Evaluation of *rabi* sorghum genotypes for the resistance against storage pest, *Sitophilus oryzae* (L.).

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***Abstract*- Among the 20 *rabi* sorghum genotypes evaluated for the resistance against rice weevil, the genotypes like M 35-1, RSJ 1, KMJ 1, AKJ 1 and CSV 216R possessed higher resistance to *S. oryzae* with respect to different characters like per cent grain damage [M 35-1 (21.20%) KMJ 1 (27.20%), AKJ 1, RSJ 1 (28.00%) and CSV 216R (36.00%)], grain weight loss [M 35-1 (4.43g), AKJ 1 (5.60g), SMJ 1 (5.60g), RSJ 1 (5.60g) and CSV 216R (7.20g)] and population buildup of rice weevils [AKJ 1 (15.00), KMJ 1 (25.00), M 35-1 (25.50), RSJ 1 (25.50) and CSV 216R (30.50)]. Whereas, BR 33, BJV 44, BRJ 204 and PhuleRevati were susceptible to the pest.**

Key words- Rice weevil Sitophilus oryzae, rabi sorghum genotypes, grain damage, grain weight loss and population buildup

I. INTRODUCTION

Rice weevil is economically important storage pest on sorghum and other cereals in tropical and sub-tropical regions of the world. Rice weevil infestation alone resulted in sorghum grain loss of 61.3 per cent over a period of five months (Venkat Rao *et al.*, 1958).

Nearly 15 per cent of the grain stored after each harvest is believed to be lost due to ravages of rats, insects, mites and microbial agents (Walter, 1971). The average loss of food grains in storage due to biotic and abiotic factors accounts for 10 per cent annually of which insects partake about 2.5 to 5.0 per cent. Major loss of food grains in storage is contributed by two internal primary feeder *viz*., rice weevil (*Sitophilus oryzae* Linn.)In a period of 100 days a single female of one of the most prolific strains rice weevil produces 24 adults and more than 57 per cent of grains are attacked. The losses of grains due to weevils are estimated to an average of 25 to 40 per cent after 100 days of storage (Ladang *et al.*, 2008).

It is well established fact that lot of efforts should be put for the production of "every single grain" but this is of no use if the produced grains are not saved, which recalls the proverb "a grain saved is a grain equally produced". This adage depends mainly on how best we protect the quality of grains during storage. Loss of grains stored as seed and future food of our country is to the tune of 7-8 per cent accounting to major share of economic loss worth Rs. 600-700 crores. At the same time scientists are putting their efforts and attempting to find ways and means to reduce losses in storage due to stored pests. Farmers retain 60 to 70 per cent of their agricultural produce for seed purpose, home consumption and for sale due to storage pest infestation (Reddy and Pushpamma, 1980).

II. MATERIAL AND METHODS

Twenty *rabi* sorghum genotypes, inclusive of some of the released hybrids, resistant and susceptible checks, good land races and restorer lines were selected for screening studies. Five hundred grams of seed samples of above 20sorghum genotypes were collected during *rabi* 2011-2012 to study per cent grain damage against *S. oryzae* under laboratory conditions. Freshly harvested seeds were obtained from All India Coordinated Sorghum Improvement Project (AICSIP) situated at the Regional Agricultural Research Station, Bijapur and Agricultural Research Station, Hebballi, Dharwad.

Sound, unaffected grains of each genotype were kept in hot air oven for six hours at 420C in order to eliminate the insect pest infestation. The moisture content of seeds was less than 12 per cent. Seeds of each variety / genotypes weighing 50 g were kept in glass containers of 250 g capacity separately for investigating population buildup of rice weevil in sorghum grains.

Five pairs of five days old adult insects were introduced in each bottle and tops were kept covered with muslin cloth and tightly fixed with rubber band. These were kept in two replications for observations up to 120 days. Each bottle was examined periodically at monthly intervals to note the per cent damaged grains. The data were subjected to statistical analysis. The data in percentages were subjected to angular transformations before statistical analysis.

