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Resistance of different wheat genotypes to *Sitophilus oryzae* L. (Coleopteran: Curculionidae)

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ABSTRACT

A study was conducted for screening the wheat genotypes against the rice weevil (Sitophilus oryzae L.) infestation. The experimental material of the study consisted of 3 susceptible (PBN51, K76 and K77) and 3 resistant (K20, K21 and K50) wheat genotypes along with their F_{1s}, F_{2s}, BC_{1s}, BC_{2s}. All together 66 entries from six generations were screened against the infestation of rice weevil in controlled laboratory conditions. The analysis of variance indicated significant difference among different treatments for weevil infestation. The seed from various generations were classified as resistant or susceptible according to their reaction to weevil infestation. In vitro screening of wheat genotypes against rice weevil revealed that the genotypes which showed resistant reaction were those having least susceptibility index and a minimum of infestation percentage, weight loss and frass mass. It was also noticed that the resistant genotypes possessed both higher content of protein and grain hardness index.

Key words: *Wheat, rice weevil, resistance, screening*

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is the second most important and staple crop in India with a 97.44 million tonnes of wheat from an area 30.72 million hectare during 2016-17 [1]. Phenomenal increase in wheat production and productivity has been achieved with the advent of high yielding improved varieties. One of the most important reasons for this success has been the relatively pest free field conditions of wheat. Producers should consider varietal suitability for long term storage when selecting crop varieties. Farmers keep their produce in homemade storage primarily to increase the net value of the crop selling when prices are more favourable. However, grain price is determined in part by test weight, absence of insects and damage caused by insects. Wheat is quite susceptible to storage pests which cause substantial qualitative (nutritional) and quantitative losses of various magnitudes depending on the pest species and duration of storage [24]. In Indian subcontinent, however wheat is heavily infested by a number of insect pests in storage, among these, *Sitophilus oryzae* (L.), *Rhizopertha dominica* (F.) and *Trogoderma granarium* Everts. are most important. The rice weevil is a pest of economic importance causing losses in weight, deterioration of quality and facilitating the development of micro-organisms in stored cereals.

Unfortunately, wheat varieties are not developed for their ability to resist insect attack at postharvest. Yield, adaptability to specific growing conditions, quality parameters and resistance to diseases and post-harvest insect-pest infestation are the main breeding objectives in wheat. Many studies document the differential susceptibility to post harvest insect to the wheat [23, 26]. The present investigation were undertaken to screen out wheat seeds resistance against rice weevil which were developed in order to identify genotypes which has resistance.

MATERIALS AND METHODS

The present investigation was carried out at N. E. Borlaug Crop Research Center and Wheat Grain Quality Laboratory, G. B. Pant University and Agriculture and Technology, Pantnagar, Uttarakhand. The experimental material of the study consisted of 3 susceptible (PBN51, K76 and K77) and 3 resistant (K20, K21 and K50) wheat genotypes. These genotypes were crossed in half diallel format to get fifteen possible single crosses. The single crosses were further used to obtain BC_{1s} and BC_{2s} and F_{2s} generations. All the six generations (P_1, P_2, F_1, F_2, BC_1, BC_2) *i.e.* 66 genotypes were screened against the infestation of *Sitophilus oryzae* L. under controlled laboratory conditions. The seed from various generations were classified as resistant or susceptible according to their reaction to weevil infestation. Each treatment was replicated thrice and the whole experiment twice. A standard no choice progeny test was conducted under uniform condition of temperature, relative humidity and grain moisture [16, 18]. The adult of *Sitophilus oryzae* (L.) was reared on grain of wheat varieties PBW343. Before use, the test entries of wheat were disinfected in the oven at 60^{o}C temperature for 12 hours. After disinfection the moisture content of wheat seeds was measured and raised to 13.5% by the mixing water in the seeds.

