per cent adult emergence}}{\text{Average developmental period (days)}}$$

3.5 Eco- safe management of rice weevil, *Sitophilus oryzae* L.:

Design : Complete Randomized Design (CRD)

Replications : Four

Treatments : 6+1

1. Black pepper (*Piper nigrum*) powder (10g/kg)
2. Neem (*Azadirachta indica*) leaf powder (10g/kg)
3. Custard apple (*Annona squamosa*) seed powder (10g/kg)
4. Cow dung ash (10g/kg)
5. Sand (25g/kg)
6. Diatomaceous earth 0.05 % (w/w)
7. Control

The experiment was carried out in a complete randomized design with four replications in the Storage Entomology Laboratory, Department of Entomology, Rajasthan College of Agriculture, Udaipur. Wheat grains were used as stored material to carry out the experiment. Black pepper (*Piper nigrum*) powder, Neem (*Azadirachta indica*) leaf powder, Custard apple (*Annona squamosa*) seed powder, Cow dung ash, Sand and Diatomaceous earth were tested for their relative efficacy in comparison to untreated control against *Sitophilus oryzae* L. in different storage periods.

Powders of black pepper, neem leaf and custard apple seed were prepared by grinding the materials in a mixer cum grinder. Wheat grains was weighed and kept in a medium sized plastic container at the rate of 100g each. Required quantity of black pepper powder, neem leaf powder, custard apple seed powder, cow dung ash, sand and diatomaceous earth (inert dust) were added to the respective containers and mixed thoroughly by shaking the containers. Twenty five pairs (50 numbers) of newly emerged adults of rice weevil from the laboratory culture were released to 100g uninfested grains and allowed to feed and oviposit for three months. Adult mortality was counted 7^{th} and 30^{th} day of insect release by sieving the grains first with 20 mesh sieve to separate the dust and then by a number 10 mesh sieve to separate the weevils. Afterward, the live insects were transferred to its respective container after replacing the grains containing plant powders and inert dusts. The corrected percent mortality was calculated by the formula given by Henderson and Tilton (1955).

$$\textbf{Corrected per cent mortality} = 100 \left(1 - \frac{T_a \times C_b}{T_b \times C_a} \right)$$

Where,

T_a = Number of weevils after treatment

T_b = Number of weevils before treatment

C_a = Number of weevils in untreated check after treatment

C_b = Number of weevils in untreated check before treatment,

The total numbers of adults in each container were counted and transferred to their respective containers 60 & 90 days after initial insect release. The damaged and undamaged grains were separated under magnifying glass and the number and weight of damaged and undamaged grains were determined at 30, 60 and 90 days after insect release on 500 grains selected randomly from each

container and finally per cent net weight loss was also computed for three storage periods i.e. 30, 60 and 90 days after insect release.

Statistical analysis:

The data obtained on various parameters in different experiment were subjected to analysis of variance technique applicable for Completely Randomized Design. The level of significance used in "F" test was P = 0.05 wherever F calculated was significant. Critical difference values were calculated for treatment comparisons. The values obtained in percentage were transformed into angular values and subjected to analysis.

4. EXPERIMENTAL RESULTS

Results of the present investigation carried out on "Varietal Preference, Life cycle and Management of Rice weevil, *Sitophilus oryzae* L." have been presented in this chapter under the following sub headings.

4.1 Varietal preference

4.2 Life cycle of *Sitophilus oryzae* L.

4.3 Efficacy of some botanicals and inert materials against rice weevil.

4.1 VARIETAL PREFERENCE:

4.1.1 Average developmental period

The average number of days taken to complete the development of the weevils from egg to adult stages differed significantly on different wheat varieties. The longest developmental period was recorded on LOK-1 (41.08 days) and the shortest on MP-1203 (31.89 days). The average developmental period recorded on different wheat varieties *viz*., RAJ-3777, RAJ-4164, RAJ-4161, RAJ-3765, MP-4110, MPO-1215, RAJ-3077 and HI-8627 were as 39.11, 38.04, 37.49, 37.37, 36.33, 36.17, 34.39 and 33.22 days, respectively. However no significant difference was observed between the treatments of RAJ-3765, RAJ-4161, MP-4010 and MPO-1215 and RAJ-3777 and RAJ-4164.

