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Physical and Biochemical Changes in Stored Maize due to Infestation of *Sitophilus oryzae* L.

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The present study was carried out to examine physical and bio chemical changes in the maize hybrids infested by rice weevil population after three months storage period. VH5 was most susceptible incurring 25.10 % weight loss while Shaktiman1 and RHM2 were moderately susceptible with minimum weight losses of 8.45%, 10.26 %, respectively. Carbohydrate and oil contents decreased after the infestation of *Sitophilus oryzae* while protein content increased irrespective of maize hybrids. Maximum depletion and changes in nutritional composition was observed in case of VH5. Correlation analysis between the progeny emerged and the starch content of the maize kernels showed positive association (0.5993) while it was negative with protein (-0.4615) and oil content (-0.8789).

Key words: *Sitophilus oryzae*, maize, grain damage, weight loss, bio chemical changes, nutritional losses

Post harvest losses occur due to delayed harvest, poor handling, poor shelling, in sufficient drying before storage, moisture in storage area and high relative humidity. The loss sustained by the Indian grain storage sector ranged from 6-33 percent in a single storage season. World wide grain losses in cereals during storage reach 50% of total harvest (Fornal *et al*., 2007). The storage pests can cause losses either directly through consumption of the grain or indirectly by creating favourable environment for the establishment of other pests/ moulds. Rice weevil (*Sitophilus oryzae* L.) is the most important post harvest insect pest on maize causing severe losses to farmers who store maize for food and seed. Early detection of grain infestation by *S. oryzae* is difficult as female weevil lays egg inside the cavity. Apart from physical loss in weight there are changes in colour, smell or taste, contamination with toxins, pathogens, insects, reduction in nutritional value and loss of viability. Since insects are uricotelic, they deposit crystalline uric acid on the grain as they multiply. Additional side effects of insect activity involve chemical changes in the kernel, altering the quantity and quality of carbohydrates, proteins, amino acids, fatty acids, and vitamins. Bergvinson (2004) observed that maize weevils can consume as much as 15% of a harvest in a few months and have the ability to reduce maize quality. Infestation by weevils commences in the field but most damage is caused during storage (Demissie *et al*., 2008). Keeping the destructive nature of the pest in view, the present study was conducted to determine the physical and biochemical changes in maize kernels induced by its infestation.

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Materials and Methods

Sitophilus oryzae weevils were reared in the laboratory on whole maize grains for ten generations and the emerging progeny of insects was used to establish the main culture according to Tefera *et al.* (2010). Adult weevils of one week old were used for the experiment. Thirty adult insects were introduced into plastic jars containing cleaned, well-sieved maize seeds 100g each of five hybrids namely Shaktiman1, RHM-1, RHM-2, VH5 and DHM117 and one inbred HKI 193. All the hybrids were kept in the deep freezer to ensure that any existing insect eggs and larvae are killed prior to the experiment. Each treatment was replicated thrice and kept for three months under ambient conditions. The jars were taken out and analysis were made after 90 days for insect population emerged, per cent infestation, grain weight loss, and biochemical changes induced by insect infestation. The following equation was used for determination of weight loss.

Percent Weight Loss = $(W\mu \times N_d) - (Wd \times N_\mu)/ W_\mu \times (Nd + N_\mu) \times 100$

W_μ = weight of undamaged grains

N_μ = number of undamaged grains

W_d = weight of damaged grains

N_d = number of damaged grains

Biochemical Analysis of maize samples

Nutritional changes of the infested grains induced by infestation of *S.oryzae* were studied for carbohydrate, crude protein, and oil contents. For this purpose, infested maize samples were cleaned

and sieved to remove insect body parts. The kernels were ground to powder by coarse and then fine grinding and defatted by petroleum ether and finally kept in dessicators for analysis. Protein content was determined by Micro-Kjeldahl method of AOAC (1970). Starch content was determined by using Anthrone reagent.Oil content was estimated by the method of AOAC using solvent extractor system.