The experiment was conducted for screening of resistance in wheat genotypes/lines against *Sitophilus oryzae* under laboratory condition. The experiment was performed in incubator at 27±1^{o}C temperature and 70 ± 5% relative humidity. Twenty seeds from each genotype were filled in 50 ml plastic vials i.e. 5 x 2.5 cm size and three pairs of unsexed *S. oryzae* aged 0 to 7 days old were released in each vials, then closed with cap and each genotypes replicated three times. The whole experiment was conducted in an incubator for their progeny development. After one month the total number of insects developed from each vials was counted. The parameters mentioned below were estimated as follows:

Weight loss

The infested grains in each vials, have been sieved to separate grain dust, exuviate and other excretions added due to *S. Oryzae* infestation. For this purpose number and weight of damaged and undamaged grains were recorded and put in the following equation for calculation of weight loss [11].

$$\text{Percent weight loss} = \frac{(W\mu \times Nd) - (Wd \times N\mu)}{W\mu \times (Nd + N\mu)} x\ 100$$

Wμ = weight of undamaged grains
Nμ = number of undamaged grains
Wd = weight of damaged grains
Nd = number of damaged grains

Weight of Frass

While determination of weight loss, the weight of exuviae, flour dust, dead as well as alive adult and immature stages of weevil and those of other excretions produced during infestation were measured and collectively termed as 'weight of frass' of the respective sample of each variety.

Comparative resistance of wheat varieties

The rate of progeny development indicated by the number of larvae produced in each sample, percentage of infested grains and weight loss were considered as an expression of comparative resistance of each variety to the weevil infestation.

Percent of infestation

After removing the frass, sample of cleaned grain was drawn from each replication of the respective wheat variety. The grains were counted for insect damaged for percent infestation by using the following equations:

$$\text{Percent of infestations} = \frac{\text{No. of insect damaged grains}}{\text{Total number of grains in the sample}} x\ 100$$

Index of susceptibility

The index of susceptibility was calculated using the method of Dobie [7] and modified by Gudrups *et al.* [10], Pixley and Dhliwayo [17] and Derera *et al.* [5]. This involves the number of F_1 progeny and the length of median developmental time.

$$\text{Index of susceptibility} = \frac{log\,e \text{ x total number of F1 progeny emerged}}{\text{median development time}} \text{ x } 100$$

The susceptibility index, ranging from 0 to 10, was used to classify the wheat genotypes.

Statistical procedures

The data was analysed in Complete Randomized Design after suitable transformation log√(x+1) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The experimental material was consisted of a total of 66 genotypes from six generations including parents (P_1, P_2), F_{1s}, F_{2s}, BC_{1s} and BC_{2s}. There were significant differences in the susceptibility of wheat genotypes to *Sitophilus oryzae* L. (Table-1) with lowest (0.0) and highest (14.76) susceptibility index (SI) values being for parent K 20 and BC_2 4 cross of K 76/K 77/K77 respectively. The present genotype, K 20 showed the least index of susceptibility and was regarded as resistant followed by K21 and K50. The other three genotypes have maximum SI and were rated as susceptible. Thirteen cross combination in different generations viz., in F_1 (PBN 51 x K 20, PBN 51 x K 21, K 76 x K 20, K 76 x K 21, K 76 x K 50, K 20 x K 21 & K 20 x K 50); in F_2 (PBN 51 x K 20); in BC_1 (PBN 51/K 77//PBN 51, PBN 51 /K 76// PBN 51 & PBN 51/K 50//PBN 51) and in BC_2 (K 20/K 21//K 21 &K 20/K 50//K 50) were resistant. While 22 cross combinations of test entries of different generations namely, in F_1 (PBN 51 x K 50, K 77 x K 20, K 77 x K 21, K 77 x K 50 & K 21 x K50); in F_2 (PBN 51 x K 21, PBN 51 x K 50, K 76 x K 20, K 76 x K 21, K 77 x K 20, K 20 x K 21, K 20 x K 50 & K 21 x K 50); in BC_1 (PBN 51/ K 20//PBN 51, K 76/K 20//K 76 & K 77/K 21//K 77) and in BC_2 (PBN 51/K 20//K 20, PBN 51/K 21//K 21, PBN 51/K 50//K 50, K 76 x K 20//K 20, K 76/K 21//K 21, K 77/K 20//K 20, K 77/K 21//K 21, K 77/K 50//K 50 & K 21/K50//K 50) were found moderately resistant out of the total 66 cross combinations.

