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Response of wheat *(Triticum aestivum)* landraces from north-western Himalaya to rice weevil (*Sitophilus oryzae*)

KULDEEP TRIPATHI[1], S K CHAUHAN[2], P G GORE[3], T V PRASAD[4], I S BISHT[5] and S BHALLA[6]

ICAR-National Bureau of Plant Genetic Resources, New Delhi 110 012

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ABSTRACT

Wheat (*Triticum aestivum* L.) landraces (one hundred) from the north-western Himalayan region were evaluated for their response to rice weevil, *Sitophilus oryzae* L. under no-choice artificial infestation conditions in the laboratory. The differential reaction was based on the parameters, viz. number of adults emerged, development period, growth index (GI) and weight loss in seeds. On the basis of GI, these landraces were categorised as resistant (six landraces with GI from 0.33-0.49), moderately resistant (13 landraces, GI from 0.52-0.97), moderately susceptible (41 landraces, GI ranging from 1.01-1.50), and susceptible (41 with GI from 1.51-1.86). On the basis of seed weight loss, eight landraces were found resistant (8.3-18.5%), 32 as moderately resistant (20.1-39.5), 51 as moderately susceptible (40.3-59.9), and 10 landraces (61.4-68.8) were found susceptible. Four landraces, viz. IC393109, IC392578, IC444217 and IC589276 were found resistant both on the basis of GI and seed weight loss. These landraces can be used in breeding programme for development of wheat cultivars resistant to *S. oryzae*.

Key words: Growth index, Himalaya, Rice weevil, *Sitophilus oryzae,* Wheat landraces

Wheat (*Triticum aestivum* L.) commonly known as bread wheat, is an important cereal crop at global level. First and foremost a food crop, wheat is being consumed by 2.5 billion people in 89 countries. It superseded maize and rice as a source of protein in low and middle-income nations and is second only to rice as a source of calories (Wheat.org). This golden seed cereal is being traditionally grown in north-western parts of Himalayas since ancient times. The Himalayan high lands are reservoir for a large number of landraces because of the preponderance of locally developed traditional crop varieties owing to high agro-climatic heterogeneity and local socio-cultural diversity (Pal *et al*. 2007).

The primitive cultivars, landraces and wild relatives of crop plants constitute a pool of useful genetic variability required for effective breeding programs. Most of the rich plant biodiversity which supported agriculture for the past 9000 years has been eroded or being rapidly eroded due to the introduction of new high yielding varieties (Brown and Brubaker 2002). Such erosions could have serious consequences, both on the genetic vulnerability of crops to changes in the spectrum of pests and diseases and on their plasticity to respond to future changes in climate or in agricultural practices (Malik *et al*. 2013).

Wheat is susceptible to various insect pests during storage which cause substantial qualitative/ nutritional and quantitative losses of different magnitudes depending on the pest species and time period of storage of infested seeds. Of various storage pests, rice weevil, *Sitophilus oryzae* L. (Coleoptera: curculionidae) is a major pest of economic importance at global level (Almasi *et al*. 2003, CAB International 2007). Chemical pest management strategies though effective, have undesirable environmental impacts. Moreover, fumigation is the most widely adopted method and has been in practice. But none of these methods and products can be declared as safe to the precious lives of human beings, birds, beneficial insects, animals and to the environment (Ebadollahi 2011). To reduce pest-linked damage in storage as well as to protect the environment from adverse effects of pesticides, use of host plant resistance against this pest is environmentally safe and economically feasible sound technique (Tripathi *et al.* 2012). Therefore, the present study was initiated to find out the natural sources of resistance in wheat landraces from north-western Himalayan region against the rice weevil, *S. oryzae*.

