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Screening of different sorghum genotypes against rice weevil, *Sitophilus oryzae* (L.) for their resistance

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Abstract
The present laboratory study was conducted to screen the different twenty three sorghum genotypes to rice weevil, *Sitophilus oryzae* (L.) for their resistance / susceptibility by no choice method during 2016-17. The least number of adult emergence, seed infestation and seed weight loss was observed in genotypes *viz*, IS 2312 (1.00 adult, 0.33 % and 0.15%), IS 2205 (2.00 adults, 0.67% and 0.28%), M 35-1 (2.00 adults, 0.33 % and 0.30%) and IS 18551 (3.00 adults, 1.00 % and 0.60 %), respectively at 30 days after storage. Similar trend was recorded at 60, 90 and 120 days after storage.

Keywords: Sorghum genotypes, no choice method, rice weevil

1. Introduction

Sorghum, *Sorghum bicolor* (Linnaeus), is the world's 5th leading cereal in global production, after rice, wheat, maize and barley. It has a comparative advantage than the other cereals in terms of adaptation in high heat and water stress condition, resistance to mycotoxin and fungi, and can be grown in dry regions. Large acreages about 80% of grain sorghum are also grown in Africa and Asia in areas where the climate is too hot and dry for corn. United State ranks 1st in sorghum production in the world. In India area under grain sorghum was 6161.4 hectares and production at 5445.4 tonnes with national average productivity of 884 kg/ha. Maharashtra stands 1st in terms of area (3288.0 ha.), production (2109.0 tonnes) and productivity (641 kg/ha) (Anonymous, 2015) [1]. Sorghum has a multiple uses as food, feed, fodder, fuel and consumed as fresh vegetable in Maharashtra in India. It has an excellent source of energy, containing about 75% complex carbohydrate, iron, zinc and is rich in vitamin 'B' complex.

The most destructive rice weevil, *Sitophilus oryzae* Linnaeus (Coleoptera: Curculionidae) is a serious grain pest in multinational store (Khan *et al.*, 2014) [8]. Additionally, the kernel damage caused by *S. oryzae* larvae, enables other species, the external feeders, which are not capable of infesting sound grain, so increase the damage rapidly. Thus, unless control measures are taken, heavy infestations may take place. Rice weevil infestation alone resulted in sorghum grain damage up to 83.5 per cent over a period of six months (Kudachi and Balikai, 2014) [9]. Seed weight loss was reported to be the best indicator of economic loss from damage by weevils (Teshome *et al.*, 1999) [15] and it causes substantial losses to stored grain amounting 18.30 per cent (Adams, 1976).

2. Material and methods

2.1 Rearing of rice weevil

The rice weevil, *S.oryzae* culture obtained from the infested sorghum seeds was introduced and multiplied on disinfested susceptible genotype Phule Yashoda in 28 x 18 cm rearing jars to obtain similar aged weevils for the experiment. The top of jar was covered with muslin cloth secured firmly by rubber band. After the new adult emergence, the weevils were introduced into sorghum seeds kept in series of cylindrical jars for building up a homogenous population and jars were placed in the rearing cage at a temperature of 30^{0}C and relative humidity of 75% (Bhoge, 2010) [3]. Rice weevil adults were differentiated using rostrum characteristics (Halstead, 1963) [7]. To initiate the culture, healthy seed of sorghum was kept into cylindrical jars and ten pairs of adult weevils were isolated and released into jars. Density of population per jar was standardized to prevent overcrowding which was reported to give rise to less reproductive active forms. Such conditioning was deemed necessary to prevent short term changes in insect behaviour or biology associated with changes in host grain (Dobie, 1974) [5].

2.2 Moisture content
Five hundred grams seed of each twenty three elite genotypes of sorghum were obtained from All India Co-ordinated Sorghum Improvement Project (AICSIP), MPKV, Rahuri and were used for present investigation. The grains were cleaned of straw, chaff, light grains and other impurities before testing. All the grains were disinfected by keeping in the oven at 60^0C for 5 hours before keeping it for oviposition, development, loss in seed weight and per cent seed infestation. Initially the moisture content of fresh seed was about 7.23 to 11.04 per cent. Moisture content was measured by oven dry method (Chalam *et al.*, 1967) [4]. The moisture of the seeds was then raised to about 12.5 to 13.0 per cent by holding the seeds at 75 per cent relative humidity maintained in desiccators with the help of saturated salt solution of sodium chloride (NaCl) (Solomon, 1981) [13]. This was done in order to get better development of test insects. Hair hygrometer was used to determine humidity inside the desiccator.

