The Pharma Innovation Journal 2021; 10(9): 1978-1983

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(9): 1978-1983

www.thepharmajournal.com
Received: 18-07-2021
Accepted: 27-08-2021

Ajay Khatavkar
M.Sc. Student, Department of Agricultural Entomology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Sanjeev Bantewad
Head, Department of Agricultural Entomology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Milind Sonkamble
Assistant Professor, Department of Agricultural Entomology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Corresponding Author:
Sanjeev Bantewad
Head, Department of Agricultural Entomology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

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

Ajay Khatavkar, Sanjeev Bantewad and Milind Sonkamble

Abstract
The present laboratory study was conducted to screen the different eight sorghum genotypes against rice weevil, *Sitophilus oryzae* (L.) for their resistance / susceptibility during 2020-21 at Dept. of Agril. Entomology, College of Agriculture, Parbhani. Among the eight genotypes some genotypes were slightly smooth, shiny, attractive, wrinkled and rough. Seed colors were pearly white, yellowish white to pale yellow and small, medium to bold size of seed. In different genotypes significantly lowest numbers of eggs (10 eggs/100 seeds) were laid on genotype Dagdi followed by M 45 (16.00 eggs/ 100 seeds) which was at par with PBN-Shakti (16 eggs/100 seeds) and PBN-Jyoti (18 eggs/100 seeds). In respect of adult emergence lowest per cent adult emergence was recorded in Dagdi (10 per cent) which was found significantly superior over other genotypes followed by PBN-Shakti (12.50 per cent) and M-45 (12.50 per cent) and developmental period range of 27.41 days on PBN-Super moti to 35.14 days on Dagdi. The range of seed infestation of sorghum genotypes was from Dagdi (8.20 per cent) to PBN-Supermoti (30.80 per cent) due to rice weevil. The genotype Dagdi followed by M 45 and Parbhani shakti was found tolerance genotype on the basis of damage, oviposition preference, and weight loss. This information is useful to improve grain protection in storage and varietal improvement and release programme.

Keywords: Sorghum genotypes, rice weevil, *Sitophilus oryzae*, screening, tolerance

1. Introduction
Sorghum, (*Sorghum bicolor* L.) is called as 'Camel of crops' because of its hardiness and ability to withstand prolonged droughts. The crop plays an important role in the food security of millions of poor people in marginal agricultural areas. It is the fifth most important cereal crop in the world after Rice, wheat, corn and barley. Although there is a continuous decrease in the area, the total production in the country has increased which is mainly due to increase in the productivity from 492 kg/ha in 1964-65 to 958 kg/ha in 1996-97. As per 2018 data, the total cultivated land is 4.96 million hectares and production of sorghum in India is about 4.95 million with productivity of 998kg/ha. Maharashtra stands first in area (2.17mha), production (1.81m tones) and productivity (833 kg/ha). Followed by Karnataka with area (1.09mha), production (1.13m tones) and productivity (1040 kg/ha) (Agriculture Statistics at a Glance, 2018) [2].
The basic underlying principle in developing a disease screening technique is to provide adequate pathogen inoculums at the most susceptible growth stage under optimal environmental conditions for infection and disease development. This helps to clearly distinguish plants and lines as resistant or susceptible class.
After the resistant plants/lines are identified, the resistance is confirmed by screening their next generation progenies under similar conditions, which provides information on heritability of resistance as well. Further, resistance stability is determined by testing the lines in different environments under high disease pressure through multi-location testing. The stable resistance sources thus identified are used in breeding programs to develop disease resistant hybrid parents and varieties. It is often desirable to study inheritance of resistance and number of genes involved before using such sources in breeding programs for effective transfer of resistance genes (Thakur *et al.*, 2007) [19].
The most destructive Rice weevil, *Sitophilus oryzae* Linnaeus (Coleoptera: Curculionidae) is a serious grain pest in multinational store and its control of storage pests by using synthetic chemicals has become a common practice among the farmers and stockholders. It is now widely known that chemical method has several harmful side-effects, which includes severe health hazards to the users and grain consumers. It causes residual toxicity, environmental pollution and development of pesticide resistance against weevils. Sometimes persistent pesticides accumulate in the higher food chain of both wildlife and human and become

concentrate by bio magnifications (Metcalf, 1975) [11].