MATERIALS AND METHODS

Laboratory experiment was conducted at the Entomology Laboratory, Division of Plant Quarantine, National Bureau of Plant Genetic Resources (NBPGR), New

[1]Ph D scholar (e mail: ktripathi60@yahoo.com), ICAR-Indian Agricultural Research Institute (IARI), [2]Senior Research Fellow (e mail: sumit6493@yahoo.com), [3]Ph D scholar, IARI (e mail: padma.pgr@gmail.com), [4]Senior Scientist (e mail: tvprasad@nbpgr.ernet.in), [5]Principal Scientist (e mail: bishtis@nbpgr.ernet.in), [6]Principal Scientist (e mail: sbhalla@nbpgr.ernet.in)

Delhi during 2013-14. One hundred wheat landraces collected from different regions of north-western Himalaya with considerable variability were obtained from NBPGR Regional Station, Bhowali, Uttarakhand. These landraces along with a local check were evaluated for their reaction to *S. oryzae* under no-choice artificial infestation conditions. The studies were based on the effect of different landraces on the growth and development of target pest and also the loss caused in each landrace by feeding activity of the pest. The parameters studied were number of eggs laid by *S. oryzae*, number of adults emerged, development period (DP) and growth index (GI) of *S. oryzae*. In addition, the seed damage and weight loss were also studied on different wheat landraces.

The cultures of test insect, *S. oryzae* were raised on a local wheat variety under the controlled conditions of temperature (28±2°C) and relative humidity (70±5%) in the Biological Oxygen Demand (BOD) incubator in the Entomology Laboratory, Division of Plant Quarantine, NBPGR, New Delhi. For screening purpose, 100 healthy seeds of each landrace were placed in separate 100 ml plastic jars with perforated lids for aeration and prepared samples were conditioned at 70% relative humidity (Jha *et al.* 2012) and after conditioning, all the samples were weighed. Ten pairs of newly emerged adults from the stock culture were released in each jar and replicated three times in completely randomized design (CRD) under no-choice test. All the experiments were conducted under the controlled conditions in a BOD incubator. The adults were allowed to oviposit for 72 hr and then removed. Next day, the egg plugs on seeds were stained with the help of acid fuchsin to detect eggs. The seeds were merged for 60 seconds in water, 45 seconds in 5% acid fuchsin stain and 30 seconds in water for de-staining, examined under a binocular microscope and eggs were counted (Arve *et al.* 2014). About 30 days after infestation (DAI) as adult emergence was initiated, observations were recorded at a regular interval of 24 hrs till 20 days. For seed weight loss, samples were sieved through a 60 mesh sieve for removing frass and weighed at 30, 60 and 90 days after storage (DAS).

Adult emergence (%) was calculated as Number of adults emerged / number of eggs laid ×100; Development period = $D_1A_1+D_2A_2+D_3A_3+\ldots..D_nA_n$ / total number of adults emerged (where D_1 is the first day at which the adults started emerging, A_1-number of adults emerged on D_1^{th} day). Growth Index (GI), an important parameter determining the host suitability was calculated as adult emergence (%) / mean development period (days). Weight loss (%) in infested seeds was observed for three months at a regular interval of 30 days of storage, i.e. 30, 60 and 90 DAS and calculated as initial weight of seeds - final weight of seeds/ initial weight of seeds × 100 (Tripathi *et al.* 2012).

Among all the parameters studied, GI and weight loss are most important. On the basis of GI, landraces were grouped on the scale of 0.00-2.00 as resistant (0.00-0.50), moderately resistant (0.51-1.00), moderately susceptible (1.01-1.50), and susceptible (1.51-2.00). On the basis of weight loss 90 DAS, landraces were categorised on the scale of 0.0-80 as resistant (0.0-20.0), moderately resistant (20.1-40.0), moderately susceptible (40.1-60.0), and susceptible (60.1-80.0).

Analysis of variance was carried out using SAS (2009) (Statistical analysis software system, Version 9.2) to determine significant differences among the landraces. Simple linear correlation analysis was performed using PROC CORR to indicate the measure of correlation and strength of relationship between various life parameters of *S. oryzae*.

RESULTS AND DISCUSSION

One hundred wheat landraces evaluated under no-choice artificial infestation conditions revealed significant variations in their response to rice weevil, *S. oryzae*. Significant differences were observed among the landraces in terms of number of eggs laid, number of adults emerged, DP and GI of *S. oryzae*. Also the significant differences were observed in the seed weight loss in the different landraces due to infestation by *S. oryzae*. Ovipositional behaviour of *S. oryzae* differed significantly on different landraces and ranged from 38.3 to 92.0 eggs per 100 seeds per 10 pairs. IC260857 was most preferred for egg laying while IC393109 least preferred for oviposition.