4.1.2 Number of F_1 progeny produced

The total number of F_1 progeny produced on different wheat varieties varied from 118.50 to 159.25 being minimum in LOK-1 and maximum in MP-1203, respectively. Lowest number of F_1 progeny was produced on LOK-1 (118.50) while the highest number on MP-1203 (159.25) varieties. However, the number of F_1 progeny produced on MP-1203 (159.25) differed significantly over rest of the varieties as with the number of progeny produced on HI-8627 (148.75), RAJ-3077 (143.25), MPO-1215 (140.25), MP-4010 (135.25) RAJ-3765 (131.00), RAJ-4161 (129.50), RAJ-4164 (128.75) and RAJ-3777 (123.00). The F_1 progeny produced on RAJ-4161 (129.50) and RAJ-4164 (128.75) were at par with each other but the number of progeny produced on LOK-1 (118.50) was found significantly less than rest of the varieties except RAJ-3777. (Table-1 & Fig.-1)

4.1.3 Per cent damage grain

A significant difference was recorded for per cent damaged grains in different wheat varieties. The results (Table-2) indicate that LOK-1 showed least damages (23.31 per cent) while MP-1203 has shown highly damaged (66.15 per cent) grains. The extent of damage recorded on HI-8627, RAJ-3077, MPO-1215, MP-4010, RAJ-3765, RAJ-4161, RAJ-4164 and RAJ-3777 were 63.38, 60.94, 50.07, 45.72, 36.88, 36.50, 33.99 and 23.80 per cent, respectively. The extent of damage caused to LOK-1 (28.87) was significantly less than on the grains over the rest of the varieties except RAJ-3777 (29.20). However, the damage found in case of RAJ-4161 (37.17) and RAJ-3765 (37.39) did not differed significantly with each other. (Fig.-2)

4.1.4 Per cent weight loss

The weight damaged and undamaged grains were taken separately through electronic balance.

Net weight loss due to the feeding of the insect was as low as 9.31 per cent in LOK-1 and as high as 18.92 per cent in MP-1203. The net weight loss recorded in HI-8627, RAJ-3077, MPO-1215, MP-4010, RAJ-3765, RAJ-4161, RAJ-4164 and RAJ-3777 were 18.35, 15.02, 14.73, 12.94, 11.59, 11.49, 10.64 and 9.87 per cent, respectively (Table-2). The difference in weight loss in case of RAJ-3765 and RAJ-4161 was not found significant, but it was significantly higher than the weight loss in LOK-1 and RAJ-3777. Similarly the difference in weight loss in

MP-1203 and HI-8627 were not found significant, but were found higher than other varieties. Variety LOK-1 was found significantly less per cent weight loss over rest of the varieties except RAJ-3777. (Table-2 & Fig.-2)

4.2 BIOLOGY OF RICE WEEVIL:

The study of insect host grain relationship and it's biology of paramount importance. This study helps to know the developmental period and population build up of insect and its spread over space and time.

The data recorded on various aspects of biology has been presented in (Table-3). The data serial that hatching period range from 5.20 to 5.26 days with a mean of 5.22 days, while larval period varies from 23.54 to 23.91 days with a mean of 23.73 days. The pupal period recorded in the ranged of 6.75 to 7.08 days with a mean of 6.93 days. Total per cent adult emergence was recorded with an average of 95.0 days with an average growth index 2.64 days.

As for as adult longevity is concerned, for male it ranged from 32.44 to 33.60 days with a mean of 33.33 days, while for female the period ranged from 38.73 to 40.71 days with a mean of 39.43 days.

The total life span of rice weevil was recorded from 71.87 to 73.91 days with a mean of 72.76 days.

4.3.1 EFFICACY OF SOME BOTANICALS AND INERT MATERIALS AGAINST RICE WEEVIL:

Seven treatments included botanicals and inert dusts were included to observe number of adults emerged as well as per cent mortality.