2.3 No choice test
The experiment on screening of twenty three sorghum genotypes against rice weevil, *S. oryzae* was conducted in Completely Randomized Design (CRD) with three replications under no choice test in storage in the laboratory of Department of Agril. Entomology, MPKV, Rahuri during *Kharif* 2016-17. No choice test was sensitive in detecting responses for orientation and colonisation (Reddy *et al.,* 2002) [12] and the details of No choice test experiment are given below.

The set of plastic containers with 50 g seeds of each genotype was used for present investigation. No choice test has the greater reliability for weevil screening as the no choice stimulate actual seed bin conditions, where insects have no choice among cultivars (Stevens and Mills, 1973) [14]. The seeds were weighed with the help of a Mono-Pan-Micro Analytical Balance (Mettler) and were counted for knowing the initial weight and number of sound seeds. The moisture content of seeds was less than 12 per cent. The seed of each genotype weighing 50 g was kept in glass containers of 250 g capacity separately for investigating population build-up of rice weevil in sorghum seeds. Five pairs of five days-old adult insects were introduced in each bottle /containers and the top was kept covered with muslin cloth and tightly fixed with rubber band. These were kept in three replications for observations up to 120 days. Each bottle was examined periodically at monthly intervals to note the number of adult emergence and damaged seeds and calculated the per cent loss in weight. Number of seed infested (showing circular emergence holes) by *S. oryzae* were counted and per cent infestation was worked out. The per cent loss in seed weight was determined using count and weight method given by Gwiner and Mack (1996) [6].

3. Statistical analysis
The data on per cent adult emergence, seed infestation and seed damage were transformed to arcsine transformed values in order to stabilise a variance, before being subjected to analysis of variance.

4. Results and Discussion
The results on the reaction of rice weevil (*S. oryzae*) adults to different genotypes of sorghum are presented in Table 1-3.

4.1 Adult emergence
The data on per cent adult emergence indicated (Table 1) that there was marked variation ranged from 1.00 to 13.00, 3.00 to 18.00, 5.00 to 28.00 and 8.00 to 40.00 adults emerged at 30, 60, 90 and 120 days, respectively. Days after released adults with mean number of adults was less (4.25 adults) in IS 2312 followed by IS 2205 (5.00) and M 35-1 (5.75). Similar result are reported by Bhoge (2014) [3] who reported the least per cent adult emergence found in M 35-1 (2.50 %) followed by germplasm RSLG-755 (3.00 %) and RSLG-743 (10.50 %). The result are also similar with Kudachi and Balikai (2014) [9]. who reported less number of adult emerged from BRJ 356, IS 18551 and RSE (14.50, 14.50 and 14.50, respectively) which were at par with each other.

4.2 Seed infestation
The data on per cent seed infestation from Table 2 revealed that there was marked variation ranged from 0.33 to 11.00, 1.33 to 22, 4.67 to 29.00 and 5.67 to 36.00 seed infestation at 30, 60, 90 and 120 days, respectively. Phule Maulee (11.00 %) was recorded highest seed infestation followed by Phule Madhur (8.00 %), Phule Chitra (6.00 %), Phule Suchitra (6.00 %) and Phule Panchami (5.00 %) at 30 days after storage. At 60 days after storage, highest infestation was recorded in Phule Maulee (22.00 %) followed by Phule Madhur (19.00 %), Phule Chitra (16.00 %), Phule Panchami (15.00 %) and Phule Suchitra (14.00 %). At 90 days after storage, highest infestation was recorded in Phule Maulee (29.00 %) followed by Phule Madhur (25.00 %), Phule Chitra (21.00 %), Phule Panchami (18.00 %) and Phule Suchitra (17.00 %).At 120 days after storage highest infestation was recorded in Phule Maulee (36.00 %) followed by Phule Madhur (34.00 %), Phule Chitra (30.00 %), Phule Panchami (27.00 %) and Phule Suchitra (27.00 %). Whereas, the least seed infestation was recorded in genotype IS 2312 (0.33 %) followed by IS 2205 (0.67 %), M 35-1 (0.33 %) and IS 18551 (1.00 %) at 30 days after storage. Similar trend was recorded at 60, 90 and 120 days. It was observed that there was significant increase in seed damage with the increase in seed infestation.

