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ESTIMATION OF QUALITY DETERIORATION IN DIFFERENT RICE GENOTYPES INFESTED BY *TRIBOLIUM CASTANEUM* (HERBST) UNDER A BIOTIC STRESS

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ABSTRACT. Rice being a major crop of Pakistan contributes major part of our economy and provides energy to a major population. So study was carried out to determine potential of nutritive losses in six rice genotypes against red flour beetle, *Tribolium castaneum* (Herbst) at 28°C, 32°C and 35°C. For nutritive losses, crude protein, fiber, ash and moisture content was analyzed through proximate analysis after 90 days of beetle infestation. Results deduced from the present findings shown significantly ($P < 0.05$) substantial variations in nutritional composition of rice grains in some advanced rice genotypes when exposed to artificial infestation of red flour beetle. High moisture content was observed in KSK-133 and Basmati-2006 as compared to KSK-282. Loss in crude fat and protein were maximum in KSK-282 and minimum in KSK-133 and Basmati-2006. Crude fiber was significantly ($P < 0.05$) high where insect infestation was low and least value where maximum infestation caused by insect. Ash content was severely affected by destructive activity of insects in all genotypes. In aggregate qualitative losses were significantly ($P < 0.05$) high in KSK-133, Basmati-2006 and Basmati-515 and low in Basmati-385 and KSK-133 proving susceptible and resistance respectability, respectively. Findings should be incorporate in breeding programme and can also be helpful in post-harvest storage.

Key words: Qualitative losses; Red flour beetle; *Tribolium castaneum* (Herbst); Resistance; Rice genotype.

INTRODUCTION

Cereals grains are dietary mainstay of mankind and one quarter of energy is obtained from these cereals grains. Among cereals, rice, *Oryza sativa* L. is a major cultivated cereal crop in Pakistan and consumed all over the world particularly in Thailand, Filipina and Bangladesh etc. The physic chemical characters of the cereals like wheat is widely used in different food products (Anon., 2011). Cereal crops contain essential amino

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acids tryptophan, lysine, isolucine and threonine (Prasanna *et al.*, 2001). During post-harvest storage of the rice, some biotic impurities like paddy pathogens like fungus, bacteria and insect pests deteriorate the quality of the grains. As they make the stored commodity infested, lowering palatability, less valuable for bakery products and unfit for foreign export (Hall, 1970; Howe, 1965; Shafique and Chaudry, 2007).

After storage of the food grains different primary and secondary insects attack like red flour beetle, Khapra beetle, rice weevil, maize weevil, granary weevil, Angoumois grain moth, Indian meal moth and rice moth. Among all mentioned stored grain insects, red flour beetle, *T. granarium* is the most notorious pest of stored cereal commodities with respect to rice crop. Larvae of the adult beetle cause more damage.

Feeding the grain from one end, larvae infest the whole kernel producing high frass and severe damage to it (Parashar, 2006). Post-harvest losses due to the attack of stored grain insect pests are high in developing countries as compared to developed countries.

About one third part of world's food production become susceptible to more than twenty thousand pests species of both field and stored products. Attack of insects not only infests the stored commodity but also their exuviae, cadavers and frass contaminate the food as investigated by different scientists (Dubey *et al.*, 2008; Talukder, 2006; Shafique and Chaudry, 2007; Shafique and Ahmad, 2003).

Among all the infesting pathogens, insect pests play important role in the degradation of stored commodities. Like other developing countries, in Pakistan the storage losses due to insects have been recorded from 5-10 percent (Ahmad, 1980). Some reported 5-10% in cereals alone due to insects infestation in which rice weevil, *Sitophilus oryzae* L., Angoumois grain moth, *Sitotroga cerealella* (Olivier), lesser grain borer, *Rhyzopertha dominica* (F), red flour beetle, *Tribolium castaneum* (Herbst) and *Khapra beetle, Trogoderma granarium* (Everts) (Haq *et al.*, 1969). In Pakistan, annually, post production losses are about 5-10 % in *Oryza sativa* L. (Ahmad, 1994). So there is a need to estimate the losses against different management tactics to check their efficacy. Our aim of study was to estimate the quality losses in different rice genotypes to elaborate relative resistance against red flour beetle, *Tribolium castaneum* (Herbst).