Data analysis: The collected data were subjected to Analysis of Variance (ANOVA) and the comparisons of significant differences of mean values were done through Duncans Multiple Range test at 5% level of significance.

Results and Discussion

The results (Table 1) revealed that the emergence of F_1 progeny was different among maize hybrids. Minimum progeny emerged in Shaktiman-1 (140.00) followed by RHM2 (194.00) while it was higher in HKI193 (432.00) followed by RHM1 (421.00), VH5 (354.00) and DHM117 (315.00). The emergence of more number of progeny indicates that these maize hybrids favour the growth and development of *S.oryzae*. Shaktiman1 and RHM2 incurred 54.50 and 59.00 per cent grain damage, respectively and consistently recorded lowe damage levels compared to other genotypes which might be due to the less number of adult weevil emergence. Garcia *et al.* (2004) found that resistance of storage pests is controlled by kernel hardness. Bamaiyi *et al.* (2007) reported grain hardiness as the main resistance parameter to *S.oryzae*. The differences in grain damage between the remaining maize hybrids VH5, DHM 117, RHM1 and HKI 193 were smaller ranging between 82% to 91%, respectively. The maximum weight loss of 25.10 % occurred in VH5, while the minimum weight loss of 8.45%, 10.26 % was recorded in Shaktiman1 and RHM2, respectively. Similarly, higher number of live *S.oryzae* in these maize hybrids resulted in relatively higher percentage damage and weight loss.

Table 1. Infestation level of *S.oryzae* in stored maize genotypes

Genotype	No.of Progeny emerged	Per cent grain damage	Per cent grain weight loss
RHM2	194.00(13.73)[b]	59.00 (50.18)[b]	10.26 (18.64)[ab]
Shaktiman1	140.00(11.87)[b]	54.50 (47.58)[b]	8.45(16.75)[ab]
RHM1	421.00(20.52)[a]	85.00(67.31)[a]	12.09(20.32)[ab]
HKI 193	432.00(20.73)[a]	91.00(70.64)[a]	24.30(29.12)[a]
VH5	354(18.74)[a]	82.00(64.89)[a]	25.10(30.06)[a]
DHM117	315(17.69)[ab]	83.50(66.60)[a]	15.26(22.99)[ab]
SEm	1.36	2.76	2.75
CV	11.19	6.40	16.95

Figures in parentheses are square root (progeny emerged) and angular (% grain damage, % grain weight loss) transformed values.
Means followed by the same letter are not significantly different (P> 0.05) from each other.

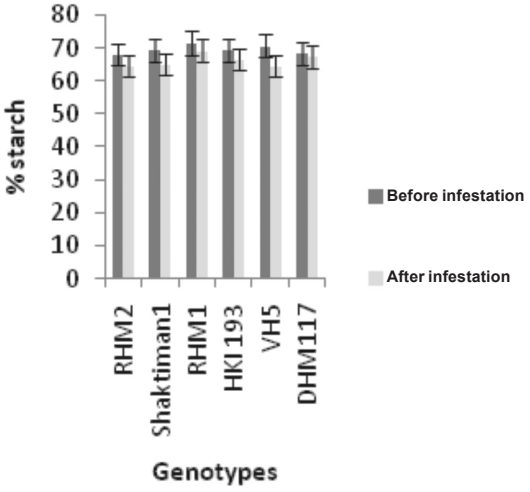

Fig.1 Starch level changes induced in stored maize by *S.oryzae*

Results of the present investigations revealed highly significant changes in nutritional composition of maize kernel of different maize varieties when subjected to artificial infestation. The results pertaining to starch level enunciated positive effect of *S.oryzae* infestation and the carbohydrate content of maize grains. Maximum reduction of 6.36% (Figure 1) was observed in VH5 having maximum progeny development and per cent grain weight loss followed by Shaktiman1 (4.29), RHM2 (3.60), HKI 193 (2.84), RHM1 (2.35) and DHM117 (1.16). Results showed a positive correlation coefficient between progeny development and carbohydrate contents (r=0.5993) with the infested grains. It is obvious from the values of correlation coefficient that reduction in carbohydrate content was not solely dependent upon the progeny development but depends on some other factors which include varietal resistance as well as insect preference. It is reported that storage pests cause considerable quantitative as well as qualitative losses and ultimately deteriorate nutritional contents (Neethirajan *et al*., 2007).