The number of adults emerged on different landraces varied from 6 to 58. Maximum adult emergence was recorded in IC345687 (58) and minimum in IC393109 (6) (Table 1). The finding of susceptibility/resistance on the basis of number of adults emerged is supported by Khan *et al.* (2014) who reported that lowest number of adults emerged (82) in A2-92 and was found to be comparatively the most resistant among 12 genotypes, while the highest number of adults emerged (145) in genotype A2-95 and was found to be the most susceptible against *S. oryzae*. Jha *et al.* (2012) also evaluated eight wheat varieties against *S. oryzae* and reported maximum number of insect emerged (57.6) in HI 8381(d) and minimum in C306 (13.33).

Table 1 Response of wheat landraces from north-western Himalaya to *Sitophilus oryzae*

Landrace	No. of adults emerged	Development period (days)	Growth index	Weight loss* (%)
IC208899	12.00±2.89	38.07±0.54	0.52±0.14	20.11±1.02
IC260845	43.33±1.76	35.46±0.46	1.63±0.05	33.65±1.71
IC260848	14.67±2.33	39.13±0.83	0.74±0.05	13.30±1.29
IC260854	47.33±5.78	36.88±0.05	1.60±0.16	49.14±4.55
IC260857	42.33±2.60	36.12±0.14	1.27±0.04	32.77±4.82
IC260858	39.00±4.16	36.24±0.17	1.45±0.07	37.82±2.02
IC260865	41.00±4.93	36.71±0.19	1.56±0.11	55.22±3.89
IC260866	11.00±2.31	37.15±1.37	0.62±0.10	14.33±1.23
IC260868	48.67±2.33	36.74±0.10	1.60±0.03	51.48±3.89
IC260869	31.67±3.18	36.31±0.08	1.39±0.13	40.76±4.21
IC260871	46.33±5.90	36.45±0.07	1.62±0.08	44.87±1.09

Contd.

Table 1 (*Continued*)