MATERIALS AND METHODS

Preparations before qualitative analysis

The research was carried out in Grain Research, Training and Storage Management Cell of the Department of Entomology, University of Agriculture Faisalabad, during 2011 to 2013. In order to evaluate the relative resistance for nutritive losses, six rice genotypes viz: Super Basmati, Basmati-515, Basmati-2006, Basmati-385, KSK-133 and KSK-282 were used against red flour beetle, *Tribolium castaneum* (Herbst) at 28°C, 32°C, and 35°C temperatures. The samples of different rice genotypes varieties were taken from Rice Research Institute, Kala Shah Kaku. In the laboratory, material was treated with heat treatment, to eliminate any prior infestation before starting the experiment. Samples were washed with water and then dried in oven at high temperature to homogenize moisture. Sample of each genotype weighing 300 g were equally divided into three parts i.e. 100 g each and put in a 500 g capacity glass jars. Adults of red flour beetle were obtained from the reared stalk cultures and batches of 30 insects were released separately in each jar. The experiment was conducted in Factorial CRD with three replicates for each treatment in incubator maintained at 28°C, 32°C, 35°C and 60-65% R.H. Beetles were allowed to infest the grain samples for 90 days. After 90 days of the storage both live and dead insects along with their shaded skin, feces and frass were sieved out from all the samples.

Qualitative analysis

Nutritional changes of the infested grains induced by infestation of red flour beetle larvae as well as adults was studied for crude protein, crude fiber and ash contents using ICC and AOAC methods (Anon., 2000). For this purpose, infested 100gm sieved samples of rice were taken for determination of crude protein, fat, and fiber and ash contents. Some of the approximate analyses were also performed in Food Science and Technology Laboratory in University of Agriculture Faisalabad.

Chemical analysis

Chemical analysis included estimation at dry weight basis of protein, fat, crude fiber and ash.

Moisture

Moisture was determined by AACC (2000) method No. 44-19. Three gram rice flour was placed in preheated and weighed metallic dish and dried in a hot air oven at 130°C for 2 hours or till constant weight (Anon., 1975). The loss in weight was calculated as percentage of moisture content (percent MC) of rice.

$$\text{Percent MC} = \frac{\text{W1} - \text{W2} \times 100}{\text{Weight of sample}},$$

where MC= Moisture content; W1=Weight of rice sample and metal dish before heating; W2=Weight of rice sample and metal dish after heating.

Determination of percent ash

A five gram well mixed sample was weighed into a shallow, relatively broad dish that had been ignited, cooled in a desiccators and weighed soon after reaching at room temperature. The sample was later on ignited in a furnace at 550°C (dull read) for 4 hours minimum until the light gray ash resulted, which was cooled in a desiccators and weighed after reaching at room temperature with AOAC Method No. 923.03.

$$\text{Percent Ash} = \frac{\text{Weight of residue} \times 100}{\text{Weight of sample}}$$

Determination of percent crude protein

Crude protein is a conventional expression for the total content of nitrogenous compounds of the analyzed product, calculated by multiplying the corresponding total nitrogen content by factor of 6.5 for rice. Whereas nitrogenous compounds was calculated by oxidizing the organic matter of the sample with concentrated sulfuric acid in the presence of a catalyst: the product of the reaction $(NH_4)_2SO^4$ was treated by alkali; free ammonia was distilled and titrated with AOAC Method No. 979.09 (Anon., 2000).

Determination of percent crude fiber

Rice samples was gelatinized in the presence of heat stable alpha amylase, and then enzymatically digested with protease and amyloglucosidase to remove digestible protein and starch. Four volumes of ethanol were added to precipitate soluble dietary fiber. Total residue was filtered off and washed with acetone and ethanol. The residue was weighed after drying. The remaining material was analyzed for protein and ash content, respectively. Calculating the fiber by subtracting the amounts measured for protein, ash and a blank control from the dry weight of the filtered residue yielded a value for total dietary fiber content with ICC Standard No.156, 1994.

$$\text{Percent Crude Fiber} = \frac{\text{A} - \text{B} \times 100}{\text{Weight of Sample}},$$

where A = Weight of crucible and residue; B = Weight of crucible and ash.