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) [8]. Seed weight loss was reported to be the best indicator of economic loss from damage by weevils (Teshome *et al.*, 1999) [18]. It has been found that Rice weevil infestation alone resulted in sorghum grain losses of (61.3%) over a period of 5 months (Venkatrao *et al.*, 1958) [20]. Hence, the present study was undertaken to screen different released promising sorghum genotypes against *Sitophilus oryzae* in storage.

2. Materials and Methods

Maize genotypes selection: Sorghum promising genotypes were collected from Sorghum Research Station, Parbhani and some genotypes from local market for screening against S. *oryzae*. The seeds further examined and foreign material removed from the lot.

2.1 No. of eggs laid on genotypes / varieties

The number of eggs laid on each variety was counted after 72 hrs of the release of *Sitophilus oryzae* L. with the help of hand lens.

2.2 Adult emergence

Per cent adult emergence was calculated using following formulae (Howe, 1971) [7].

$$\text{Per cent adult emergence} = \frac{\text{Number of adult emerged}}{\text{Number of egg laid}} \text{ X } 100$$

2.3 Total developmental period of Rice weevil on each genotypes

The mean developmental periods of the Rice weevil in the test varieties was calculated by using the data obtained from the number of adults emerged on each day and the number of days required for adult emergence. This can be determined by subtracting the first day of egg laying from day of adult emergence as suggested by Howe, (1971) [7].

$$\text{Mean Development Period} = \frac{d_1a_1+d_2a_2+d_3a_3+\text{------------}+ d_a n_a}{\text{Total Number of adult emerged}}$$

Where, d_1 - day at which the adults started emerging (1st day), a_1 - Number of adults emerged on d_1 th day.

2.4 Growth index of Rice weevil on different genotypes

The growth index was calculated by the formula given by Singh and Pant (1955) as- Growth Index = S / T

Where, S = Per cent of adult emergence,

T = Average developmental period (days).

The genotypes susceptibility to *Sitophilus oryzae* L. was determined on the basis of per cent grain damage and loss in seed weight.

2.5 Per cent seed infestation by Rice weevil on sorghum genotypes

55 days after starting the experiment 100 grains of each tray were used to calculate the per cent seed infestation. The damaged and healthy grains were sorted out and counted in each replication. One or more holes per seed were considered as damaged grains.

The following formula was used to work out the per cent seed infestation.

$$\text{Per cent seed infestation} = \frac{\text{Number of damaged grains}}{\text{Total number of grains}} \text{ X } 100$$

2.6 Weight loss due to Rice weevil on different genotype

For working out the weight loss, the weevils, frass, excreta *etc*. were removed from each cylindrical tube and then weighted by using single pan electronic balance. The 55 days after starting experiment 100 grain on tray of each were used to calculate the weight loss.

The per cent loss in weight was calculated by using following formula.

$$\text{Weight loss (\%)} = \frac{I-F}{I} \times 100$$

Where, I = initial weight of grains,

F= final weight of grains after removal of weevils, frass and excreta etc.

3. Result and Discussion

3.1 Screen the seeds of different sorghum genotypes against *Sitophilus oryzae*

Eight genotypes of sorghum were taken to morphological characteristics and tested the pest ovipositional preference, total developmental period (egg to adult), adult emergence, growth index, per cent seed infestation and per cent weight loss caused by rice weevil, *Sitophilus oryzae* of each genotype. The details of assesses of test weight, width of seed, length of seed, seed characters, seed colour and seed size like morpho/physical characters of eight different sorghum genotypes against *Sitophilus oryzae* are as under (Table 1).