4.3 Seed weight loss
The data from Table 3 on per cent seed weight loss indicated that there was also marked variation ranged from 0.15 to 6.81, 0.23 to 9.04, 0.30 to 11.42 and 82.38 to 18.84 % adults emerged at 30, 60, 90 and 120 days, respectively. The least per cent seed weight was observed in IS 2312 (0.15 %) followed by IS 2205 (0.28 %), M 35-1 (0.30 %) and IS 18551 (0.60 %) at 30 days after storage. Similar trend was observed at 60, 90 and 120 days. Highest per cent seed weight was recorded in Phule Maulee (6.81%) followed by Phule Madhur (6.05 %), Phule Chitra (5.37 %), Phule Suchitra (4.67 %) and Phule Panchami (4.50 %) at 30 days after storage. Similar trend was recorded at 60, 90 and 120 days.

These results are found similar with Kudachi and Balikai (2014) [9].who reported genotype IS 2312 showed high degree of resistance by recording minimum weight loss of 0.23 per cent followed by IS 2205 (0.38%) after one month of storage. He also reported rice weevil infestation alone resulted in sorghum grain damage up to 83.5 per cent over a period of six months. Similarly, Bheemanna *et al.* (1994) [2] reported least weight loss in DMS 652 (2.35%), DJ 6514 (4.86%) and M35-1 (5.25%) by *S. oryzae*. Ladang *et al*. (2008) [10] also reported the losses of grains due to weevils estimated to an average of

25 to 40 per cent after 100 days of storage. Lokhande (1986) [11]. revealed that SPV-491 was observed to be the least susceptible having recorded the lowest emergence of 17.00 progeny weevils/100 grains, grain infestation of 10.66 per cent and loss in grain weight of 2.69 per cent. The sorghum cultivar CSH-8R was the most susceptible with the highest adult emergence of 45.66 weevils/100 grains, grain infestation of 43.66 per cent and loss in grain weight of 13.91 per cent.

These findings indicated that there is an association in adult emergence from seeds of sorghum with seed infestation and seed weight loss under no choice test. Also the less seed weight loss in resistant genotypes might be due to low seed damage by *S. oryzae*. Teshome *et al*. (1999) [15] reported seed weight loss was to be the best indicator of economic loss from damage by weevils.

Table 1: Adult emergence of rice weevil from different genotypes of sorghum

Sr. No.	Genotypes	Per cent adult emergence			
		30 Days	60 Days	90 Days	120 Days
1	Phule Yashoda	7.00 (15.31)	10.00 (18.41)	16.00 (23.56)	27.00 (31.29)
2	Phule Chitra	11.00 (19.35)	15.00 (22.77)	25.00 (29.99)	35.00 (36.25)
3	Phule Maulee	13.00 (21.12)	18.00 (25.09)	28.00 (31.93)	40.00 (39.22)
4	Phule Vasudha	9.00 (17.43))	13.00 (21.12)	22.00 (27.95)	33.00 (35.04)
5	Phule Anuradha	6.00 (14.04)	10.00 (18.41)	16.00 (23.56)	24.00 (29.32)
6	Phule Suchitra	10.00 (18.39)	14.00 (21.96)	21.00 (28.64)	35.00 (36.26)
7	Phule Rohini	7.00 (15.23)	11.00 (19.36)	17.00 (24.33)	28.00 (31.94)
8	Phule Revati	8.00 (16.40)	12.00 (20.25)	16.00 (23.56)	28.00 (31.93)
9	Phule Panchami	9.00 (17.40)	13.00 (21.10)	22.00 (27.95)	34.00 (35.65)
10	Phule Madhur	12.00 (20.23)	16.00 (23.56)	26.00 (30.64)	37.00 (37.45)
11	Phule Uttara	6.00 (14.14)	9.00 (17.40)	14.00 (21.96)	21.00 (27.25)
12	Phule Godhan	8.00 (16.36)	12.00 (20.25)	19.00 (25.83)	31.00 (33.82)
13	Phule Amruta	6.00 (14.14)	9.00 (17.43)	15.00 (22.75)	23.00 (28.64)
14	Phule Vasundhara	8.00 (16.40)	13.00 (21.12)	20.00 (26.55)	33.00 (35.05)
15	RSE 03	7.00 (15.31)	12.00 (20.25)	18.00 (25.09)	30.00 (33.20)
16	CSV 19SS	4.00 (11.53)	7.00 (15.31)	11.00 (19.35)	16.00 (23.54)
17	CSV 22	5.00 (12.87)	8.00 (16.40)	12.00 (20.25)	17.00 (24.33)
18	IS 18551	3.00 (9.88)	5.00 (12.87)	10.00 (18.38)	14.00 (21.96)
19	IS 2205	2.00 (8.13)	4.00 (11.47)	6.00 (14.17)	8.00 (16.40)
20	IS 2312	1.00 (5.74)	3.00 (9.88)	5.00 (12.87)	8.00 (16.37)
21	SSV 84	5.00 (12.87)	7.00 (15.31)	12.00 (20.22)	16.00 (23.56)
22	ICSV 745	6.00 (14.14)	8.00 (16.42)	14.00 (21.96)	20.00 (26.52)
23	M 35-1	2.00 (7.95)	4.00 (11.53)	7.00 (15.23)	10.00 (18.41)
S.E.±		0.81	0.60	0.66	0.57
C.D. at 5%		2.31	1.71	1.88	1.64
CV (%)		9.64	5.71	4.88	3.40