Table 1: Susceptibility Index (SI), % of weight loss, % of infestation and frass weight of wheat genotypes against *Sitophilus oryzae* L.

S.No.	Generations	Susceptibility Index	% Wt. Loss	% of Infestation[$]	Frass wt. (mg)
1	**P_1 (PBN 51)**	10.14	34.63	100.00 (4.72)	106.67
2	**P_2 (K 76)**	9.71	31.58	100.00 (4.62)	100.00
3	**P_3 (K 77)**	9.36	30.03	93.33 (4.55)	91.67
4	**P_4 (K 20)**	0.00	0.00	0.00 (0.00)	0.00
5	**P_5 (K 21)**	0.91	0.80	6.67 (1.99)	3.33
6	**P_6 (K 50)**	2.17	0.75	10.00 (2.32)	9.00
7	**F_1 1 (PBN 51 x K 20)**	0.00	0.04	0.00 (0.00)	0.00
8	**F_1 2 (PBN 51 x K 21)**	1.22	3.16	03.33 (2.65)	20.00
9	**F_1 3 (PBN 51 x K 50)**	3.77	2.76	4.65 (3.48)	19.00
10	**F_1 4 (PBN 51 x K 76)**	10.44	32.17	100.00 (4.33)	116.67
11	**F_1 5 (PBN 51 x K 77)**	10.52	37.50	86.65 (4.45)	106.67
12	**F_1 6 (K 76 x K 20)**	1.93	5.94	1.75 (2.03)	15.00
13	**F_1 7 (K 76 x K 21)**	1.58	5.16	2.35 (1.94)	18.33
14	**F_1 8 (K 76 x K 50)**	1.03	1.46	5.35 (1.40)	20.00
15	**F_1 9 (K 76 x K 77)**	8.30	36.08	93.00 (4.54)	120.00
16	**F_1 10 (K 77 x K 20)**	3.19	5.16	5.15 (2.34)	35.00
17	**F_1 11 (K 77 x K 21)**	3.93	2.43	3.35 (2.72)	26.67
18	**F_1 12 (K 77 x K 50)**	4.46	4.36	4.85 (2.90)	33.33
19	**F_1 13 (K 20 x K 21)**	0.43	0.00	0.00 (0.00)	0.00
20	**F_1 14 (K 20 x K 50)**	2.58	2.27	1.68 (1.40)	5.67
21	**F_1 15 (K 21 x K 50)**	3.93	2.50	5.00 (2.52)	9.33
22	**F_2 1 (PBN 51 x K 20)**	2.68	5.92	18.33 (1.81)	14.33
23	**F_2 2 (PBN 51 x K 21)**	3.08	7.44	20.00 (1.87)	16.67
24	**F_2 3 (PBN 51 x K 50)**	3.50	9.54	16.67 (3.42)	21.67
25	**F_2 4 (PBN 51 x K 76)**	9.84	23.74	83.33 (4.50)	93.33
26	**F_2 5 (PBN 51 x K 77)**	9.46	23.26	63.88 (4.28)	90.00
27	**F_2 6 (K 76 x K 20)**	5.58	7.24	61.67 (3.58)	34.33
28	**F_2 7 (K 76 x K 21)**	3.75	4.65	10.00 (2.41)	15.00
29	**F_2 8 (K 76 x K 50)**	6.98	12.41	25.00 (3.62)	22.67
30	**F_2 9 (K 76 x K 77)**	10.82	26.20	62.22 (4.49)	130.00
31	**F_2 10 (K 77 x K 20)**	4.23	8.66	20.00 (3.08)	18.33
32	**F_2 11 (K 77 x K 21)**	6.85	10.16	25.00 (2.86)	30.00
33	**F_2 12 (K 77 x K 50)**	6.79	9.22	23.33 (2.92)	33.33
34	**F_2 13 (K 20 x K 21)**	3.06	10.61	8.88 (1.39)	14.33
35	**F_2 14 (K 20 x K 50)**	4.58	16.09	10.55 (2.32)	16.33
36	**F2 15 (K 21 x K 50)**	4.81	7.62	11.17 (2.32)	20.00
37	**BC 1 1 (PBN 51/K20//PBN51)**	5.08	5.61	46.36 (2.52)	30.00
38	**BC 1 2 (PBN 51/ K21//PBN 51)**	6.40	9.61	44.48 (2.99)	40.00
39	**BC 1 3 (PBN 51/K 50//PBN 51)**	6.63	17.85	48.33 (3.08)	30.00
40	**BC 1 4 (PBN 51/K76//PBN 51)**	10.45	25.11	97.33 (4.23)	123.33
41	**BC 1 5 (PBN 51/K 77//PBN 51)**	9.41	17.67	53.33 (4.40)	103.33
42	**BC 1 6 (K 76/K20//K 76)**	5.60	16.20	42.50 (3.03)	50.00
43	**BC 1 7 (K 76/K 21//K 76)**	6.23	6.38	25.00 (3.20)	26.67
44	**BC 1 8 (K 76/K50//K 76)**	6.62	17.22	39.18 (3.16)	20.00
45	**BC 1 9 (K 76/K 77//K 76)**	9.61	37.25	93.33 (4.29)	90.00
46	**BC 1 10 (K77/K 20//K77)**	6.50	5.46	46.68 (1.81)	16.67