Table 1: Categorization of different sorghum genotypes on the basis of morphological characters

Sr. No.	Genotypes	Weight of 1000 seed (g)	Width of seed (mm)	Length of seed (mm)	Character of seed	Seed colour	Seed size
1	Parbhani Shakti	27.35	2.68	2.86	Soft	Pearly white	Small
2	Parbhani Jyoti	28.3	3.77	3.89	Wrinkled	Yellowish white	Medium
3	Parbhani Moti	30.12	4.06	4.13	Slightly smoother	Light yellow	Bold
4	Parbhani Supermoti	30.93	4.12	4.23	Smoothest attractive	Pale yellow	Bold
5	CSC-48	30.23	4.1	4.26	Smooth	Pale yellow	Bold
6	M-45	29.94	3.39	3.62	Slightly wrinkled	Light yellow	Medium to Bold
7	Barshi Jute	29.47	3.65	3.73	Smooth & shiny	Pearly white	Medium
8	Dagdi	27.84	2.7	2.81	Slightly rough	Creamy white	Small

3.2 Test weight of seed (1000 seeds)

The test weight of 1000 seeds/grains of different sorghum genotypes was taken by numerical counting and weighing of sound grains. The grains in 1000 g sample of each variety were counted replication wise and their average was taken them with biological aspects of test insect. The maximum test weight of 1000 seeds of genotypes PBN-Supermoti (30.93 g) followed by CSC-48 (30.23 g) and PBN-Moti (30.12 g). The

PBN-Shakti and Dagdi (c) had least test weight of seed (27.35 g and 27.84 g) as compared to Barshi jute and M-45 (29.47 g and 29.94 g). Whereas, Bhoge (2010) [4] reported that the hundred seed weight of sorghum ranged from 2.88 g to 4.29 gand its weight was depend upon the genotypes.

3.3 Seed width
The seed width of grains observed in different sorghum genotypes was found varied during course of study and the genotype PBN-Supermoti recorded the maximum width of seeds (4.12 mm) was followed by CSC-48 (4.10 mm) and PBN-Moti (4.06 mm). The lower seed width was recorded in genotypes PBN-Shakti (2.68 mm) and was followed by Dagdi (c) (2.70 mm) and M-45 (3.39 mm) and seed width of PBN-Jyoti was (3.77 mm), respectively.

3.4 Seed length
The differences in the seed length of grains observed in different genotypes. CSC-48 (4.26 mm) had highest followed by PBN-Supermoti (4.23 mm) and PBN-Moti (4.13 mm) seed length was observed in genotypes. The smallest seed length was observed in Dagdi (c) (2.81 mm) followed by PBN-Shakti (2.86 mm) and M-45 (3.62 mm) respectively.

3.5 Seed colour
Seed colour is the one of the character for attractant to insect for egg laying. As genotypes CSC-48 and PBN-Supermoti were (pale yellow) in colure, and PBN-Moti (light yellow) were observed more preferred to adult Rice weevil for ovi-position. The least preference to attack was observed in Dagdi (c) (creamy white) followed by PBN-Shakti (pearly white) and Barshi Jute was (pearly white), respectively.
It is evident from the above findings that results are found similar with Bhoge (2010) [4] reported that most preferred germplasm RSLG-611, RSLG-704, RSLG-737, RSLG-756 and CSH-15R showed pale yellow, yellowish white, yellowish white and yellowish white, respectively and the least preferred by *S. oryzae* L. i.e. RSLG-743, RSLG-755, RSLG-779, RSLG-848, M-35-1 showed cream, light yellow, pale yellow and cream colour shades of the seed, respectively.

3.6 Seed characters, colour and size
The differences in the seed characters as seed colour and size of grains were observed in eight sorghum genotypes. Some genotypes were slightly smooth, shiny, attractive, wrinkled and rough. Seed colours were pearly white, yellowish white to pale yellow and small, medium to bold size of seed were present.
The present findings are in confirmation with Bhoge (2010) [4] reported M-35-1, Phule M aulee, Phule Swati, Phule Chitra and Phule Yashoda has medium size seed and result shows that *S. oryzae* L. Preferred medium and bold size seed and least preferred for small size seeds which are confirmed with the results of Singh *et al.*, (1974) [15] and Ram and Singh, (1996) [12] reported that *S. oryzae* L. prefer to oviposition varieties with larger seeded as bold.