Table: 1 List of different *rabi* Sorghum genotypes imposed in treatments used for screening studies.

Treatments	Genotype
T_1	M35-1
T_2	CSV 18
T_3	Phule Chitra
T_4	PKV Kranti
T_5	Parabani Joti
T_6	Phule Vasudha
T_7	Phule Revati
T_8	5-4-1(Muguti)
T_9	BR 33
T_{10}	BJV 44
T11	BRJ 204
T12	KMJ 1
T13	SMJ 1
T14	AKJ 1
T15	RSJ 1
T16	CSV 22
T17	CSV 216R
T18	SPV 2033
T19	DSV 4
T20	DSV 5

Per cent grain damage

Before sampling, the grains were thoroughly mixed and samples of 100 grains were drawn for five times from each bottle. The damaged and healthy grains in 100 seeds were counted, separated and per cent damaged seeds were worked out.

Population build up

The observation on population build up was recorded by counting the total number of adult beetles emerged from each genotype separately at monthly intervals.

Weight loss in grains

Observations on the loss in grain weight was done by weighing the grains of each genotypes at monthly intervals and the same was recorded and the difference was calculated to that of the initial weight of 50 grams.

III. RESULTS AND DISCUSSION

Per cent grain damage

The data pertaining to per cent grain damage caused by *S. oryzae* to sorghum at 30, 60, 90 and 120 days after storage (table 1) revealed that at 30 days after storage**,** minimum grain damage of 0.2 per cent each was noticed in KMJ 1, SMJ 1 and AKJ 1 genotypes and they differed significantly with all varieties / genotypes followed by genotype M 35-1 (0.45%), which was also superior over others. Maximum of 12.40 per cent damaged grains were recorded in the genotype BR 33 which was significantly inferior to all other varieties/genotypes followed by BJV 44 (9.00%), 5-4-1 (8.00%) and BRJ 204 (6.75%),they significantly differ with each other. The grain damage in rest of the genotypes was ranging between 2.00 per cent and 4.30 per cent.

At 60 days after storage the genotypes M 35-1 and AKJ 1 showed high degree of resistance to *S. oryzae* by recording minimum grain damage of 1.00 per cent each and differ significantly with other varieties / genotypes followed by the genotypes RSJ 1, SMJ 1 and CSV 18 with 3.00, 3.40 and 4.40 per cent, respectively and they differ significantly with each other. Whereas, genotypes BR 33 and BJV 44 found more susceptible by recording maximum grain damage of 23.80 and 22.90 per cent, respectively and differ significantly with each other followed by Phule Revati, PKV Kranti, BRJ 204 and 5-4-1 ranging from 12.00 to 17.45 per cent and all these genotypes differ significantly from each other.

At 90 days after storage highest grain damage was continued to be in the genotype BR 33 (46.40%) followed by BJV 44 (44.00%) and they differed significantly between them. The least grain damage was recorded in M 35-1 (16.00%) which differed significantly with all other varieties/genotypes followed by RSJ 1 (18.00%), KMJ 1, AKJ 1, SMJ 1 (20.00% each), DSV 4 (23.30%), CSV 216R (24.00%), CSV 18 (25.40%), SPV 2033 (26.00%) and DSV 5 (26.20%). The other genotypes differed significantly from each other.

At 120 days after storage significantly minimum grain damage was observed in the genotype M 35-1 (21.20%) followed by KMJ 1 (27.20%), AKJ 1, RSJ 1 (28.00%) and SMJ 1 (33.90%) were differing significantly with each other. The genotype BR 33 continued to show susceptibility by recording significantly maximum grain damage of 59.00 per cent followed by BJV 44 (57.00%) and Phule Revati (51.00%).The results are in comparison with the study conducted by Kudachi *et al.* (2014) who reported that, significantly minimum per cent damaged seeds were noticed in DJ 6514 (17.0%) followed by RS 585, CSV 216R, SPV570, BRJ 356 with minimum per cent damage ranging from 21.00 to 24.00 indicating their higher degree of resistance. The per cent damaged seeds were significantly maximum in Y 75 (83.50%) followed by RSE 03 (69.00%) and Maulee (59.00%) showing their susceptibility to the pest (Kudachi 2008). The results are also in conformity with the similar study conducted by Reddy *et al.* (2002) who reported that, significantly less damage to seed was observed in IS 11758, CSV 8R, IS 9487 and local yellow.