47	**BC 1 11 (K 77/K21//K 70)**	3.87	7.52	43.33 (2.41)	20.00
48	**BC 1 12 (K 77/K 50//K 77)**	6.93	15.27	45.00 (2.76)	23.33
49	**BC 1 13 (K 20/K 21//K 20)**	1.58	11.40	6.33 (2.54)	11.33
50	**BC 1 14 (K 20/K 50//K 20)**	2.03	2.18	7.50 (2.70)	12.33
51	**BC 1 15 (K 21/K 50//K 21)**	2.23	8.28	9.18 (2.59)	15.00
52	**BC 21 (PBN 51/K20//K 20)**	3.30	8.39	6.68 (2.93)	18.33
53	**BC 2 2 (PBN 51/ K21//K 21)**	3.87	7.87	10.00 (2.90)	20.00
54	**BC 2 3 (PBN 51/K 50//K 50)**	4.59	12.43	13.26 (2.54)	18.33
55	**BC 2 4 (PBN 51/ K 76//K 76)**	14.76	29.79	85.83 (4.28)	113.33
56	**BC 2 5 (PBN 51/K 77//K 77)**	10.93	27.36	96.83 (4.32)	100.00
57	**BC2 6 (K 76/ K20//K 20)**	3.42	7.76	10.83 (3.43)	28.33
58	**BC 2 7 (K 76/ K 21//K 21)**	5.50	11.68	11.68 (2.70)	20.00
59	**BC 2 8 (K 76/ K50//K 50)**	6.37	4.94	14.12 (2.96)	25.00
60	**BC 2 9 (K 76/K 77//K 77)**	10.02	30.97	95.18 (4.29)	103.33
61	**BC 2 10 (K 77/K 20//K 20)**	3.23	9.92	11.26 (2.83)	18.33
62	**BC 2 11 (K 77/ K21//K 21)**	4.23	3.06	11.67 (2.96)	21.67
63	**BC 2 12 (K 77/K 50//K 50)**	4.65	9.59	17.50 (2.83)	15.00
64	**BC 2 13 (K 20/K 21//K 21)**	2.39	3.83	11.68 (2.77)	20.00
65	**BC 2 14 (K 20/K 50//K 50)**	2.79	3.11	14.18 (3.22)	15.00
66	**BC 2 15 (K 21/K 50//K 50)**	3.22	10.64	10.00 (2.81)	13.33
	CD at 1%	2.36	15.59	1.66	23.72
	SEm±	0.63	4.22	0.45	6.42