RESULTS AND DISCUSSION

Qualitative losses due to voracious feeding of red flour beetle caused reasonable losses in protein, fat, fiber and ash contents in different rice varieties. Effect of temperature variation alone and in interaction was not effective in protein loss. As compare to control, Basmati-282 (6.93%) showed minimum protein loss at with Basmati-385 (6.71%) and Super Basmati (6.29%). Maximum protein loss calculated due to beetle infestation was in Basmati-2006 (4.77%) and KSK-133 (4.94%) as mentioned in *Table 1 and Fig.1*. Processing of cereals and pulses brought about 24.93 to 28.29 percent increase in protein digestibility (*in vitro*) of weaning mixtures. Among major a biotic factors of storage conditions, moisture contents play important role in the attack of pathogens (Hossain *et al.*, 2007). Why larger kernel size permitted less progeny production, it is unclear but we suppose that grain length may order a few number of developmental site per unit accumulation of grain (Arthur *et al.*, 2012). Similar conclusions were described by other workers, such as research conducted by Butt *et al.*, 1997, who reported substantial change in protein contents after one and half month of the experiment along with moisture contents. Hossain *et al.* (2007) reputed susceptibility for low protein content due to pericarp thickness and configuration of endosperm in hybrid genotypes.

While in case of crude fiber, considerably low fiber contents (0.46%) were find out at 35^{o}C but maximum (0.52%) at 28^{o}C at bar with 32^{o}C. As compare to control, crude fiber was (0.5867%), (0.53%), (0.52%), (0.51%), (0.38%) and (0.30%) in Basmati-2006, KSK-133, Basmati-515, Basmati-282, Basmati-385 and Super Basmati in ascending order, respectively. In case of mutual comparison, small amount of fiber was extracted from KSK-133 (0.25%) and Basmati-2006 (0.27%) at 32 and 35^{o}C at bar with other varieties as given in *Table 2, Fig.2*. In the same way like in crude fiber, carbohydrate was reported by previous workers, such as Hameed *et al.*, 1984, who concluded significant change in carbohydrate content in cereal grains due to the attack of stored grains insect pests. Reduction or increase in fiber contents may be due to loss or decomposition of carbohydrates in the rice grains. In like manner, such effect on fiber in maize was checked by Reed *et al.* (2007) and some scientists. Nasir *et al.* (2003) reported increase in fat deterioration with rise in moisture percentage. In the same way, Idler *et al.* (2012) called this breakdown as a result due to different storage structures like polyethylene bags and granary storage on the quality of cereal grains. In like manner, increase in fiber was directly related to the red flour beetle infestation during storage was reported by different workers, such as Jood *et al.* (1992), Hameed *et al.* (1984), Raza *et al.* (2010).

Table 1 and Figure 1 - Comparison* and regression line for mean values of the data regarding percent crude protein in various rice varieties infested by red flour beetle, *Tribolium castaneum* (Herbst) at 28°C, 32°C and 35°C

Treatments	Temperatures			Treatments means
	28°C	32°C	35°C	
KSK 282	6.63ab±0.26	6.87a±0.25	6.63ab±0.27	6.71AB
Basmati 385	6.73ab±0.27	6.47ab±0.26	5.87bc±0.28	6.36BC
Basmati 515	6.20ab±0.27	6.23ab±0.29	6.10ab±0.27	6.18C
Basmati 2006	4.97cd±0.25	4.50d±0.27	4.83d±0.26	4.77D
KSK 133	4.87d±0.26	4.90cd±0.28	5.07cd±0.27	4.94D
Super basmati	6.20ab±0.29	6.33ab±0.27	6.33ab±0.28	6.29BC
Control	7.00a±0.26	6.90a±0.27	6.90a±0.26	6.93A

*Mean values with different letter(s) in a column are significantly different at P≤0.05.