3.6.1 Ovi-positional preference
With the view to test the ovi-positional preference of *Sitophilus oryzae* L. free-choice test was used in which twenty five pairs of one to two days old adults of *Sitophilus oryzae* L. were released in petri-dish placed in the center of the tray after putting the seeds of eight different sorghum genotypes/varieties. Eggs were counted 72 hours after release of rice weevil and number of grains with eggs worked out and summarized, here under (Table 2).

Table 2: Ovi-positional preference (Free choice test), adult emergence and developmental period of *Sitophilus oryzae* L. on different sorghum genotypes

Sr. No.	Genotypes	Total Number of Egg laid by female per 100 seeds*	No. of Adult emergence (%) **	Total developmental periods (Days)*
1	Parbhani Shakti	16.00 (4.14)	12.50 (20.68)	33.02 (5.82)
2	Parbhani Jyoti	18.00 (4.35)	16.66 (24.06)	31.10 (5.66)
3	Parbhani Moti	23.00 (4.89)	21.73 (27.77)	28.43 (5.42)
4	Parbhani Supermoti	27.00 (5.28)	25.92 (30.57)	27.41 (5.32)
5	CSC-48	24.00 (4.99)	20.83 (27.12)	27.96 (5.37)
6	M-45	16.00 (4.12)	12.50 (20.68)	32.14 (5.75)
7	Barshi Jute	20.00 (4.58)	20 (26.54)	29.20 (5.49)
8	Dagdi (C)	10.00 (3.31)	10 (18.42)	35.14 (6.01)
	“F” test	Sig	Sig	Sig
	SE (m)±	0.10	0.67	0.13
	CD at 5%	0.32	2.03	0.40
	CV (%)	4.20	4.76	4.13

* Figures in parentheses are square root transformation values.
****** Figures in parentheses are angular transformation values.

3.6.2 Number of eggs laid by *Sitophilus oryzae*
The data shows significant variation with a range of 10 to 27 eggs/100 seeds in number of eggs laid by female of Rice weevil *Sitophilus oryzae* L. on different varieties of sorghum (Table 2). Among the genotypes significantly lowest number of eggs (10 eggs/100 seeds) were laid on variety Dagdi (c) as compared to other genotypes. The next set of the genotypes M 45 (16.00 eggs/ 100 seeds) which was at par with PBN-Shakti (16 eggs/100 seeds) followed by PBN-Jyoti (18 eggs/100 seeds), respectively.
These findings are similar with the results of Reddy *et al.*, (2002) [13] who reported that greater levels of antixenosis for ovi-position on genotype M 35-1 and IS 2312 and Russell (1966) [14] reported that least ovi-positional preference to smaller seeds by *S. oryzae*. Results in respect of morphological seed characters and egg laying preference indicated that Subbarayudu *et al.* (2013) [17] reported maximum eggs laid in bold genotypes like CSH 14 (39.1), CSH 13 (39.1) and NSS 104 (38.6) indicating maximum susceptible to *S. oryzae*.

3.6.3 No. of adult emergence of *Sitophilus oryzae*
The data presented in Table 2 indicated that lowest per cent adult emergence was recorded in Dagdi (10 per cent) which was found significantly superior over other genotypes. The other set of the genotypes PBN-Shakti (12.50 per cent) which was at par with M-45 (12.50 per cent).
Whereas, the genotypes PBN-Jyoti (16.66 per cent) followed

by Barshi Jute and CSC 48 recorded moderate adult emergence as 20.00 per cent and 20.83 percent followed by PBN-Moti (21.73 per cent). Highest per cent adult emergence was recorded in PBN-Supermoti (25.92 per cent).
The result revealed that smaller the seed lesser the egg laid and less the adult emerged which is confirmed by the Russell (1962) who reported that smaller the seeds, the shorter and lighter were the weevils that emerged. The mortality of adult weevils feeding on seed samples in no choice tests can be attributed either to high levels of anti-xenosis for feeding and it also confirmed by the earlier study conducted by Reddy *et al.* (2002) [13] and Adetunji (1988) [1].