Population build up

The data collected with respect to population build up of *S. oryzae* in different *rabi* sorghum genotypes at 30, 60, 90 and 120 days after storage in the table 2 indicated that at 30 days after storage among the genotypes there was no significant difference in the number of weevil emergence.

At 60 days after storage, population of adult insects were minimum in BRJ 204, Phule Revati, M 35-1, KMJ 1, AKJ 1, DSV 4, DSV 5, SMJ 1, RSJ 1, CSV 18, Phule Vasudha and SPV 2033ranging from 12.00 to 15.00 per cent. Whereas, significantly maximum number of adult emergence was recorded in BR 33 (20.75) followed 5-4-1 (19.50) and CSV 22 (18.50) and are significantly differ with each other.

At 90 days after storage, emergence of adult weevils was significantly less in AKJ 1 (15.00), KMJ 1 (15.00), M 35-1 (15.50) which were on par with each other followed by RSJ 1 (17.50) and CSV 216R (17.50). Population buildups were maximum in CSV 22 (32.00) and BR 33 (31.75) which were on par with each other followed by Parabani Joti (27.50).

At 120 days after storage it is clear that, the genotype AKJ 1 exhibited higher degree of resistance by recording significantly less number of adult weevils (24.50) followed by KMJ 1 (25.00), M 35-1 (25.50) and SMJ 1 (26.50). The latter three genotypes were almost equally resistant to the pest. However, maximum number of adults were emerged from BR 33(41.00) followed by Parabani Joti (39.00), 5-4-1 (35.50) and DSV 5 (35.00).The results were in conformity with earlier studies conducted by Kudachi *et. al.*(2014), Kudachi (2008) and Jadhav (2006) where in, CSV 8 and DSV 3 recorded minimum number of *S. oryzae* population.

Grain weight loss

The data mentioned in the table 3 regarding the weight loss of the grains of various genotypes due to infestation by *S. oryzae* expressed in grams at 30, 60, 90 and 120 days after storage where the initial weight was 50.00g in each genotype.

The grains of the genotype BR 33 (6.00g) have shown maximum loss in weight which was followed by BJV 44 (4.48g) and 5-4-1 (4.00g) where all the three have significant difference with each other. The minimum loss of weight has recorded in KMJ 1 (0.10g), SMJ 1 (0.10g), AKJ 1 (0.10g) which are on par with each other, next best genotypes were M 35-1 (0.20g), RSJ 1 (0.50g), CSV 18 (0.51g) and SPV 2033 (0.98g) followed by the rest of the genotypes where the loss in weight ranging between 1.00 gram and 3.00 gram after a month of storage.

At 60 days after storage, the genotype M 35-1 (0.50g) and AKJ 1 (0.50g) have recorded minimum loss in grain weight which are on par with each other followed by CSV 18 (1.00g), SMJ 1 (1.50g) and RSJ 1 (1.53g) the latter two are significantly differ with each other. Whereas, the maximum loss of grain weight has occurred in BR 33(7.75g) followed by BJV 44 (6.88g) and BRJ 204 (5.83g). In rest of the genotypes the grain weight loss was recorded in the range between 2.48 gram and 5.28 gram.