4.3.1 Population growth of *S. oryzae* in different treatments

Population of *S. Oryzae* adults at 60 and 90 days after insect release in wheat grains treated with different plant and inert materials varied significantly. Population of the insect was found significantly lesser than untreated check in all treatments. It was recorded that complete control of insect population was in

grains treated with Diatomaceous earth (0.00) and highest population of insect was in grain treated with sand (218.00) at 60 day after release. Adult population of the insect in black pepper powder (27.50) which was at par with custard apple seed powder treatment (28.25). The weevils population in grains treated with neem leaf powder (76.50) and cow dung ash (89.50) were intermediate and statistically at par to each other. (Table-4 & Fig.-3)

Among various plant and inert materials tested for insect population emerged at 90 days after the release was again found none in grains treated with Diatomaceous earth (0.00) and were highest in grains treated with sand (277.25). The insect population in grains treated with custard apple seed powder (37.50) was at par with the number of adults in grains treated with Black pepper powder (39.25). Insect population (adults) observed in grains treated with custard apple seed powder were lower than grains treated with Black pepper powder but it was found at par at 90 days after insect release. Although the difference in adult population in grain treated with neem leaf powder (110.75) and cow dung ash (127.50) was non-significant, to each other. Number of individuals were observed in grains treated with cow dung ash and neem leaf powder at 90 days after insect release were at par with each other. (Table-4 & Fig.-3)

4.3.2 Adult mortality in different treatments

A highly significant difference in adult morality was observed in different treatments (Table-5). The plant materials and Inter dust *viz.*, Diatomaceous earth, black pepper (*piper nigrum*) powder, and custard apple (*Annona squamosa*) seed powder exhibited better effects on the mortality at both 7 days and 30 days which recorded corrected mortality per cent for Diatomaceous earth, Black pepper powder and custard apple seed were 90.05, 84.76 and 79.49 per cent, respectively within 7 days after releasing the adults in the grains of wheat. The mortality in Diatomaceous earth (90.05) was found significantly higher than the rest of the treatments. Among the materials, mortality recorded in sand mixed grains (37.89) was found significantly lower over other tested materials. (Fig.-3)

The corrected adult mortality recorded at 30 days after it release of adult of *S. oryzae* in grains treated with Diatomaceous earth, Black pepper powder, custard apple powder, neem leaf powder, cow dung ash and sand were 99.20, 89.35,

84.67, 81.67, 65.27 and 39.54 per cent, respectively (Table-5). The Diatomaceous earth treatment was found significant superior over Black pepper powder, custard apple seed powder, neem leaf powder, cow dung ash and sand. Inert material *viz*. cow dung ash and sand were performed poor response over other treatments. Next to diatomaceous earth treatment, black pepper powder was found effective (89.35) and was significantly better over neem leaf powder (81.67), cow dung ash (65.27) and sand (39.54) but it was at par with custard apple seed powder (84.67). (Fig.-3)

4.3.3 Number of damaged grains

The number of damaged grains in different treatments were found significantly less than the number of damaged grains in untreated check at all three storage period *viz*. 30, 60 and 90 days after the insect release in healthy grains.However, different treatments exhibited different level of efficacy in terms of number of damaged grains. (Table-6 & Fig.-4)

The number of damaged grains at 30 days after insect released were comparatively less in all the treatments than 60 and 90 days after release, which increased progressively at 60 and 90 days after storage period, however the rate of increase in number of damaged grains were different in various treatments. Significantly less number of damaged grains were found which were treated with Diatomaceous earth (4.25) and black pepper powder (8.25) at 30 and 60 days of storage period, respectively. At 90 days of storage period the same pattern of less damage were found in Diatomaceous earth and custard apple seed powder treatment than rest of the materials tested against *S. Oryzae*. The number of damaged grains in neem leaf powder (19.25) and cow dung ash (21.00) were found statistically at par at 30 days after release, which were significantly higher than Diatomaceous earth, Black pepper powder and custard apple seed powder treatments. Highest damage was observed in the treatment with sand in all 30, 60 and 90 days after insect release. Among the tested material sand was found least effective. (Table-6 & Fig.-4)

The relative efficacy of different treatments shared more or less similar trend up to 30 and 60 days of storage period after insect release in the treated grains, but changed their level of efficacy from 90 days onwards after the insect release.