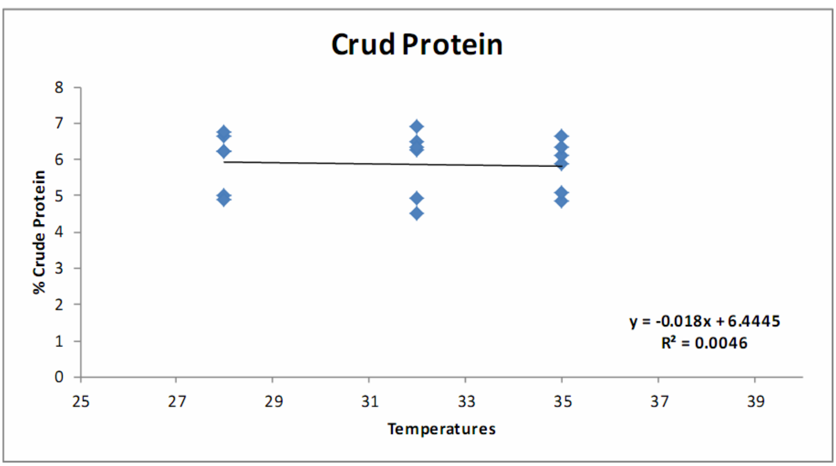
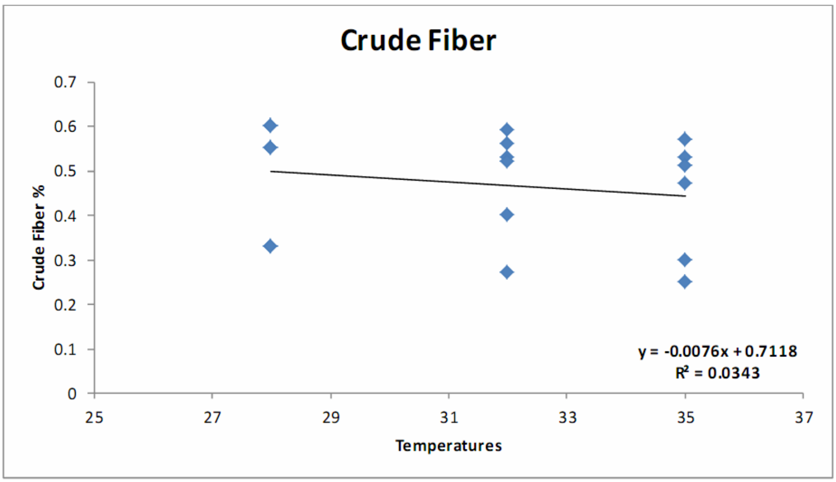


Table 2 and Figure 2 - Graphical and tabular representation concerning percent crude fiber in various rice varieties infested by *Tribolium castaneum* (Herbst) at 28°C, 32°C and 35°C

Treatments	Temperatures			Treatments means
	28°C	32°C	35°C	
KSK 282	0.60ab±0.056	0.59ab±0.055	0.57ab±0.057	0.58AB
Basmati 385	0.55ab±0.057	0.53abc±0.056	0.47abcde±0.057	0.51AB
Basmati 515	0.60ab±0.058	0.40bcde±0.058	0.53abc±0.057	0.51B
Basmati 2006	0.33cde±0.057	0.27e±0.058	0.30de±0.059	0.30C
KSK 133	0.33cde±0.056	0.56ab±0.057	0.25e±0.055	0.38C
Super basmati	0.55ab±0.058	0.52abc±0.056	0.51abcd±0.057	0.53AB
Control	0.65a±0.057	0.60ab±0.057	0.60ab±0.056	0.61A

*Mean values with different letter(s) in a column are significantly different at P≤0.05.