3.6.4 Total developmental period of *Sitophilus oryzae*

The perusal of total developmental period of Rice weevil (number of days taken by the adult to emergence since the ovi-position period) on different genotypes had range of 27.41days (PBN-Supermoti) to 35.14 days on Dagdi genotypes. The shortest developmental period was recorded of 27.41 days in PBN-Supermoti which was at par with the genotypes CSC-48 (27.96 days) followed by Barshi jute (28.43 days), PBN-Moti (29.20 days), respectively. The longest developmental period was recorded in PBN-Jyoti (31.10 days) followed by M-45 (32.14 days), PBN-Shakti (33.02 days), and Dagdi (c) (35.14 days), respectively (Table 2).
Thus, the result indicated that seed colour did not play important role in influencing total developmental period. However, seed size and varieties seed surface have some influence on total developmental period of *Sitophilus oryzae* L. The fewer eggs laid, longer developmental period of sorghum genotypes indicated clear evidence of non-preference and as consequences of resistance of sorghum genotype. Results are in conformity with Adetunji (1988) [1] indicating that one effect of resistance is a prolongation of the developmental period of *S. oryzae* L. on different cultivars of sorghum. Same results were also obtained by Dobie (1974) [5] reported that resistant maize varieties extended developmental period of *S. zeamais* L. It can be concluded that if resistant sorghum varieties extend the developmental period and because a high mortality of the developing *Sitophilus oryzae* L. the post-harvest loss incurred during storage of farm produce will be greatly minimized.

3.6.5 Growth index of *Sitophilus oryzae* L.

The data pertaining to growth index of *Sitophilus oryzae* L. on different genotypes revealed that growth index (Table 3) range from (0.10 to 1.01).The lowest growth index was recorded in Dagdi (c) (0.10) which was followed by PBN-Shakti (0.32), PBN-Jyoti (0.54), M-45 (0.63), respectively. The next promising group of genotypes with increasing growth index were Barshi jute (0.77) followed by PBN-Moti (0.80), CSC-48 (0.90) and PBN-Supermoti (1.01). Whereas, higher growth index was recorded in more preferred varieties which has bigger size, maximum food value as protein for the development of *Sitophilus oryzae* L. as compared to resistant varieties.
The present findings are accordance with the result of Bhoge (2010) [4] reported growth index ranged from 0.06 to 1.28. The result reveals that sorghum genotypes having maximum developmental period provided minimum growth index and varieties having minimum developmental period provided maximum growth index. The results are in conformity with Gupta *et al.* (1999) [6] observed minimum growth index in least preferred varieties in which *S. oryzae* L. have longer developmental period and maximum growth index in most preferred varieties of maize.

Table 3: Growth index of *Sitophilus oryzae* L. on different genotypes of sorghum

Sr. No.	Genotypes	Growth Index	Per cent seed infestation (%)** (55 DAR of RW)*	Per cent weight loss (%)** (55 DAR of RW)*
1	Parbhani Shakti	0.32	11.60 (19.89)	2.47 (9.03)
2	Parbhani Jyoti	0.54	14.30 (22.19)	5.02 (12.93)
3	Parbhani Moti	0.80	19.40 (26.12)	10.56 (18.95)
4	Parbhani Supermoti	1.01	30.80 (33.67)	12.52 (20.69)
5	CSC-48	0.90	23.70 (29.10)	11.16 (19.49)
6	M-45	0.63	12.20 (20.42)	4.68 (12.48)
7	Barshi Jute	0.77	20.10 (26.61)	9.89 (18.31)
8	Dagdi (C)	0.10	8.20 (16.63)	1.80 (7.70)
	‘F’ test	Sig	Sig	Sig
	SE(m)±	0.01	0.69	0.41
	CD at 5%	0.04	2.10	1.24
	CV (%)	1.81	4.96	4.76

