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EFFECT OF SALT STRESSED WHEAT VARIETIES ON LIFE HISTORY OF *Tribolium castaneum* (Hebrst) (Tenebrionidae: Coleoptera)

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In the present investigation an attempt was made to determine the antibiosis of three salt stressed wheat varieties (Shafaq, Inqlab-91 and Sehar-2006) at three salinity levels (8, 12 and 16 dS m^{-1}) to red flour beetle, *Tribolium castaneum* (Herbst). The grains of three varieties were ground and sieved through 80 mesh. Life history parameters, i.e., larval and pupal durations and survivals, adult emergence, fecundity and egg hatching was observed by introducing 10 pairs of pupae, from previously reared beetles, on three varieties at their respective salt levels. One control was included with grains of the plants, which were irrigated with distilled water only. Results have shown that varieties had significant difference among the treatments for larval duration, which was significantly extended in different varieties at various salt levels. Mean longest larval duration (31.67 days) was recorded in Shafaq as respectively 8 (33.00 days), 12 (33.33 days) and 16 (30.33 days) dS m-1 salt level as compared to its control (31.00 days). Fecundity and egg hatching of *T. castaneum* differed among the wheat varieties irrespective of salt levels. In another experiment, response of SARC-1, SARC-2, SARC-3, SARC-4, SARC-5, SARC-6, SARC-7, SARC-8, LU-26S, to life history parameters of *T. castaneum* showed that significant difference in the number of eggs, hatching percentage, larval and pupal survival was found. The number of eggs was significantly lower in variety SARC 1 (126.00) followed by SARC 2 (128.75), SARC 3 (132.25) while was significantly higher in SARC 5 (151.75). Egg hatching percentage was lower in SARC 6 (39.38%) and significantly higher in SARC 5 (58.42%). Larval survival was significantly less in SARC 7 (36.99%) and more in SARC 1 (52.25%). Pupal survival was significantly lower in SARC 1 (20.54%) while higher in SARC 8 (42.11%). Based on results it may be stated that salt stressed wheat varieties have significant impact of the biology of *T. castaneum*.
Keywords: salt stress, wheat varieties, life history, *Tribolium castaneum*, flour

INTRODUCTION

Plants are subjected to various stresses, which they express by their response in the form of various biochemical changes in them, which may or may not beneficial to them. Salinity has a two-phase effect on plant growth, an osmotic effect due to salts in the outside solution and ion toxicity in a second phase due to salt build-up in transpiring leaves. Some of these responses are adaptive. The ability of variety; Kiran-95 to maintain optimum K level in addition to saline condition may be the reason of its better survival (Shirazi *et al*., 2002). Saline tolerant wheat genotypes had high proline accumulation, high K/Na ratio and less chlorophyll degradation as compared to sensitive ones (Khan *et al*., 2009).

Besides changes in inorganic constituents of the plants, protein levels of salt affected or tolerant varieties showed that the expression of more than 50% proteins was changed, but the difference between the genotypes in various categories of protein change (up-regulated, down-regulated, disappeared, and new-appeared) was only 1-8 % (Saqib *et al*., 2006). Activities of the enzymes, proteases, aminopeptidase and carboxypeptidase changed in seedlings of rice cultivars with different salt tolerances raised under increasing levels of NaCl salinity (Dubey and Rani, 1990). Total water-soluble carbohydrate (WSC), glucose, fructose, sucrose, and fructan content of stems (non-photosynthetic tissue) showed that tolerant genotypes accumulated more soluble carbohydrate than did sensitive ones (Kerepesi and Galiba, 2000). Increasing level of NaCl, from 50, 100, 150 to 200 mM, reduced the germination percentage, the growth parameters (fresh and dry weight), potassium, calcium, phosphorus and insoluble sugars content in both shoots and roots of 15-day old seedlings in barley (*Hordeum vulgare* cv Gerbel) (El-Tayeb, 2005). The inhibitory effect of salinization of soil with Na_2SO_4, $CaCl_2$, $MgCl_2$, and NaCl (70:35:10:23) on nitrate reduction rate (via nitrate reductase activity) was more pronounced at the reproductive stage than at the vegetative stage of three wheat (*Triticum aestivum* L.) cultivars ('LU-26S,' 'Sarsabaz' and 'Pasban-90') (Iqbal *et al.,* 2006). Salt-tolerant variety LU-26S had ability to maintain a higher grain weight in the saline soil

(Ahmad *et al*., 2005). Salinity (electrical conductivity 0.9, 5.7, 11.5, or 21.5 mS cm^{-1} in potted rice plants provided with seawater from 10 days after transplanting (DAT) to 35 DAT, and from 75 to 100 DAT) decreased the contents of sugars and proteins, dry mass, and rate of dry mater accumulation in developing grains (Sultana *et al*., 2002).