4.3.4 Per cent damaged grains

The per cent damaged grains in Diatomaceous earth (0.42), (0.00) and (0.00) and custard apple seed powder (0.53), (0.75) and (1.43) treated wheat grains were found significantly less than rest of the treatments at different storage period i.e. 30, 60 and 90 days, respectively. Although, the per cent damaged grains in untreated check was significantly higher than rest of the treatments at 30, and 60 and 90 days after storage period of the treated grains. The damaged grains in treatment with sand was significantly higher among the other treatments at all three storage period i.e. 30, 60 and 90 days. The effective treatments with neem leaf powder and cow dung ash were found next to Diatomaceous earth, custard apple seed powder and Black pepper powder at 30, 60 & 90 days after storage in reducing the per cent grain damage. The per cent damaged grains in the treatment with neem leaf powder was at par with cow dung ash at 30 days after storage, but the damage recorded at 60 and 90 days after storage, significantly higher damaged was observed in neem leaf powder over grains treated with cow dung ash. (Table-6 & Fig.-5)

4.3.5 Per cent net weight loss

The relative efficacy of different treatments in terms of per cent net weight loss of wheat grains were found significant. Diatomaceous earth (0.38) and custard apple seed powder (0.48) were found highly effective in terms of net weight loss of wheat grains due to the *S. Oryzae* at 30 days storage period and maintained their superiority in 60 and 90 days of storage. Diatomaceous earth and custard apple seed powder treatments were found most effective at 30 days after storage period. At 60 and 90 days after storage the per cent net weight loss was significantly differed with in diatomaceous earth and custard apple seed powder treatments. Black pepper powder (0.82), neem leaf powder (1.91) and cow dung ash (2.21) were also found significantly effective in reducing the weight losses up to 30 days after the infestation over sand treatment. The effectiveness of black pepper powder and cow dung ash increased loss to little extent up to 90 days. Sand was found least effective treatment though the per cent weight loss in the

grains treated with sand was found significantly better over untreated check. (Table-6 & Fig.-6)

5. DISCUSSION

The results obtained in different aspects of present investigation "Varietal preference, Life cycle and Management of Rice weevil, *Sitophilus oryzae* L." are described in the preceding pages and are being discussed here in the light of available evidences.

5.1 VARIETAL PREFERENCE:

5.1.1 Average developmental period

The developmental period of *S. oryzae* varied and differed significantly in different wheat varieties included as host for the test insect. The longest and shortest developmental period achieved in LOK-1 (41.08) and MP-1203 (31.89) respectively. LOK-1 was found significantly better over rest of the wheat varieties. The developmental period within RAJ-3765 and RAJ-4161 as well as within MP-4010 and MPO-1215 were found at par.

The present findings are in close conformity with the findings of Singh and Thapar (1998) and Barbhuiya and Devashish (2002) who also reported different developmental periods on wheat varieties in the range of 35-42 days.

5.1.2 Number of F_1 progeny produced

The total number of F_1 progeny emerged in varying numbers matched with their total developmental period (days) of the *S. oryzae* i.e. higher the developmental period lower the F_1 progeny produced. LOK-1 variety observed as higher developmental period completed by the pest (41.08 days) emerged lowest F_1 progeny (118.50). These findings are in accordance with the findings of Uttam *et al.* (2004) who reported that with more of fecundity (251.66 days), higher the F_1 progeny emerged (166.23).

5.1.3 Per cent grain damage

Per cent grain damage was recorded among the different wheat varieties ranged from 23.31 (LOK-1) to 66.15 (MP-1203). LOK-1 and RAJ-3777 were

found at par to next i.e. RAJ-4161 and RAJ-3765 were also found at par to each other. Remaining six varieties *viz.*, RAJ-3077, MP-1203, HI-8627, MPO-1215, MP-4010 and RAJ-4164 significant difference was recorded among them. Similar to these findings Paul *et al*. (2005) also determined per cent grain damage in the range of 41.67 to 80.00 per cent in different wheat varieties.