***** DAR of RW – days after release of rice weevil.
****** Figures in parentheses are angular transformation values.

3.6.7 Per cent seed infestation due to *Sitophilus oryzae*

The result on per cent seed infestation by *Sitophilus oryzae* L. on different sorghum genotypes varied significantly. The range of seed infestation on different sorghum varieties was from Dagdi (8.20 per cent) to PBN-Supermoti (30.80 per cent) (Table 3). The per cent seed infestation genotype Dagdi (c) (8.20 per cent) which was recorded lowest seed infestation and found significantly superior over other genotypes. The next set of the genotypes moderate seed infestation was recorded on PBN-Shakti (11.60 per cent) which was at par with M-45 (12.20 per cent). The next group of varieties comprised of PBN-Jyoti (14.30 per cent) followed by PBN-Moti (19.40 per cent), Barshi jute (20.10 per cent) and CSC-48 (23.70 per cent) recorded per cent seed infestation. The maximum per cent seed infestation were recorded in PBN-Supermoti (30.80 per cent) and found more preferred for seed infestation.
Thus, the result indicated that seed surface plays important role in causing per cent seed infestation. However, the variety PBN-Supermoti had smoother surface and was found more suitable for seed damage while Dagdi (c) and PBN-Shakti were least preferred for seed damage. Results are accordance with Kudachi and Balikai (2014) [8] reported minimum seed damage was noticed in IS 18551 (1.00%) along with other genotypes and the maximum of 16.00 per cent damaged seeds were recorded in Maulee followed by Y 75 (14.50%), RSE 03

(11.00%) and M 35-1 (11.00%) and were on par with each other. It was found that the susceptible genotypes showed higher percentage of damaged seeds similar with the result of Subbarayudu *et al.*, (2013) [17].

3.6.8 Per cent weight loss due to *Sitophilus oryzae*

The per cent weight losses were recorded in different genotypes with the lowest weight loss in Dagdi (1.80 per cent) followed by PBN-Shakti (2.47 per cent) which indicating tolerance to rice weevil (table 3). The next group of genotypes which recorded moderate per cent weight loss due to rice weevil onM-45 (4.68 per cent) and PBN-Jyoti (5.02 per cent). In contrast to that, significantly highest weight losses were recorded in PBN-Supermoti (12.52 per cent) followed by CSC-48 (11.16 per cent) PBN-Moti (10.56 per cent) as compare to Barshi jute (9.89 per cent) which was indicating susceptibility to Rice weevil. Thus, the results indicated that susceptibility had much influence on per cent weight loss. The varieties PBN-Supermoti and CSC-48 had smooth surface and bold which found more susceptible for seed damage ultimately more per cent weight loss recorded as compared to least susceptible varieties.

These results are found similar with Kudachi and Balikai (2014) [8] 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. Similarly, the results are also found with Bheemanna *et al.* (1994) [3] who reported least weight loss in DMS 652 (2.35%), DJ 6514 (4.86%) and M35-1 (5.25%) by *S. oryzae*. Whereas, Ladang *et al.* (2008) [9] reported the losses of grains due to weevils estimated to an average of 25 to 40 per cent after 100 days of storage and Lokhande (1986) [10] 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.

4. Conclusions

The findings showed that the sorghum genotypes had different response to *Sitophilus oryzae* attack from susceptible to tolerance level. Out of eight genotypes *viz*. Dagdi, Parbhani Shakti, Parbhani Jyoti and M-45 were found to be resistant/ tolerance against rice weevil in respect of low ovipositional preference, minimum adult emergence, medium developmental period, minimum per cent seed infestation. While, the genotype *viz.*, Parbhani supermoti were found shortest developmental period and highest seed infestation and weight loss as were highly susceptible to rice weevil in respect of above parameters. Hence, there is ample opportunity to explore and utilize such genotypes in post-harvest insect pest management, sorghum breeding programs and varietal improvement as well as release.

5. Acknowledgement

The authors are thankful to the Associate Dean & Principal, College of Agriculture Parbhani and Director of Instruction & Dean, VNMKV Parbhani for providing the necessary facilities during the course of investigation.