Landrace	No. of adults emerged	Development period (days)	Growth index	Weight loss* (%)
IC260877	34.00±3.21	36.28±0.07	1.47±0.09	32.30±1.74
IC260880	51.67±2.60	36.79±0.11	1.75±0.06	56.55±2.45
IC260887	47.00±2.08	36.03±0.17	1.59±0.08	47.50±2.49
IC260888	39.33±1.86	36.54±0.22	1.51±0.06	40.52±2.83
IC260890	24.67±2.33	38.56±0.58	1.04±0.08	25.30±4.39
IC260894	42.00±4.04	36.77±0.20	1.56±0.10	45.07±1.43
IC260895	51.67±2.03	36.87±0.15	1.71±0.10	61.43±3.66
IC260901	49.00±3.46	36.60±0.16	1.65±0.10	54.78±2.10
IC260902	45.00±4.36	36.63±0.25	1.63±0.12	46.07±1.20
IC266764	29.67±2.33	36.37±0.10	1.36±0.08	35.73±6.12
IC266789	22.67±2.60	36.85±0.81	1.01±0.06	23.90±1.36
IC266791	38.67±7.54	37.21±0.74	1.32±0.22	31.62±1.87
IC266831	11.00±1.73	39.36±0.36	0.46±0.07	20.43±3.02
IC266847	38.00±4.36	36.64±0.17	1.32±0.07	44.22±2.01
IC266852	38.67±6.57	37.63±0.47	1.32±0.16	35.62±3.19
IC266854	33.00±5.29	36.85±0.25	1.39±0.12	34.54±3.23
IC266872	10.67±1.76	38.96±0.47	0.47±0.04	23.46±0.83
IC266884	19.67±0.88	40.04±0.40	0.80±0.03	26.37±2.14
IC266921	40.67±3.93	35.80±0.53	1.45±0.09	48.47±6.13
IC266976	27.00±2.00	38.64±0.71	1.05±0.04	45.25±5.65
IC266977	24.33±3.93	39.49±0.32	0.96±0.11	41.37±2.44
IC266978	38.67±1.76	36.22±0.14	1.44±0.07	46.60±2.00
IC345589	54.67±2.03	36.51±0.19	1.78±0.02	62.61±2.29
IC345598	57.67±2.33	36.36±0.05	1.85±0.04	68.85±1.36
IC345604	31.67±1.20	36.38±0.01	1.45±0.03	37.37±1.98
IC345620	51.33±0.33	37.01±0.09	1.73±0.02	65.85±2.16
IC345671	56.00±2.31	36.81±0.06	1.77±0.04	63.16±0.69
IC345673	45.67±4.84	36.77±0.03	1.65±0.10	54.86±2.22
IC345687	58.00±1.73	36.68±0.15	1.78±0.08	67.64±1.28
IC345688	48.33±3.38	36.93±0.20	1.65±0.07	51.85±2.33
IC345690	36.00±4.36	36.75±0.24	1.64±0.17	26.92±3.27
IC381111	21.67±2.60	37.72±1.16	1.15±0.08	26.08±3.10
IC381124	47.67±3.71	36.50±0.09	1.66±0.02	55.69±2.64
IC381190	35.00±1.15	36.51±0.03	1.44±0.05	31.10±5.05
IC382649	36.33±1.76	35.37±0.20	1.42±0.07	43.77±5.45
IC382653	38.33±1.67	36.40±0.09	1.42±0.12	45.44±2.07
IC382658	36.33±3.93	36.74±0.86	1.38±0.10	50.1±3.31
IC382664	27.67±2.19	38.76±0.36	1.02±0.02	45.97±3.45
IC383581	38.33±4.10	36.38±0.47	1.50±0.14	41.10±3.67
IC383592	16.33±1.76	38.36±0.57	0.96±0.04	14.28±2.70
IC383593	24.67±2.73	37.05±1.27	1.17±0.14	43.22±2.57
IC392578	13.00±0.58	39.86±0.73	0.44±0.03	16.47±0.85
IC393109	6.00±0.58	40.07±0.34	0.40±0.08	9.10±0.56
IC393110	19.33±2.03	38.10±0.28	0.96±0.05	18.45±2.93
IC393112	50.33±1.76	36.87±0.29	1.66±0.06	52.31±1.75
IC393113	53.00±1.53	36.89±0.15	1.70±0.04	51.16±0.69
IC393114	38.00±3.21	36.81±0.29	1.47±0.11	38.83±2.96
IC393115	42.33±4.10	36.67±0.25	1.58±0.11	30.66±5.21
IC393116	38.00±2.89	36.43±0.14	1.36±0.04	53.06±0.94
IC393117	51.33±3.18	36.63±0.28	1.71±0.09	56.08±4.53
IC393118	49.67±2.40	36.79±0.23	1.79±0.08	56.23±2.48

Contd.

Table 1 (*Concluded*)