5.1.4 Per cent weight loss

Among the varietal preference to *S. oryzae* when the per cent weight loss (net) was calculated on the basis of grain damage, then the variations recorded from 9.31 (LOK-1) to 18.92 (MP-1203) with much close to HI-8627 (18.35). LOK-1 and RAJ-3777 as well as RAJ-4161 and RAJ-3765 were among the varieties which were found at par. Similar to our findings Lasker and Ghosh (2005) reported that weight loss in different wheat varieties varies accordingly, highest PBW (13.50 %) and lowest in HP-1731 (6.33 %) while Sharma *at al.* (2005) recorded maximum weight loss in HP-1731 (9.25 %) and minimum in K-9107 (3.15 %).

5.2 BIOLOGY OF RICE WEEVIL:

The biology of *S. oryzae* was studied under laboratory conditions on wheat grains. The present findings reveal that average hatching period observed was 5.22 days which supports the findings of Hove, 1952 reported incubation period is about 6.00 days., while, Barbhuiya and Devashish (2002) reported incubation period varies from 5-7 days. The present investigation shows that total larval period varied from 23.54 to 23.91 days which is supported by the earlier woker Birch 1944 and Hove 1952 during the course of our investigations, the average pupal period recorded 6.93 days. Considering the developmental period our findings tally with the findings of Barbhuiya and Devashish (2002) who reported developmental period of rice weevil is 35 days on wheat.

In the present studies the average growth index derived as 2.64 which is in accordance with the findings of Teotia and Singh (1968) who reported growth index 2.13.

5.3 EFFECT OF SOME BOTANICALS AND INERT MATERIALS AGAINST RICE WEEVIL:

5.3.1 Population growth of *S. oryzae* in different treatments

Among the plant materials and inert dusts which were used to check the population growth, inert dust i.e. diatomaceous earth (0.05 %) proved excellent to check the population cent per cent at both 60 and 90 days of storage period followed by black pepper and custard apple seed powder at 10g/kg seed of wheat. The present findings get full support by Ulrichs and Mewis (2000) who reported that diatomaceous earth provided significant result to check the number of surviving beetles.

5.3.2 Adult mortality in different treatments

In the same pattern as observed in "check of population growth", highest per cent mortality was also recorded in diatomaceous earth followed by black pepper and custard apple seed powder recorded at 7 and 30 days after the treatment. The present investigations are in close conformity with the findings of Athanassiou *et al*. (2004) who reported that treatment of diatomaceous earth achieved 100 per cent mortality of *S. oryzae* adults after 7 days of exposure.

5.3.3 Number of damaged grains

Damaged grains were recorded on 30, 60 and 90 days of storage period after the application of different treatments. The diatomaceous earth (0.05 %) provided better result and found significantly superior over rest of the treatments except black pepper powder which was at par to diatomaceous earth. The present investigation is supported by Mishra *et al*. (1992) who reported that seed powder of custard apple and neem provided better results in terms of less damaged grains of wheat by *S. oryzae*.

5.3.4 Per cent damaged grains

Per cent infestation based on damaged grains diatomaceous earth gave least damage at 30 days while no damage was occured at 60 and 90 days of storage period after treatment application followed by custard apple seed powder. Earlier workers, Mishra *et al*., 1992 also reported custard apple seed powder and neem seed powder as most effective seed protectants with regard to minimize the per cent damage on wheat grains.

5.3.5 Per cent net weight loss

On the basis of damaged and undamaged grains with respect to their net weight loss was computed with ultimately to see the effectiveness of different treatments during storage. Results clearly show that diatomaceous earth provided most effective treatments with utmost minimum per cent net weight loss and safer for longer period of storage of wheat grains followed by custard apple seed powder. Our findings get supported by Mishra *et al.*, 1992 who reported custard apple seed powder treatment gave minimum weight loss to wheat seeds.

6. SUMMARY

The present investigation "Varietal preference, life cycle and management of rice weevil, *Sitophilus oryzae* L. was carried out in the Department of Entomology, Rajasthan College of Agriculture, Udaipur during the year 2008.

Among the ten wheat varieties, *S. oryzae* preferred MP-1203 as most suitable host to complete their developmental period in a faster rate with more F_1 progeny. In contrast, LOK-1 variety was not much preferred by rice weevil because of their slower rate of development with less number of F_1 progeny. As far as damage is concerned varieties *viz.*, LOK-1 and RAJ-3777 proved better in terms of less percentage of grain damage as well as weight loss.