Some physical and biochemical properties of the cultivars have been assessed to determine their respective level of resistance to the stored grain insects such as *Rhyzopertha dominica* (F.) and *Trogoderma granarium* (Everst). The resistance of these cultivars to *R. dominica* infestation might be attributed to the low content of protein and high content of carbohydrate compared to susceptible cultivars. Kernel hardness, gluten / amylose content, larval and adult preference and emergence showed difference between resistant and susceptible cultivars (Sayed *et al*., 2006; Mebarkia *et al*., 2009; Batta *et al*., 2007; Chanbang *et a*l., 2008). Though very little is known about the biochemical changes in the grains of salt stressed wheat, rice, maize and millet varieties. The response of stored grains insect pests to these changes in varieties has not been reported.

The varieties of wheat show different level of infestation of *Tribolium castaneum* (Herbst). The infestation levels have been studied on the whole grain or flour made from these grains. Mostly these studies included whole grain. Population buildup of pest insects was index of infestation and resistance in these varieties. The infestation levels were also correlated with biochemical characters of varieties. Further, varieties were grown under optimum growing conditions on high fertile soil (Latif *et al*., 1991; Ishtiaq *et al*., 1997; Renteria *et al.*, 2000; Syed *et al*., 2001; Ahmed *et al*., 2002). Development of varieties for saline soil has been carried out and a number of varieties / lines have been developed. Again, these studies were based on agronomic success of the varieties on saline soils (Yaseen *et al*., 2004; Hussain and Riaz, 2005). Performance of the salt stressed varieties in storage in the presence of insect pests has not been studied; similarly none is available on response of flour made from these varieties towards life history of insect pests of storage. The present project has been designed to determine the effect of salt stressed wheat grains on the biology of *Tribolium castaneum* (Herbst).

MATERIALS AND METHODS

The research work was conducted in the Toxicology Laboratory, Department of Agricultural Entomology, University of Agriculture, Faisalabad. The grains of salt stressed (at 15-20 dS m^{-1} salt levels) wheat varieties viz; SARC-1, SARC-2, SARC-3, SARC-4, SARC-5, SARC-6, SARC-7, SARC-8, LU-26S, were obtained from the Experimental Area of Saline Agriculture Research Cell in the Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad, . The grains of three varieties, Shafaq, Inqlab-91 and Sehar-2006 at salt levels of 8, 12, 16 dS m^{-1} were obtained from Botanical Garden, University of Agriculture, Faisalabad. All varieties were planted in pots and were irrigated with salt solution as and when required. Control treatment in this case was varieties irrigated with distilled water only. The sound grains of these varieties were acclimatized in the laboratory for a period of 20 days until all of them acquired almost equal moisture level, which was tested through Riceter (standard moisture tester).

The grains of these wheat varieties were grounded by an electrical grinder (Anex Mode AG1046) for 20 seconds. The stock culture of *T. castaneum* (Herbst) was maintained in flour (Taj Mahal flour, Faisalabad) + yeast mixture at 30-32°C and 70% RH. In this way fresh culture for the experiment was obtained. F1 of the beetles collected from this stock was reared on flour of each variety at respective salt level. Plastic bottles of capacity 100 g was purchased from local market. The plastic bottles containing 20 g flour of each variety and salt level along with control comprised of a treatment. The whole experiment was replicated four times in CRD.

Ten pairs of pupae (both male and female) of *T. castaneum* were introduced in each plastic bottle having 20 g flour of salt stressed varieties and mouth of bottle was covered with muslin cloth held in place by the rubber bands, after sieving through mesh size 60. The data were recorded twice a week on the following parameters.