6. References

1. Adetunji JF. A study of resistance of some sorghum seed cultivars to *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae). J stored products Res 1988;24(2):67-71.
2. Agriculture Statistics at a Glance. GOI, Ministry of Agriculture and Farmers Welfare, Directorate of Economics and Statistics 2018.
3. Bheemanna M, Kulkarni KA, Shekharappa. Susceptibility of some sorghum genotypes to rice weevil. J Maharashtra Agric. Univ 1994;19:148.
4. Bhoge RS. Screening of different sorghum germplasm against rice weevil, *Sitophilus oryzae* (L.). M. Sc. (Agri.) Thesis, Univ. MPKV, Rahuri, Maharashtra, India 2010.
5. Dobie P. The laboratory assessment of the inherent susceptibility of maize varieties to post harvest infestation by *Sitophilus zeamais* Motsch (Coleoptera: Curculionidea) infesting field corn. J Ent. Sci 1974;21:367-375
6. Gupta AK, Behal SR, Awasthi BK, Verma RA. Screening of some maize varieties against *Sitophilus oryzae* L. Indian J Ent 1999;61(3):265-268.
7. Howe RW. A parameter for expressing the suitability of an environment for insect development. Journal of Stored Products Research 1971;**7**(1):63-65. International Journal of Chemical Studies 5(4):1296-1301.
8. Kudachi DC, Balikai RA, Evaluation of rabi sorghum genotypes against rice weevil, *Sitophilus oryzae* L. in storage. Indian J Ent 2014;76(2):87-91.
9. Ladang YD, Ngamo LTS, Ngassoum MB, Mapongmestsem PM, Hance T. Effect of sorghum cultivars on population growth and grain damages by the rice weevil, *Sitophilus oryzae* L. (Coleoptera: Curculionidae). African Journal of Agriculture Research 2008;3(2):255-258.
10. Lokhande SM. Studies on reaction of some cultivars of Rabi sorghum, *Sorghum bicolor* (L.)Moench to rice weevil, *Sitophilus oryzae* (L.) and Lesser grain borer, *Rhyzopertha dominica* (F.) in storage. M.Sc. (Agri.) thesis submitted to M.P.K.V., Rahuri 1986.
11. Metcalf RL. Insecticides in pest management. *In*: Metcalf, R.L. and Luckman, W. (eds.) Introduction to insect pest management. Willey Inter Science, New York 1975, 235-273.
12. Ram, Singh VS. Resistance to *Sitophilus oryzae* in wheat and associated grain characteristics. Indian Journal of Entomology 1996;58(1):79-90.
13. Reddy KPK, Singh PU, Reddy KD. Sorghum resistance to the rice weevil, *S. oryzae* (L.): Antixenosis Sci. and Appl 2002;22:1-19.
14. Russel MP. Effects of four sorghum varieties on the longevity of the rice weevil *Sitophilus oryzae* L. Journal of Stored Production Research 1966;(2):75-79.
15. Singh K, Agrawal NS, Girish GK. The oviposition and development of *Sitophilus oryzae* (L.) in different high yielding varieties of wheat. J Stored Products Res 1974;10:105-111.
16. Singh KRP, Pant NC. Nutritional studies on Trogoderma gramarium, effect of variuos natural foods on the development. J Zool. Soc. India 1955;7:155-161.
17. Subbarayudu B, Kalaisekar A, Prasad G, Shyam Bhagwat VR, Babu Srinivas K, Patil JV. Sorghum resistance to rice weevil, *Sitophilus oryzae*: Antibiosis and Antixenosis. Indian J Pl. Protec 2013;41(1):1-5.
18. Teshome J, Kenneth Torrance, Bernard Baum, Lenore Fahrig. Traditional farmers knowledge of Sorghum (*Sorghum bicolor* (Poaceae) landrace storability in

Ethiopia, January 1999 Economic Botany 1999;53(1):69-78.
19. Thakur RP, Reddy BV, Mathur K. Screening Techniques for Sorghum Diseases. Information Bulletin No. 76. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics 2007, 92.
20. Venkatrao S, Nuggenhalli RN, Swaminathan N, Pingle SV, Subramanian V. Effect of insect infestation on stored grain II. Studies of kafir corn (*Sorghum vulgar* L.). J Sci. Fd. Agric 1958;9:837-839.