* Figures in parentheses are arc sin transformed values

Table 2: Seed infestation of different genotypes of sorghum

Sr. No.	Genotypes	Per cent seed infestation			
		30 Days	60 Days	90 Days	120 Days
1	Phule Yashoda	3.00 (9.97)	12.00 (20.25)	16.00 (23.56)	20.00 (26.55)
2	Phule Chitra	6.00 (14.14)	16.00 (23.56)	21.00 (27.26)	30.00 (33.20)
3	Phule Maulee	11.00 (19.36)	22.00 (27.96)	29.00 (32.57)	36.00 (36.85)
4	Phule Vasudha	4.67 (12.46)	13.00 (21.12)	17.00 (24.33)	25.33 (30.20)
5	Phule Anuradha	3.00 (9.97)	10.00 (18.14)	13.00 (21.12)	19.00 (25.83)
6	Phule Suchitra	6.00 (14.14)	14.00 (21.96)	17.00 (24.33)	27.00 (31.29)
7	Phule Rohini	3.00 (9.97)	10.00 (18.41)	15.00 (22.77)	20.00 (26.55)
8	Phule Revati	3.67 (11.01)	14.00 (21.96)	17.00 (24.33)	21.33 (27.50)
9	Phule Panchami	5.00 (12.87)	15.00 (22.77)	18.00 (25.09)	27.00 (31.29)
10	Phule Madhur	8.00 (16.40)	19.00 (25.83)	25.00 (29.99)	34.00 (35.65)
11	Phule Uttara	2.33 (8.74)	5.00 (12.87)	15.33 (23.04)	17.33 (24.59)
12	Phule Godhan	4.00 (11.53)	15.00 (22.77)	17.00 (24.33)	25.00 (29.99)
13	Phule Amruta	2.67 (9.36)	8.00 (16.40)	13.00 (21.12)	18.33 (25.33)
14	Phule Vasundhara	4.33 (11.99)	11.00 (19.35)	16.00 (23.56)	23.67 (29.09)
15	RSE 03	4.00 (11.47)	16.33 (2382)	14.00 (21.96)	21.67 (27.72)
16	CSV 19SS	1.00 (5.74)	4.00 (11.47)	10.00 (18.41)	13.00 (21.12)
17	CSV 22	2.00 (8.13)	4.33 (11.99)	13.00 (21.12)	14.67 (22.49)
18	IS 18551	1.00 (5.74)	3.00 (9.97)	7.00 (15.31)	10.00 (18.41)
19	IS 2205	0.67 (3.83)	2.33 (8.74)	6.00 (14.14)	7.00 (15.31)
20	IS 2312	0.33 (1.91)	1.33 (6.53)	4.67 (12.46)	5.67 (13.75)
21	SSV 84	1.33 (6.53)	4.00 (11.47)	12.00 (20.25)	14.67 (22.49)
22	ICSV 745	2.00 (8.13)	5.00 (12.87)	15.00 (22.77)	16.00 (23.56)
23	M 35-1	0.33 (1.91)	2.67 (9.36)	5.67 (13.75)	8.33 (16.77)
S.E.±		0.83	0.57	0.47	0.49
C.D. at 5%		2.36	1.63	1.35	1.39
CV (%)		14.61	5.70	3.71	3.25