1. Hatching percentage**:** the number of grubs from 100 eggs in the reported time.
2. Egg hatching period**:** time between placing of eggs and emergence of first grub.
3. Larval period**:** emergence of first grub to formation of first pupa.
4. Pupal period**:** formation of pupae to emergence of first adult.
5. Larval survival**:** the number of larvae transformed into pupae.
6. Pupal survival**:** the number of pupae meta-morphosed into adult.

The collected data were analyzed statistically, by ANOVA using LSD test for separation of means.

RESULTS

***Experiment No. 1*:** Duration of larval period (days) was significantly different in three wheat varieties. Longest and statistically different larval period as (31.67 days) was recorded in Shafaq followed by Inqlab-91 (23.15 days) and Sehar-2006 (21.08 days) varieties; latter two varieties had a non significant difference between each other. Interaction between varieties and salt levels showed a slight increase in larval period but it was statistically non significant. Larval period (27.22 days) was longest at 12 dSm^{-1} salt level, and was significantly different from the control (Table 1).

Fecundity was affected by both the varieties and salt levels. Inqlab-91 and Sehar-2006 had no significant difference between each other, and latter two had significant difference with Shafaq variety having maximum number of eggs (113.58). The fecundity was statistically apart at different salt levels, however, number of eggs were less as compared to control. Interaction between varieties and salt levels showed statistically significant difference of Shafaq with Inqlab-91 and Sehar-2006 (Table 2). The same effect was recorded in egg hatching percentage, the Shafaq being highest (71.08%) as compared to Inqlab-91 and Sehar-2006 (64.12 and 60.17%, respectively). Interaction between varieties and salt levels showed the lowest (50.20%) hatching in Sehar-2006 at 12 dSm^{-1} salt level (Table 3).

Table 1. Larval period (days) of *T. castaneum* at different levels of three salt stressed varieties

Varieties	Control	Salt levels (dSm^{-1})			Means
		8	12	16	
Shafaq	31.00 abc	33.00 a	32.33 ab	30.33 abc	31.67 a
Inqlab-91	20.33 d	23.67 bcd	25.66 abcd	24.00 bcd	23.15 b
Sehar-2006	20.00 d	21.00 d	23.67 bcd	19.66 d	21.08 b
	23.78 b	25.67 ab	27.22 a	24.66 ab	

Table 2. Fecundity of *T. castaneum* at different levels of three salt stressed varieties

Varieties	Control	Salt levels (dSm^{-1})			Means
		8	12	16	
Shafaq	100.00 abc	106.33 abc	124.33 a	123.67 a	113.58 a
Inqlab-91	112.67 ab	86.33 bcd	85.33 bcd	75.00 cd	89.83 b
Sehar-2006	110.67 ab	95.67 abc	55.00 d	96.00 abc	89.33 b
	107.78 a	88.22 a	96.11 a	98.00 a	

Table 3. Egg hatching in *T. castaneum* at different levels of three salt stressed varieties

Varieties	Control	Salt levels (dSm^{-1})			Means
		8	12	16	
Shafaq	62.57 cde	75.88 a	75.86 ab	70.01 abc	71.08 a
Inqlab-91	70.76 abc	63.59 bcd	59.99 cde	62.14 cde	64.12 b
Sehar-2006	65.07 abcd	54.64 de	50.20 e	70.75 abc	60.17 b
	67.53 a	56.13 a	64.70 a	64.02 a	

Table 4. Number of eggs, hatching percentage, larval and pupal survival of *T. castaneum* in different salt stressed wheat varieties

Varieties	Number of eggs	Hatching percentage	Larval survival	Pupal survival
SARC-5	151.75 a	58.42a	45.28cd	29.55bc
SARC-7	146.25 b	47.61c	36.99f	27.71cd
SARC-6	146.00 b	39.38d	48.09bc	36.95a
SARC-4	143.00 bc	55.31ab	43.20de	31.21bc
LU-26S	138.75 cd	54.82ab	50.47ab	32.62ab
SARC-8	137.50 d	43.03d	40.56ef	42.11de
SARC-3	132.25 e	42.03d	45.32cd	31.04bc
SARC-2	128.75 ef	41.13d	40.30ef	22.73e
SARC-1	126.00 f	53.19ab	52.25a	20.54e

***Experiment No. 2*:** Statistically significantly difference in the number of eggs was found among varieties. Significantly highest number of eggs (151.75) were laid in SARC 5 and the lowest (126.00) in SARC 1, latter being at par statistically with SARC 2; there was non significant difference among LU-26S, SARC 4 and SARC 8. Hatching percentage though highest in SARC 5 (58.42%) but there was no significant difference with SARC 4, LU-26S and SARC 1. Egg hatching was non significant among SARC 6, SARC 8, SARC 3 and SARC 2, as well. SARC 1 had significantly higher larval survival (52.25%) and had non-significant difference with LU-26S (54.82%). SARC 6 had significant highest pupal survival (36.95%) which was statistically at par with LU-26S (Table 4).