Landrace	No. of adults emerged	Development period (days)	Growth index	Weight loss* (%)
IC393131	37.00±3.06	35.63±0.61	1.49±0.05	57.86±2.35
IC398292	40.00±2.52	36.41±0.36	1.46±0.05	48.76±3.28
IC398294	44.00±3.21	35.95±0.43	1.49±0.03	49.68±1.46
IC398296	29.33±1.20	39.24±0.37	0.96±0.05	45.39±2.22
IC398297	22.33±1.76	40.79±0.56	0.67±0.07	34.36±0.99
IC398298	40.67±1.76	36.26±0.34	1.51±0.17	33.99±0.98
IC398302	17.00±2.52	39.14±0.28	0.68±0.08	23.79±1.93
IC398303	37.33±4.06	35.74±0.29	1.36±0.11	40.37±6.41
IC398305	37.33±4.10	37.12±0.73	1.35±0.13	42.20±1.46
IC398307	28.00±2.08	36.37±0.48	1.10±0.09	40.94±3.79
IC398309	52.00±2.08	36.47±0.08	1.69±0.03	63.64±1.99
IC406688	27.67±2.60	37.74±0.77	1.07±0.08	27.84±2.37
IC406690	47.00±1.15	36.64±0.32	1.58±0.07	42.06±2.49
IC406697	35.00±2.52	35.84±0.44	1.34±0.03	36.91±3.37
IC406715	40.67±2.33	35.95±0.05	1.50±0.15	49.42±1.82
IC406724	46.67±3.53	36.34±0.57	1.70±0.10	39.49±2.78
IC430330	18.00±2.65	38.93±0.19	0.74±0.10	23.52±0.88
IC430369	19.33±4.06	37.79±0.63	0.84±0.14	37.99±2.80
IC430373	45.33±3.84	36.44±0.20	1.56±0.14	47.77±7.81
IC444217	8.00±1.73	37.73±1.53	0.49±0.09	8.32±1.34
IC444226	41.33±2.03	36.39±0.45	1.50±0.03	30.56±1.30
IC444229	26.67±3.48	37.56±0.72	1.11±0.15	35.62±7.15
IC444232	45.67±1.76	36.44±0.33	1.57±0.02	54.55±2.94
IC564090	43.67±0.88	36.47±0.47	1.56±0.07	24.30±5.34
IC564096	50.67±1.20	36.61±0.09	1.69±0.05	59.94±3.22
IC564113	48.00±1.73	36.58±0.10	1.67±0.02	48.86±2.95
IC564114	41.33±1.86	36.53±0.18	1.52±0.10	51.79±2.57
IC564159	39.00±2.89	36.40±0.12	1.46±0.15	50.57±5.15
IC573137	28.67±3.18	35.98±0.11	1.21±0.17	49.75±2.03
IC573138	19.00±1.15	39.36±0.54	0.85±0.07	26.70±2.62
IC573140	55.00±2.08	37.00±0.11	1.71±0.03	55.67±2.47
IC573157	54.00±3.00	36.95±0.25	1.74±0.06	52.95±1.91
IC589276	7.67±1.76	38.96±0.28	0.33±0.08	11.54±2.31
IC589278	26.67±3.53	36.56±0.59	1.06±0.10	40.33±2.82
IC589300	41.33±4.41	36.57±0.25	1.45±0.06	43.16±5.94
IC589303	37.67±4.33	36.34±0.32	1.30±0.04	56.80±5.96
IC595382	51.67±1.76	36.73±0.25	1.69±0.09	61.54±1.78
IC595395	52.67±4.33	36.87±0.28	1.71±0.17	61.50±2.51
Local check	54.00±3.51	35.49±0.42	1.82±0.09	62.15±3.77
Mean	36.58	37.07	1.34	41.69
Range	6.00-58.00	35.37-40.79	0.33-1.85	8.32-68.85
Variance	173.20	1.30	0.15	205.79
CD (P=0.05)	10.45	1.14	0.31	11.02

Values represent mean ± SE of three replications. *90 Days after storage

The developmental period of *S. oryzae* on different wheat landraces differed significantly and varied from 35.37 to 40.79 days (Table 1). Development period of *S. oryzae* was maximum in the landrace IC398297, i.e. adult emergence took more time in comparison to other landraces and therefore found relatively least susceptible to *S. oryzae*

(Patel 2006). Arve *et al.* (2014) also recorded shortest life cycle of *S. oryzae* on variety GW 496 (32.83 days) and longest on HD 2189 (37.50 days) among seven wheat cultivars.

The developmental suitability of the food material/ genotype is determined on the basis of GI, which is an important parameter of insect growth and development. It is a criterion for comparing the growth responses of insects to different plants. Genotypes with a low GI are considered as resistant and those with a high GI as susceptible. This is based on the assumption that a few insect progenies would emerge out of a resistant genotype and progeny development would take a longer time in a resistant than in a susceptible genotype. On the basis of GI, landraces such as IC589276 (GI=0.329) and IC393109 (0.404) were resistant while IC345598 (1.855) was most susceptible to *S. oryzae* as compared to local check (1.818) (Table 1).