$-Data in paranthesis indicate log√(x+1) transformed value

Table 2: Selected Physio-Chemical properties of wheat grain under investigation

S.No.	Generations	Protein content (% d.wt.)	1000 Grain Wt.(g)	Grain Hardness Index
1	**P_1 (PBN 51)**	11.80	43.20	71.0
2	**P_2 (K 76)**	12.70	47.33	76.0
3	**P_3 (K 77)**	12.07	44.53	69.0
4	**P_4 (K 20)**	13.80	37.87	81.0
5	**P_5 (K 21)**	13.33	40.27	76.0
6	**P_6 (K 50)**	13.20	38.43	78.0
7	**F_1 1 (PBN 51 x K 20)**	12.83	36.30	88.0
8	**F_1 2 (PBN 51 x K 21)**	12.17	41.87	78.0
9	**F_1 3 (PBN 51 x K 50)**	12.47	33.17	80.0
10	**F_1 4 (PBN 51 x K 76)**	12.10	46.60	73.0
11	**F_1 5 (PBN 51 x K 77)**	12.43	42.33	73.0
12	**F_1 6 (K 76 x K 20)**	13.20	50.37	76.0
13	**F_1 7 (K 76 x K 21)**	13.10	49.03	73.0
14	**F_1 8 (K 76 x K 50)**	13.03	46.57	75.0
15	**F_1 9 (K 76 x K 77)**	12.63	49.83	68.0
16	**F_1 10 (K 77 x K 20)**	13.27	45.00	77.0
17	**F_1 11 (K 77 x K 21)**	13.07	44.70	77.0
18	**F_1 12 (K 77 x K 50)**	12.13	39.07	78.0
19	**F_1 13 (K 20 x K 21)**	13.50	42.80	85.0
20	**F_1 14 (K 20 x K 50)**	13.47	39.63	81.0
21	**F_1 15 (K 21 x K 50)**	13.40	45.53	80.0
22	**F_2 1 (PBN 51 x K 20)**	12.17	39.07	81.0
23	**F_2 2 (PBN 51 x K 21)**	11.67	37.67	79.0
24	**F_2 3 (PBN 51 x K 50)**	12.07	41.63	79.0
25	**F_2 4 (PBN 51 x K 76)**	12.43	37.60	73.0
26	**F_2 5 (PBN 51 x K 77)**	12.37	38.57	72.0
27	**F_2 6 (K 76 x K 20)**	13.43	43.60	78.0
28	**F_2 7 (K 76 x K 21)**	11.00	32.83	75.0
29	**F_2 8 (K 76 x K 50)**	12.70	49.87	78.0
30	**F_2 9 (K 76 x K 77)**	12.33	37.27	70.0
31	**F_2 10 (K 77 x K 20)**	13.10	47.93	76.0
32	**F_2 11 (K 77 x K 21)**	12.07	43.30	73.0
33	**F_2 12 (K 77 x K 50)**	12.00	31.90	82.0
34	**F2 13 (K 20 x K 21)**	12.40	42.57	81.0
35	**F2 14 (K 20 x K 50)**	12.00	43.80	76.0