* Figures in parentheses are arc sin transformed values

Table 3: Seed weight loss of different genotypes of sorghum

Sr. No.	Genotypes	Per cent seed weight loss			
		30 Days	**60 Days**	**90 Days**	**120 Days**
1	Phule Yashoda	2.09 (8.31)	3.51 (10.79)	3.96 (0.04)	6.27 (14.50)
2	Phule Chitra	5.37 (13.39)	8.74 (17.19)	10.55 (0.04)	16.29 (23.79)
3	Phule Maulee	6.81 (15.12)	9.04 (17.49)	11.42 (22.43)	18.84 (25.71)
4	Phule Vasudha	4.12 (11.70)	6.90 (15.22)	9.26 (20.61)	14.76 (22.58)
5	Phule Anuradha	1.99 (8.11)	2.94 (9.87)	3.38 (11.47)	7.08 (15.43)
6	Phule Suchitra	4.67 (12.47)	7.92 (16.34)	10.02 (20.96)	15.09 (22.85)
7	Phule Rohini	2.28 (8.68)	3.98 (11.50)	4.49 (13.14)	8.01 (16.43)
8	Phule Revati	2.72 (9.50)	3.22 (10.33)	4.22 (13.63)	10.25 (18.66)
9	Phule Panchami	4.50 (12.23)	7.46 (15.85)	9.64 (20.73)	14.82 (22.63)
10	Phule Madhur	6.05 (14.24)	8.87 (17.32)	11.07 (21.97)	17.00 (24.34)
11	Phule Uttara	1.42 (6.83)	2.16 (8.45)	2.52 (9.98)	5.94 (14.10)
12	Phule Godhan	3.72 (11.11)	5.45 (13.50)	7.61 (18.88)	13.21 (21.31)
13	Phule Amruta	1.56 (7.18)	2.45 (8.99)	2.78 (10.32)	6.58 (14.85)
14	Phule Vasundhara	3.92 (11.41)	5.71 (13.82)	8.04 (19.50)	13.54 (21.58)
15	RSE 03	2.88 (9.77)	4.25 (11.89)	5.03 (14.25)	12.53 (20.72)
16	CSV 19SS	0.79 (5.08)	1.01 (5.77)	1.20 (6.94)	4.01 (11.550
17	CSV 22	1.15 (6.16)	1.64 (7.35)	1.83 (8.30)	5.00 (12.91)
18	IS 18551	0.60 (4.45)	0.83 (5.21)	0.92 (5.89)	3.30 (10.45)
19	IS 2205	0.28 (3.03)	0.38 (3.53)	0.47 (4.42)	2.83 (9.69)
20	IS 2312	0.15 (2.22)	0.23 (2.76)	0.30 (3.57)	2.38 (12.36)
21	SSV 84	0.94 (5.55)	1.30 (6.55)	1.48 (7.54)	4.59 (13.21)
22	ICSV 745	1.30 (6.54)	1.85 (7.82)	2.27 (9.69)	5.23 (13.21)
23	M 35-1	0.30 (3.14)	0.45 (3.84)	0.55 (4.73)	2.55 (9.17)
S.E.±		0.15	0.09	0.13	0.17
C.D. at 5%		0.42	0.25	0.36	0.48
CV (%)		3.00	1.45	1.66	1.71

* Figures in parentheses are arc sin transformed values

5. Conclusion

The resistant genotypes were IS2312 followed by IS 2205, M 35-1 and IS 1851 as they showed the least number of adult emergence, seed infestation and seed weight loss. These genotypes may be incorporated in sorghum breeding programme to evolve hybrids which are less susceptible to insect pests damage under storage condition as a new approach of non-chemical protection over long term sorghum storage.

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