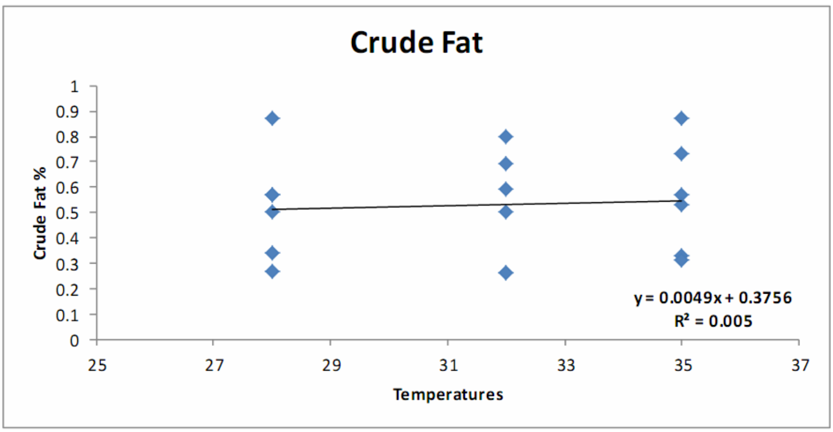


No effect of temperature variation and their interaction with treatments was effective in crude fat loss. Low fat contents were calculated in KSK-133 (0.28%) and Basmati-2006 (0.31%). While due to less infestation, high amount of fat was calculated in Basmati-282 (0.84%) following by Basmati-515 (0.66%). as given in *Table 3, Fig.3*. This decrease in fat may be as a result of enzymatic activity present in the grains due to variation in temperature and moisture, which change it into small units like simple fatty acids. Samuels and Modgil (2003) reported a significant relation between infestation and amount of crude fiber along with storage period. In the same way increase in crude fat was directly related to the red flour beetle infestation during storage was reported by different workers, such as Jood *et al.* (1992), Hameed *et al.* (1984), Raza *et al.* (2010).

Table 3 and Figure 3 - Mean values of the data on the subject of percent crude fat in different rice genotypes attacked by *Tribolium castaneum* (Herbst) at 28°C, 32°C and 35°C

Treatments	Temperatures			Treatments means
	28°C	32°C	35°C	
KSK 282	0.87ab±0.071	0.80abc±0.072	0.87ab±0.074	0.84A
Basmati 385	0.57cdef±0.072	0.59cde±0.073	0.57cdef±0.072	0.57BC
Basmati 515	0.57cdef±0.070	0.26h±0.072	0.73abcd±0.075	0.66B
Basmati 2006	0.34efgh±0.071	0.69bcd±0.074	0.33efgh±0.073	0.32D
KSK 133	0.50defgh±0.074	0.26h±0.076	0.33fgh±0.075	0.28D
Super basmati	0.27gh±0.073	0.50defgh±0.072	0.53cdefg±0.074	0.51C
Control	0.97a±0.070	0.97a±0.072	0.97a±0.071	0.97A

*Mean values with different letter(s) in a column are significantly different at P≤0.05.

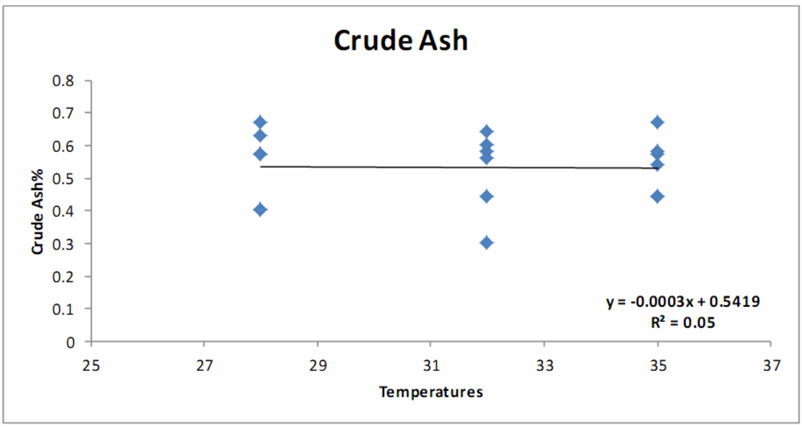


Ash content was significantly calculated in all rice genotypes. But no effect of temperature variation was observed in ash finding as shown in *Table 4, Fig.4*. Comparing to control, less ash contents were calculated in KSK-133 (0.38%) and Basmati-2006 (0.43%). While due to less infestation, High amount of ash content was calculated in Basmati-282 (0.66%). But interaction was non-significant indicating no combine effect of both. Overall results depicts that insect infestation has also affected the ash contents along with crude fiber, protein and fat). By the infestation of *S. zeamais* the quantity of fatty acid and uric acid is increased in grains and grains kernal involves in rancidity Infected grains decreases the rate of airflow through grains causes the deterioration of stored products (Hagen *et al.*, 1975).