36	**F2 15 (K 21 x K 50)**	13.03	41.70	79.0
37	**BC 1 1 (PBN 51/K20//PBN51)**	12.20	40.03	80.0
38	**BC 1 2 (PBN 51/ K21//PBN 51)**	12.10	46.07	79.0
39	**BC 1 3 (PBN 51/K 50//PBN 51)**	12.40	41.47	78.0
40	**BC 1 4 (PBN 51/K76//PBN 51)**	12.67	44.63	71.0
41	**BC 1 5 (PBN 51/K 77//PBN 51)**	12.47	41.83	70.0
42	**BC 1 6 (K 76/K20//K 76)**	12.43	47.47	77.0
43	**BC 1 7 (K 76/K 21//K 76)**	11.73	45.40	74.0
44	**BC 1 8 (K 76/K50//K 76)**	11.57	40.73	75.0
45	**BC 1 9 (K 76/K 77//K 76)**	12.23	33.80	69.0
46	**BC 1 10 (K77/K 20//K77)**	11.73	48.27	77.0
47	**BC 1 11 (K 77/K21//K 70)**	12.20	43.40	74.0
48	**BC 1 12 (K 77/K 50//K 77)**	12.33	47.43	79.0
49	**BC 1 13 (K 20/K 21//K 20)**	12.17	43.40	80.0
50	**BC 1 14 (K 20/K 50//K 20)**	13.37	43.77	78.0
51	**BC 1 15 (K 21/K 50//K 21)**	13.40	40.80	80.0
52	**BC 21 (PBN 51/K20//K 20)**	13.30	36.27	78.0
53	**BC 2 2 (PBN 51/ K21//K 21)**	12.47	42.47	77.0
54	**BC 2 3 (PBN 51/K 50//K 50)**	12.23	32.93	76.0
55	**BC 2 4 (PBN 51/ K 76//K 76)**	12.57	46.77	71.0
56	**BC 2 5 (PBN 51/K 77//K 77)**	11.90	42.33	71.0
57	**BC2 6 (K 76/ K20//K 20)**	11.10	47.60	77.0
58	**BC 2 7 (K 76/ K 21//K 21)**	11.43	41.43	74.0
59	**BC 2 8 (K 76/ K50//K 50)**	12.73	48.40	75.0
60	**BC 2 9 (K 76/K 77//K 77)**	12.43	48.83	70.0
61	**BC 2 10 (K 77/K 20//K 20)**	12.23	47.40	79.0
62	**BC 2 11 (K 77/ K21//K 21)**	12.17	42.27	76.0
63	**BC 2 12 (K 77/K 50//K 50)**	11.87	38.33	76.0
64	**BC 2 13 (K 20/K 21//K 21)**	13.23	42.53	78.0
65	**BC 2 14 (K 20/K 50//K 50)**	12.67	39.23	76.0
66	**BC 2 15 (K 21/K 50//K 50)**	12.57	44.10	76.0
	CD at 1%	0.693	3.622	6.480
	CV%	2.60	4.001	3.202
	SEm±	0.186	0.980	1.726

On the other hand, 13 genotypes viz., F_1 (K 76 x K 77,); F_2 (K 76 x K 50, K 76 x K 77, K 77 x K 21 & K 77 x K 50); in BC_1 (PBN-51/K 21//PBN-51, PBN-51/K 50//PBN-51, K 76/K 21//K 76, K 76/K 50//K 76, K 77/K 20//K 77 & K 77/K 50//K 77) and BC_2 (K 76/K 50//K 50) had shown moderate susceptible reaction, 7 genotypes namely, parents K76 and K77; in F_1 (K 76 x K 77); in F_2 (PBN 51 x K 76 & PBN 51 x K 77); in BC_1 (PBN 51/K 77/PBN 51 & K 76/K 77/K 76) were seen susceptible and the other 8 genotypes/cross combinations have shown highly susceptible reaction viz., in parent PBN 51; in F_1 (PBN 51 x K 76 and PBN 51 x K 77); in F_2 (K 76 x K 77); in BC_1 (PBN 51/K 76//PBN 51) and in BC_2 (PBN 51/K 76//K 76, PBN 51/K 77//K 77 and K 76/K 77//K 77). The resistant genotypes had low progeny emerging from them while the susceptible genotypes had high number of F_1 progeny emergence. Resistance characteristic might be due to genetic and intrinsic factors. This result is in agreement with the findings of Santos *et al.* [21] and Abebe *et al.* [21].