The grains of the genotype BR 33 (9.68g) have shown maximum loss in weight which was followed by BJV 44 (8.78g), BRJ 204 (7.23g) and 5-4-1 (7.20g) where the latter two have no significant difference with each other. The minimum loss of weight has recorded in M 35-1 (3.10g) and RSJ 1 (3.68g) followed by KMJ 1 (4.00g), SMJ 1 (4.00g), AKJ 1 (4.00g), DSV 5 (4.78g) and CSV 216R (4.80g) the latter two were on par with each other where the other differ significantly, followedby the rest of the genotypes where the loss in weight ranging between 5.23 grams and 7.00 grams after 90 days of storage. After 4 months of storage the grains of the genotype M 35-1 (4.43g), AKJ 1 (5.60g), SMJ 1 (5.60g) and RSJ 1 (5.60g) have recorded minimum loss in grain weight and significantly superior over the other genotypes in terms of grain weight loss, followed by KMJ 1 (6.40g), CSV 216R (7.20g), SPV 2033 (7.20g) and DSV 4 (7.20g) all the genotypes differ significantly. Whereas, significantly maximum loss of grain weight has occurred in BR 33 (11.90g) followed by BJV 44 (11.10g) and Phule Revati (10.15g). In rest of the genotypes the grain weight loss was recorded in the range between 7.63 grams and 10.00 grams.

Among the 20 genotypes M 35-1 (4.43g), AKJ 1 (5.60g), SMJ 1 (5.60g) and RSJ 1 (5.60g) suffered less by weevil as evidenced by lower grain weight loss. This may be due to non preference of the grains by *S. oryzae* beetles. The present study is in agreement with studies conducted by Kudachi *et. al.*(2014) who reported, significantly minimum seed weight loss in IS 2312 (4.80%) followed by IS 2205 (5.60%), DJ 6514 (6.30%), SPV 489 (7.87%), RS 585 (7.88%) and RS 29 (7.90%)(Kudachi 2008).Similar kind of observations were also made by Sattigi (1982) who reported, highest grain weight loss occurred in hybrid CSH 5 and lowest in DHS 652. Similar kind of observations were made by Reddy *et al.* (2002), Bheemanna (1994) and Balikai (1988) who recorded significantly minimum weight loss in RS 29 (0.157%) and IS 2312 (0.254%) and Bhagapur local, IS 2205, SPV 462 and SPV 924 and DMS 652 (2.35%), DJ 6514 (4.86%) and M 35-1 (5.25%) by *S. oryzae* respectively.

To conclude, *rabi* sorghum genotypes M 35-1, KMJ 1, AKJ 1, RSJ 1 and SMJ 1 showed high degree of resistance to *S. oryzae* by recording minimum per cent grain damage, lower grain weight loss and lower population buildup after 120 days of storage. These varieties can be best exploited for further breeding and hybridization research programme by extracting the traits in better way in the development of resistant varieties and can be also suggest these genotypes for farmer cultivation in the areas where rice weevil is a serious pest in storage condition.

IV. REFERENCES

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Table: 1 Per cent grain damage to different *rabi* sorghumgenotypes by rice weevil at monthly intervals