DISCUSSION

Antibiosis of salt stressed wheat varieties to red flour beetle, *T. castaneum* in both experiments showed that the varieties differed significantly in the rate of fecundity and hatching percentage ($P<0.05$). Earlier studies have shown this effect when stored grain insects other than *T. castaneum* were fed on sound grains of different wheat varieties. *T. castaneum* cause little damage to these grains. Wheat flour was used for determination of difference in life history parameters of the beetle, thus two feeding media, i.e., sound grains and wheat flour, can be related for comparison. None of varieties reported elsewhere was totally resistant when insects were fed on sound grains. However, biology of the tested insects varied significantly. Conventional index of susceptibility / resistance, grain damage and weight loss, was not recorded as main focus of this study was biology of *T. castaneum* in wheat flour.

Pupal duration, larval and pupal survival, adult emergence and larval weight had no significant difference among varieties and their interaction with salt levels (data not shown). Statistically significant difference was found in larval duration among varieties and salt levels. Larval duration was increased at 8 and 12 dS m^{-1} salt level but not at 16 dS m^{-1}; latter had non significant difference with control. Low salt levels showed longer larval duration than high salt level which indicates biochemical changes in varieties due to salinity had affected fecundity of the beetle.

Although, major insect nutritional requirements for growth and reproduction are known for years, only a few dozen insects have been studied to learn their nutritional requirements. Extraordinary nutritional requirements were found in a few insects from even these few studies (Genc, 2006). Vitamin E is required for reproduction in some insects, which improves the fecundity of some moths and beetles (McFarlane, 1992). *Tribolium* sp. can use starch, mannitol, raffinose, sucrose, maltose and cellobiose, as well as various monosaccharides. *Tenebrio*, *Ephestia*, and *Oryzaephilus* require carbohydrate source to attain maturity. *Tenebrio* sp. stops their development unless carbohydrate content should be at least 40% of the diet, and growth is the best with 70% carbohydrate diet (Chapman, 1998). Though change in protein has been found non significant among salt stressed varieties (Saqib *et al*., 2006) but estimates on other constituent, carbohydrates, fats, amino acids etc. are lacking.

Flour extraction has significant effect on fecundity of *Tribolium destructor* Uytt. It was shown that 85 % extraction flour leads to about double the fecundity found on 60 or 75% extraction flour. The pre-oviposition period is shown to be affected by both larval and adult food (Reynolds, 2008). The flour extraction does not seem to be factor for difference in fecundity of *T. castaneum* as control treatment was similarly sieved as salt treatments.

Ionic balance of salt stressed varieties is disturbed (Kerepesia and Galiba, 2000; Ahmad *et al*., 2005; Shirazi *et al*., 2002; Khan *et al*., 2009) and these inorganic elements can be the source of difference in fecundity as a number of enzymes are dependent upon these elements. This factor can be future course of study to find out the difference in fecundity of the beetle, reared in medium of salt stressed wheat flour.

The varieties of wheat show different level of infestation of *T. castaneum*. These varieties were grown under optimum growing conditions on high fertile soil (Latif *et al*., 1991; Ishtiaq *et al*., 1997; Renteria *et al.*, 2000; Syed *et al*., 2001; Ahmed *et al*., 2002). Development of varieties for saline soil has been carried out and a number of varieties / lines have been developed. These studies were based on agronomic success of the varieties on saline soils (Yaseen *et al*., 2004; Hussain and Riaz, 2005). Performance of nine (SARC-1, SARC-2, SARC-3, SARC-4, SARC-5, SARC-6, SARC-7, SARC-8, LU-26S) varieties in second experiment has not been studied for the insects of stored grains which feed on sound grains, which might help to compare the results on *T. castaneum*.

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