Table 4 and Figure 4 - Data arranged a propos percent crude ash in various rice genotypes infested by *Tribolium castaneum* (Herbst) at 28°C, 32°C and 35°C

Treatments	Temperatures			Treatments means
	28°C	32°C	35°C	
KSK 282	0.67ab±0.039	0.64ab±0.035	0.67ab±0.036	0.66AB
Basmati 385	0.57bc±0.036	0.58bc±0.039	0.57bc±0.038	0.57C
Basmati 515	0.63ab±0.037	0.56bc±0.038	0.58bc±0.036	0.59BC
Basmati 2006	0.40de±0.038	0.44cde±0.036	0.44cde±0.037	0.42D
KSK 133	0.40de±0.039	0.30e±0.037	0.44cde±0.036	0.38D
Super basmati	0.57bc±0.037	0.60ab±0.039	0.54bcd±0.036	0.57C
Control	0.74a±0.039	0.69ab±0.036	0.69ab±0.038	0.70A

Mean values with different letter(s) in a column are significantly different at P≤0.05

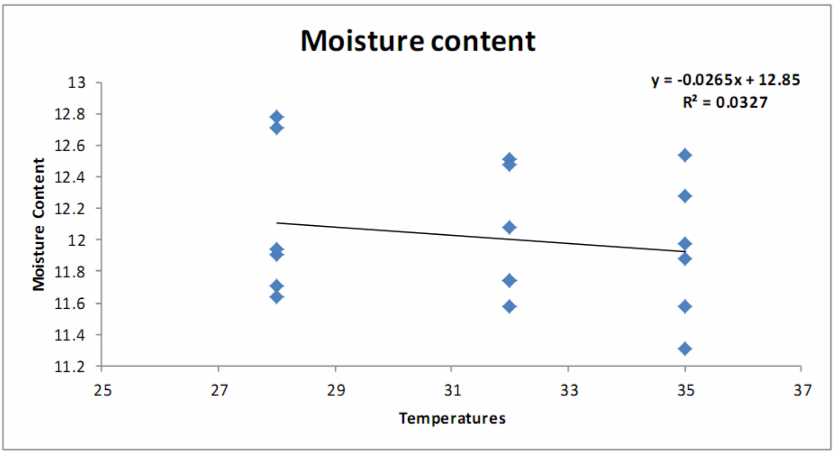


In the start of nutrient analysis moisture content of each genotype was calculated. Voracious feeding of red flour beetle was fortified due to high moisture contents in food grains, was significantly variable among all genotypes as shown in following *Table 5, Fig.5*. Effect of temperature variations was not so effective in the variation of moisture content. As compare to control, moisture content was high in KSK-133 (12.589%) and Basmati-2006 (12.489%) due to insect respiration and biochemical changes as given in the *Table 5*. The above result depicted that high infestation was occurred where the percentage moisture content was high. Moisture may be gain from the atmosphere. Chaudhry *et al.* (1987) reported that in cereal crops like wheat at low temperature moisture had gained from the jute bag. This moisture variation in all genotypes can also be corelate with moisture absorbance from biotic and a biotic factor like environment, volatile compounds in grains and insect respiration. Moisture contents influence the infestation and insect multiplication rate as reported by different workers, such as Longstaff *et al.* (1981).

Table 5 and Figure 5 - Moisture percentage in various rice genotypes infested by *Tribolium castaneum* (Herbst) at 28°C, 32°C and 35°C

Treatments	Temperatures			Treatments means
	28°C	32°C	35°C	
KSK 282	11.90cdefgh±0.168	11.57gh±0.168	11.30h±0.168	11.59C
Basmati 385	11.70efgh±0.168	11.73efgh±0.168	11.97cdefg±0.168	11.80BC
Basmati 515	11.63fgh±0.168	11.73efgh±0.168	11.57gh±0.168	11.64C
Basmati 2006	12.70ab±0.168	12.50abcd±0.168	12.27abcdef±0.168	12.49A
KSK 133	12.77a±0.168	12.47abcd±0.168	12.53abc±0.168	12.59A
Super basmati	11.93cdefgh±0.168	12.07bcdefg±0.168	11.87defgh±0.168	11.96B
Control	12.30abcde±0.168	12.47abcd±0.168	12.47abcd±0.168	12.41A

Mean values with different letter(s) in a column are significantly different at P≤0.05.



REFERENCES

Ahmad F.U., 1980 - Insect pest and their control in stored wheat. Pakistan Agriculture, (3): 9-10.

Ahmad M., 1994 - From the desk of editor-in-chief. Grain storage management newsletter, (2): 1-5.

Anon., 1975 - Official methods of analysis. Association of Official Agricultural Chemists, Washington DC, USA.

Anon., 2000 - Approved methods of American Association of Cereal Chemists. The American Association of Cereal Chemists. Inc., Saint Paul, Minnesota, USA.