It is evident from Figure 2 that protein level increased after infestation by *S.oryzae*. A maximum increase of 8% was observed in VH5 followed by HKI 193 (4.69), Shaktiman 1(1.43), DHM117 (0.74), RHM1(0.62) and RHM2 (0.31). The results are in conformity with the findings of Mebarkia *et al*. (2010)

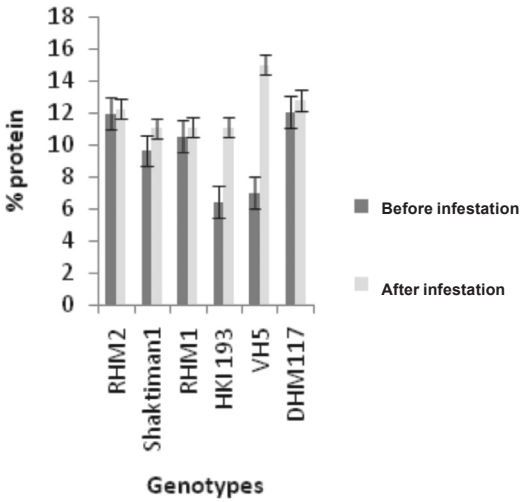

Fig. 2 Protein level changes induced in stored maize by *S.oryzae*

who reported high content of protein and low content of carbohydrate in wheat varieties due to infestation of *Sitophilus granarius.* Increase in crude protein contents in infested grains is attributed to the production of non beneficial rather harmful proteins such as cast skins, exuviae, dead insects, wings, legs and other body parts of the insects that come along with infested grain samples and also might be due to significant depletion of carbohydrate percentage. True proteins or beneficial proteins are actually reduced as the insect feeds on both endosperm and embryo causing quantitative and qualitative damage (Prabhakumary and Sini, 2008).

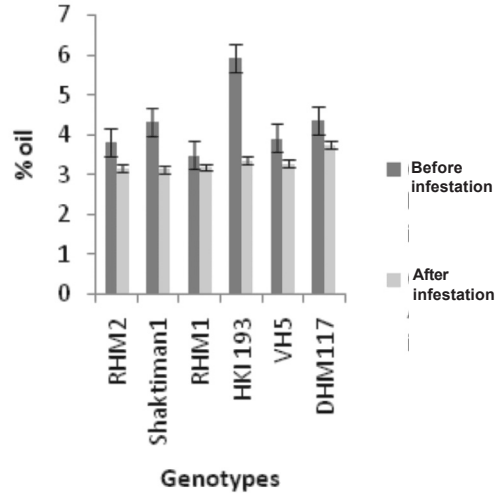

Fig.3 Oil level changes induced in stored maize by *S.oryzae*

There was negative correlation (-0.46155) between progeny development and protein content of maize grains. Oil content decreased after infestation of *S.oryzae* (Figure 3) irrespective of maize hybrids . A maximum of 2.57% was decreased in case of HKI 193 followed by Shaktiman1 (1.20), RHM2 (0.65), VH5(0.64), DHM117 (0.63) and RHM1(0.30). Present investigation showed a higher negative correlation (-0.87891) between progeny development and oil content of maize grains.

The results of these studies indicated that *S. oryzae* is a highly destructive storage insect pest that could cause grain weight loss between 8.45% and 25.10%, grain damage between 54.50% and 91.00% in infested maize grains within three months. As the carbohydrate and oil content of maize kernels are reduced due to rice weevil infestation, adequate preservation of stored maize grains from infestation by *S. oryzae* is therefore essential to reduce physical and nutritional losses during storage.

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