Sl. No.	**Varieties/ Genotypes**	**30 DAS**	**60 DAS**	**90 DAS**	**120 DAS**
1.	M 35-1	0.45 (3.85)	1.00 (5.74)	16.00 (23.59)	21.20 (27.42)
2.	CSV 18	1.00 (5.74)	4.40 (12.11)	25.40 (30.28)	37.40 (37.70)
3.	PhuleChitra	3.10 (10.15)	9.15 (17.62)	33.00 (35.08)	48.00 (43.85)
4.	PKV Kranti	4.09 (11.67)	12.80 (20.97)	34.00 (35.69)	50.00 (45.00)
5.	ParabaniJoti	4.15 (11.76)	8.00 (16.44)	33.00 (35.08)	47.00 (43.28)
6.	PhuleVasudha	3.00 (9.98)	11.00(19.38)	36.40 (37.13)	49.00 (44.43)
7.	PhuleRevati	4.00 (11.54)	12.00 (20.28)	35.00 (36.29)	51.00 (45.57)
8.	5-4-1(Muguti)	8.00 (16.44)	17.45 (24.70)	37.45 (37.75)	49.45 (44.71)
9.	BR 33	12.40 (20.63)	23.80 (29.21)	46.40 (42.96)	59.00 (50.18)
10.	BJV 44	9.00 (17.47)	22.90 (28.60)	44.00 (41.58)	57.00 (49.02)
11.	BRJ 204	6.75 (15.07)	14.00 (21.98)	34.40 (35.93)	43.30 (41.15)
12.	KMJ 1	0.20 (2.56)	5.00 (12.93)	20.00 (26.58)	27.20 (31.44)
13.	SMJ 1	0.20 (2.56)	3.40 (10.63)	20.00 (26.58)	33.90 (35.61)
14.	AKJ 1	0.20 (2.56)	1.00 (5.74)	20.00 (26.58)	28.00 (31.95)
15.	RSJ 1	1.00 (5.74)	3.00 (9.98)	18.00 (25.12)	28.00 (31.95)
16.	CSV 22	4.30 (11.97)	11.80 (20.10)	28.00 (31.96)	43.20 (41.09)
17.	CSV 216R	2.00 (8.13)	6.90 (15.24)	24.00 (29.35)	36.00 (36.87)
18.	SPV 2033	2.00 (8.13)	6.00 (14.19)	26.00 (30.67)	36.00 (36.87)
19.	DSV 4	2.15 (8.44)	6.00 (14.19)	23.30 (28.88)	36.00 (36.87)
20.	DSV 5	2.40 (8.92)	8.00 (16.44)	26.20 (30.80)	38.70 (38.47)
	SEm±	0.03	0.03	0.07	0.09
	C.D. (1%)	0.11	0.11	0.29	0.31
	C.V.(%)	0.40	0.37	0.31	0.30

DAS= Days after storage

.Table: 2 Population build up of rice weevil in different *rabi* sorghum genotypes at monthly intervals

Sl. No.	Varieties/Genotypes	30 DAS	60 DAS	90 DAS	120 DAS
1.	M 35-1	9.93 (3.65)	12.50 (4.04)	15.50 (4.44)	25.50 (5.55)
2.	CSV 18	10.00 (3.66)	14.50 (4.31)	19.00 (4.86)	29.00 (5.89)
3.	PhuleChitra	9.95 (3.65)	17.75 (4.71)	21.00 (5.08)	29.00 (5.89)
4.	PKV Kranti	10.00 (3.66)	17.00 (4.62)	25.90 (5.59)	29.50 (5.93)
5.	ParabaniJoti	9.90 (3.65)	17.50 (4.68)	27.50 (5.74)	39.00 (6.74)
6.	PhuleVasudha	10.00 (3.66)	14.90 (4.36)	20.00 (4.97)	31.00 (6.07)
7.	PhuleRevati	10.00 (3.66)	12.00 (3.96)	20.00 (4.97)	30.00 (5.98)
8.	5-4-1(Muguti)	10.00 (3.66)	19.50 (4.92)	18.90 (4.85)	35.50 (6.46)
9.	BR 33	10.00 (3.66)	20.75 (5.06)	31.75 (6.13)	41.00 (6.90)
10.	BJV 44	10.00 (3.66)	17.00 (4.62)	20.00 (4.97)	32.00 (6.16)
11.	BRJ 204	10.00 (3.66)	12.00 (3.96)	21.90 (5.18)	25.50 (5.55)
12.	KMJ 1	9.85 (3.64)	12.50 (4.04)	15.00 (4.37)	25.00 (5.50)
13.	SMJ 1	9.90 (3.65)	13.50 (4.17)	17.75 (4.71)	26.50 (5.65)
14.	AKJ 1	9.95 (3.65)	12.50 (4.04)	15.00 (4.37)	24.50 (5.45)
15.	RSJ 1	9.93 (3.65)	14.00 (4.24)	17.50 (4.68)	25.50 (5.55)
16.	CSV 22	10.00 (3.66)	18.50 (4.80)	32.00 (6.16)	39.00 (6.74)
17.	CSV 216R	9.90 (3.65)	17.00 (4.62)	17.50 (4.68)	30.50 (6.02)
18.	SPV 2033	9.85 (3.64)	15.00 (4.37)	21.70 (5.16)	31.00 (6.07)
19.	DSV 4	9.80 (3.63)	13.00 (4.11)	19.70 (4.94)	31.00 (6.07)
20.	DSV 5	9.55 (3.59)	13.50 (4.17)	24.50 (5.45)	35.00 (6.42)
	SEm±	0.07	0.08	0.14	0.04
	C.D. (1%)	0.23	0.25	0.41	0.13
	C.V.(%)	2.17	2.68	3.83	1.05