As far as biology of *S. oryzae* is concerned, the studies reveal that mean hatching period and larval period was 5.22 and 23.73 days. While, mean pupal period recorded was 6.93 days. Average growth index was recorded 2.64. Mean adult longevity for male and female was 33.33 and 39.43 days, respectively. The total life span was recorded with a mean of 72.76 days.

Among the different treatments comprising plant and inert materials as seed protectants, diatomaceous earth proved better in terms of zero recovery of adults observed at 60 and 90 days storage period followed by black pepper powder and custard apple seed powder along with higher per cent mortality also. Diatomaceous earth treatment could also be proved excellent in terms of minimum per cent of grain damage with least per cent in net weight loss and also found much safer for longer period of storage.

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"Studies on the varietal preference of rice weevil, *Sitophilus oryzae* ***L. and its management in stored wheat"***

Mr. Ashok Kumar Research Scholar*

Dr. T. Hussain Major Advisor**

ABSTRACT

Investigation on "Varietal preference, life cycle and management of rice weevil, *Sitophilus oryzae* L." was carried out in the Storage laboratory of the

Department of Entomology, Rajasthan College of Agriculture, Udaipur during the year 2008.

LOK-1 variety of wheat was least preferred host by *S. oryzae* while MP 1203 was most preferred host. LOK-1 and RAJ 3777 provided less percent grain damage with minimum loss in weight which may be result of hardness of the grains.

The studies on the biology of rice weevil has shown that average growth index was observed 2.64. Adult longivity for male and female was 33.33 and 39.43 days, respectively.

The management practices comprising of plant materials and inert dusts were used to over come the problem of *S oryzae*; diatomaceous earth (0.05%) exhibited an excellent treatment with respect to minimum percentage of grain damage as well as percent grain weight loss followed by black pepper powder (10g/kg) and Custard apple seed powder (10g/kg) of grain.

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Table: 1. Development of *S. oryzae* in different wheat varieties 2008.

S. No.	Varieties	Average developmental period (days)	Total no. of F_1 progeny emerged
1.	RAJ-3765	37.37	131.00
2.	LOK-1	41.08	118.50
3.	RAJ-3077	34.39	143.25
4.	RAJ-3777	39.11	123.00
5.	MP-1203	31.89	159.25
6.	HI-8627	33.22	148.75
7.	MPO-1215	36.17	140.25
8.	RAJ-4161	37.49	129.50
9.	MP-4010	36.33	135.25
10.	RAJ-4164	38.04	128.75
SEm±		0.54	2.42
CD (5%)		1.57	7.01
C.V.		2.98	3.57

Table: 2. Response of wheat varieties to *S. oryzae* 2008.

S. No.	Varieties	Average per cent grain damage	Average per cent loss in weight
1.	RAJ-3765	36.88 (37.39)	11.59 (19.90)
2.	LOK-1	23.31 (28.87)	9.31 (17.76)
3.	RAJ-3077	60.94 (51.32)	15.02 (22.80)
4.	RAJ-3777	23.80 (29.20)	9.87 (18.31)
5.	MP-1203	66.15 (54.43)	18.92 (25.78)
6.	HI-8627	63.38 (52.76)	18.35 (25.36)
7.	MPO-1215	50.07 (45.04)	14.73 (22.56)
8.	RAJ-4161	36.50 (37.17)	11.49 (19.80)
9.	MP-4010	45.72 (42.54)	12.94 (21.08)
10.	RAJ-4164	33.99 (35.66)	10.64 (19.03)
SEm±		0.376	0.348
CD (5%)		1.086	1.004
C.V.		4.56	5.23

* Figures in parentheses are angular transformed values.

Table: 3. Growth and development of *S. oryzae* in stored wheat 2008.

Replication	Hatching period (days)	Larval period (days)	Pupal period (days)	Adult longevity (days)		Per cent adult emergence	Growth Index	Total life span (days)
				Male	Female			
R1	5.26	23.73	7.08	33.60	39.07	92.00	2.54	72.78
R2	5.20	23.54	6.75	32.44	38.73	96.00	2.70	71.87
R3	5.20	23.75	6.91	34.20	40.71	96.00	2.67	73.91
R4	5.25	23.91	7.00	33.09	39.23	96.00	2.65	72.50
Average	5.22	23.73	6.93	33.33	39.43	95.00	2.64	72.76

Table: 4. Effect of botanicals & inert materials on the adult emergence of *S. oryzae* at different storage period 2008.