Anon., 2011 - Global cereal supply and demand brief. Available online at http:// faostat.fao.org (Acessed on 27-3-2012).

Arthur F.H., Ondier G.O., Siebenmorgen T.J., 2012 - Impact of *Rhyzopertha dominica* (F.) on quality parameters of milled rice. J. Stored Prod. Res., 48: 137-142.

Butt M.S., 1997 - Physico chemical and protein composition of spring wheat in relation to end use quality. PhD. Thesis, Institute of Food Science and Technology University of Agriculture Faisalabad, Pakistan.

Chaudhry N.M., Ullah M., Anjum F.M., 1987 - Effect of storage conditions on grain quality characteristic of wheat. Pakistan J. Agric. Res., 1: 17-23.

Dubey N.K., Srivastava B., Kumar A., 2008 - Current status of plant products as botanical pesticides in storage pest management, J. Biopesticide, 2: 182-186.

Hagen, B.W., Atkins M.D., 1975 - Between generation variability in the fat content and behavior of Ipsparaconfuses Lanier. Zeitschrift fur angewandte Entomologie, 79: 169-172.

Hall, D.W., 1970 - Handling and storage of food grains in tropical and subtropical areas. FAQ, Rome, 350.

Hameed A., Qayyum H.A., Ali A., 1984 - Biochemical factors affecting susceptibility of flour wheat varieties to *Trogoderma granarium* (Everts). Pak. J. Entomol., 6: 57-64.

Haq H., Anwar M.S., Anisa B., 1969 - Control of Khapra beetle in larval stage by the use of malatian. J. Agric. Pak., 20: 279-286.

Hossain T., Boddupalli P.M., Sharma R.K, Kumar P., Singh B.B., 2007 - Evaluation of quality protein maize genotypes for resistance to stored grain weevil *Sitophilus oryzae* (Coleoptera: Curculionidae). Inter. J. Trop. Insect Sci. 27: 114-121.

Howe R.W., 1965 - Losses caused by insects and mites in stored food and feeding stuffs. Nature Abstract, 35: 285-293.

Idler C., Wagner, Weber A.U., Hoffmann T., 2012 - Effect of short term storage on quality of wheat stored in large polyethylene bags. Agric. Eng. Int. CIGR. J., 14: 149-156.

Jood S., Kapoor A.C., Singh R., 1992 - Biological evaluation of protein quality of maize as infected by insect infestation. Trop. Agric., 73: 161-164.

Longstaff B.C., 1981 - Biology of the grain pest species of the genus *Sitophilus* (Coleoptera: Curculionidae): a critical review. Prot. Ecology., 2: 83-130.

Nasir M., Butt M., Anjum F.M., Sharif K., Minhas R., 2003 - Effect of moisture on shelf life of wheat flour. International J. Agric. Bio., 4: 458-459.

Parashar M.P., 2006 - Post harvest profile of black gram. Govt. India, Ministry of Agric. Deptt. Agric. and Coop. Directorate of Marketing and Inspection, Nagpur-440001.

Prasanna B.M., Vasal S.K., Kassahun B., Singh N.N., 2001 - Quality protein maize. Current sci., 10: 1308-1319.

Raza S., Khalil S., Naseem K., Gilani M.A., Amjad M., Masud T., Naqvi S.M.S., 2010 - Effect of household storage receptacles on physic chemical characteristics of wheat. Sarhad J. Agric., 26: 275-287.

Reed C.D., Stella J., Brian, Anna G., 2007 - Response of storage molds to different initial moisture content of maize (corn) at 25^{o}C and effect on respiration rate and nutrient composition. J. Stored Prod. Res., 43: 443-45.

Samuels R., Modgil R., 2003 - Physico-chemical changes in insect infested wheat stored indifferent storage structures. Ind. J. Agric. Sci., 73: 562-563.

Shafique M., Ahmad A., 2003 - Susceptibility of milled rice genotypes to Angoumois grain moth. SAARC J. Agric., 1:193-197.

Shafique M., Chaudry M. A., 2007 - Susceptibility of maize grain to storage insects. Pak. J. Zool. 39:77-81.

Talukder F.A., 2006 - Plant products as potential stored product insect management agents: a mini review, Emirates J. Agric. Sci. 18:17-32.