*figures in the parenthesis are square root X + 0.5 transformed values

DAS= Days after storage

Table: 3 Grain weight losses in different *rabi* sorghum genotypes infested by rice weevil at monthly intervals.

Sl. No.	Varieties/ Genotypes	Loss in wt. 30 DAS (g)	Loss in wt. 60 DAS (g)	Loss in wt. 90 DAS (g)	Loss in wt. 120 DAS (g)
1.	M 35-1	0.20 (0.95)	0.50 (1.21)	3.10 (2.26)	4.43 (2.60)
2.	CSV 18	0.51 (1.21)	1.00 (1.50)	4.78 (2.69)	7.63 (3.26)
3.	PhuleChitra	1.50 (1.72)	2.80 (2.17)	6.60 (3.07)	9.60 (3.60)
4.	PKV Kranti	2.00 (1.91)	3.00 (2.23)	6.78 (3.10)	10.00 (3.66)
5.	ParabaniJoti	2.00 (1.91)	2.85 (2.19)	6.60 (3.07)	9.58 (3.60)
6.	PhuleVasudha	1.50 (1.72)	2.95 (2.22)	6.78 (3.10)	9.85 (3.64)
7.	PhuleRevati	1.99 (1.91)	2.93 (2.21)	7.00 (3.15)	10.15 (3.69)
8.	5-4-1(Muguti)	4.00 (2.50)	5.28 (2.80)	7.20 (3.18)	9.45 (3.57)
9.	BR 33	6.00 (2.95)	7.75 (3.28)	9.68 (3.61)	11.90 (3.95)
10.	BJV 44	4.48 (2.62)	6.88 (3.12)	8.78 (3.46)	11.10 (3.83)
11.	BRJ 204	3.00 (2.23)	5.83 (2.91)	7.23 (3.19)	9.45 (3.57)
12.	KMJ 1	0.10 (0.82)	2.48 (2.07)	4.00 (2.50)	6.40 (3.03)
13.	SMJ 1	0.10 (0.82)	1.50 (1.72)	4.00 (2.50)	5.60 (2.87)
14.	AKJ 1	0.10 (0.82)	0.50 (1.21)	4.00 (2.50)	5.60 (2.87)
15.	RSJ 1	0.50 (1.21)	1.53 (1.74)	3.68 (2.42)	5.60 (2.87)
16.	CSV 22	2.00 (1.91)	4.48 (2.62)	5.55 (2.86)	8.00 (3.33)
17.	CSV 216R	1.00 (1.50)	3.00 (2.23)	4.80 (2.69)	7.20 (3.18)
18.	SPV 2033	0.98 (1.49)	3.00 (2.23)	5.23 (2.79)	7.20 (3.18)
19.	DSV 4	1.00 (1.50)	3.00 (2.23)	4.78 (2.69)	7.20 (3.18)
20.	DSV 5	1.21 (1.60)	3.95 (2.49)	5.60 (2.87)	8.00 (3.33)
	SEm±	0.02	0.02	0.04	0.05
	C.D. (1%)	0.06	0.09	0.12	0.20
	C.V.(%)	1.29	1.44	1.65	2.11

*figures in the parenthesis are square root X + 0.5 transformed values

DAS= Days after storage