S. No.	Treatment	Dosage (g/kg grain)	No. of adults released	No. of Adults emerged	
				60 days	90 days
1.	Black pepper powder	10	50	27.50	39.25
2.	Neem leaf powder	10	50	76.50	110.75
3.	Custard apple seed powder	10	50	28.25	37.50
4.	Cow dung ash	10	50	89.50	127.50
5.	Sand	25	50	218.00	277.25
6.	Diatomaceous earth	0.05 % (w/w)	50	0.00	0.00
7.	Control	-	50	262.25	403.00
SEm±				5.94	7.75
CD (5%)				17.49	22.81

Table: 5. Effect of different botanicals and inert materials on the mortality of *S. oryzae* in stored wheat 2008.

S. No.	Treatment	Dosage (g/kg grain)	Number of insects survived		Mortality (Per cent)	
			7 days	30 days	7 days	30 days
1.	Black pepper powder	10	7.25	5.00	84.76 (67.02)	89.35 (70.96)
2.	Neem leaf powder	10	11.25	8.75	76.34 (60.90)	81.67 (64.65)
3.	Custard apple seed powder	10	9.75	7.25	79.49 (63.07)	84.67 (66.95)
4.	Cow dung ash	10	18.00	16.50	62.09 (52.00)	65.27 (53.89)
5.	Sand	25	29.50	28.25	37.89 (37.99)	39.54 (38.96)
6.	Diatomaceous earth	0.05 % (w/w)	4.75	0.75	90.05 (71.62)	99.20 (84.88)
7.	Control	-	47.50	46.75	0.00 (0.00)	0.00 (0.00)
SEm±					0.98	1.65
CD (5%)					2.90	4.88
C.V.					3.92	6.09

* Figures in parentheses are angular transformed values.

Table: 6. Efficacy of different botanicals and inert materials against *S. oryzae* in stored wheat 2008.

S. No.	Treatment	Dosage (g/kg grain)	Number of damaged grain			Per cent grain damaged			Per cent net weight loss		
			30 days	60 days	90 days	30 days	60 days	90 days	30 days	60 days	90 days
1.	Black pepper powder	10	8.25	13.50	19.75	0.89 (5.40)	1.53 (7.04)	2.03 (8.18)	0.82 (5.18)	1.22 (6.32)	1.95 (8.02)
2.	Neem leaf powder	10	19.5	56.25	71.00	2.09 (8.29)	6.23 (14.44)	7.04 (15.38)	1.91 (7.94)	5.45 (13.49)	7.64 (16.04)
3.	Custard apple seed powder	10	9.25	14.75	19.00	0.53 (4.14)	0.75 (4.92)	1.43 (6.84)	0.48 (3.88)	0.79 (5.06)	1.39 (6.75)
4.	Cow dung ash	10	21.00	35.25	47.50	2.17 (8.43)	3.75 (11.16)	4.82 (12.68)	2.21 (8.54)	3.45 (10.70)	4.88 (12.76)
5.	Sand	25	43.25	95.50	140.25	4.65 (12.45)	10.46 (18.87)	13.24 (21.33)	4.92 (12.81)	9.61 (18.06)	17.10 (24.42)
6.	Diatomaceous earth	0.05% (w/w)	4.25	0.00	0.00	0.42 (3.69)	0.00 (0.00)	0.00 (0.00)	0.38 (3.51)	0.00 (0.00)	0.00 (0.00)
7.	Control	-	68.25	134.25	158.00	7.48 (15.87)	14.82 (22.64)	14.88 (22.69)	8.70 (17.15)	14.12 (22.07)	19.65 (26.31)
SEm±			1.58	2.94	4.22	0.13	0.14	0.18	0.10	0.14	0.16
CD (5%)			4.65	8.66	12.43	0.40	0.44	0.54	0.30	0.41	0.48
C.V.			-	-	-	10.66	5.56	5.94	7.35	5.68	4.41

* Figures in parentheses are angular transformed value