Seeds of all the landraces were preferred by *S. oryzae* but preference differed significantly with the landrace. Weight loss in the infested seeds was recorded at an interval of 30 days up to 90 days of storage and it increased gradually and progressively with the storage time. Seed weight loss, 90 DAS, was maximum in IC345598 (68.85%) and minimum in IC444217 (8.32%) (Table 1). Landraces with minimum weight loss are considered as having least preference or maximum resistance against *S. oryzae*. Arve *et al.* (2014) also observed that none of the wheat variety was immune to *S. oryzae.* Our results are in conformity of those reported by Khan *et al.* (2014) who observed lowest weight loss 6.21% in genotype A2-92, and highest weight loss (16.99%) in genotype A2-95 and reported genotype A2-92 comparatively the most resistant while genotype A2-95 as most susceptible, against *S. oryzae* among 12 wheat genotypes. Jha *et al.* (2012) evaluated eight wheat varieties against rice weevil after 90 days of storage and reported maximum weight loss (18.28%) in HI 8381(d) and minimum in C306 (4.88). The differential reaction of different landraces of wheat to *S. oryzae* may be due to differences in the nutritional quality of the landraces.

On the basis of GI, landraces were grouped into four categories. Out of 100 landraces studied for their differential reaction to *S. oryzae*, six landraces, viz. IC589276, IC393109, IC392578, IC266831, IC266872 and IC444217 were found resistant (GI = 0.33-0.49), 13 as moderately resistant (0.52-0.97), 41 as moderately susceptible (1.01-1.50), and 41 landraces (1.51-1.86) were found susceptible (Table 2). The differential reaction of different landraces of wheat to *S. oryzae* may due to differences in the nutritional quality of the accessions. On the basis of weight loss, eight landraces viz., IC444217, IC393109, IC589276, IC260848, IC383592, IC260866, IC392578 and IC393110 were found resistant (8.3-18.5%), 32 as moderately resistant (20.1-39.5), 51 as moderately susceptible (40.3-59.9), and 10 landraces (61.4-68.8) were found susceptible (Table 2). Four landraces, viz. IC393109, IC392578, IC444217 and IC589276 were found resistant based on both the parameters of GI and weight loss.

Correlation between GI and growth parameters of *S. oryzae* in different landraces indicated that GI had a significant positive relationship with number of eggs laid by *S. oryzae* (r = +0.72) and number of adults emerged (r = +0.96). Whereas GI had significant negative relationship with mean development period (r = -0.77). GI have a positive relationship with weight loss at 30, 60 and 90 DAS but it was significant at 60 DAS and 90 DAS (r = + 0.76) and (r = +0.80) respectively (Table 3). Syed *et al.* (2001) and Khan

Table 2 Frequency distribution of wheat landraces in different reaction categories based on growth index of *Sitophilus oryzae* and seed weight loss

Grade	Growth index			Weight loss (%)		
	Scale	Range	No. of landraces	Scale	Range	No. of landraces
Resistant	0.00-0.50	0.33-0.49	6	0.0 -20.0	8.3-18.5	8
Moderately resistant	0.51-1.00	0.52-0.97	13	20.1-40.0	20.1-39.5	32
Moderately susceptible	1.01- 1.50	1.01-1.50	41	40.1- 60.0	40.3-59.9	51
Susceptible	1.51- 2.00	1.51-1.86	40	60.1- 80.0	61.4-68.8	9

Table 3 Correlation matrix of life parameters of *Sitophilus oryzae* on wheat landraces

	Growth index	No of eggs	No. of adults emerged	Developmental period	Weight loss (%) 30 DAS	60 DAS	90 DAS
Growth index		0.719*	0.961*	-0.769*	0.311	0.764*	0.798*
No of eggs			0.861*	-0.476*	0.287	0.752*	0.777*
No. of adults emerged				-0.678*	0.309	0.81*	0.851*
Developmental period					-0.188	-0.539*	-0.543*
Weight loss 30 DAS						0.489*	0.468*
60 DAS							0.956*
90 DAS							

*Significant at P = 0.01, Significant at P = 0.05

et al. (2005) have also reported the positive correlation between pest population increase and seed weight loss.

Out of the 100 landraces of wheat screened for the differential reaction against rice weevil, *S. oryzae,* six landraces were found resistant on the basis of GI and eight were resistant on the basis of seed weight loss. Four landraces viz., IC393109, IC392578, IC444217 and IC589276 were found resistant based on both the parameters of GI and seed weight loss. These landraces could be used in breeding programme for development of wheat cultivars resistant to *S. oryzae*.

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