Significant differences were observed in percent of infestation and seed weight loss among the genotypes tested (Table-1). The highest percent of infestation (100%) was observed in P1 (PBN 51) which was most susceptible genotype while least infestation (0%) was recorded in P4 (K 20) followed by F_1 1, F_1 13, F_1 14, F_2 13, P5 (K 21) and P6 (K 50) considered as resistant. Highest percent of seed weight loss (37.50) was observed in the genotype F_1 5 (PBN 51 x K 77) while least (0%) was recorded in P4 (K 20) followed by F_1 1, P5 (K 21) and P6 (K 50). Similar types of results were reported by Suleman *et al.* [25], Saljoqi *et al.* [20], Mebarkia *et al.* [13] and Mahmoud *et al.* [14] reported that susceptible varieties had high number of high percentage damage and weight loss.

It is evident from Table-1 that maximum weight of frass (130 mg) was observed in F_2 9 (K 76 x K 77) while least (00 mg) was recorded in P4 (K 20). It was observed that the genotypes showed resistance against weevil had least amount of frass production. There was a positive correlation between percent of infestation weight loss and weight of frass. The result is in conformity with the previous findings of Ahmedani *et al.* [2].

Table-2 shows selected physio-chemical properties of wheat grain which bear influence on *S. Oryzae* development. Depending upon the physico-chemical characters, wheat varieties may vary in resistance or susceptibility to different storage pests like *Sitophilus oryzae.* These parameters are grain hardness index, protein content and kernel weight. All determined properties were significantly different among the studied wheat genotypes.

Although genotypes were statistically different for protein content, P1 (K 20) showed significantly higher value of protein content i.e.13.80 followed by P5 (K 21) and P6 (K 50) while in other hand P1 (PBN 51) had lowest values (11.80) followed by P3 (K 77) and P2 (K 76) among parents. Among different generations, the 14 genotypes have protein content above 13 per cent. This revealed a tendency for genotypes with higher protein content to be resistant against weevil along with resistant parents. Percentage of total protein was directly related with percentage of sound kernels and ultimately to weevil resistance. This is consistent with what other investigators have found like Ram and Singh [18], Rao and Sharma [19], Mebarkia *et al.* [14] and Mahmoud *et al.* [13].

Thousand kernel weight varies from 31.90 ($F_2$12: K77 x K 50) to 50.37 ($F_1$6: K76 x K 20). The result showed that this character is not clear cut associated with resistance of wheat kernel against weevil. But percent of infestation increases with increase in 1000 kernel weight. A lower 1000 kernel weight is indicative of smaller size and shape of wheat genotypes, could discourage weevils from laying eggs inside the kernels. This result is supported by the findings of Irshad *et al.* [12], Campbell [4], Tiwari and Sharma [27].

Grain hardness index (HI) values were observed ranging from 69 (P3: K 77) to 88 (P4: K 20). Table-2 revealed that the genotypes having grater HI showing resistance against *Sitophilus oryzae* and it was closely related to weevil resistance because it can strongly influence the reproductive ability of *Sitophilus oryzae* [23]. This character is also negatively correlated with index of susceptibility, weight loss and percent of infestation. It is well known that hardness or softness of wheat grain is genetically controlled; therefore growing conditions have limited influence on grain hardness. Similar results were reported by Ram and Singh [18], Gudrups *et al.* [10], Tiwari and Sharma [27], Rao and Sharma [19].

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