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VARIABILITY STUDIES IN SORGHUM (*Sorghum bicolor* (L.) Moench) GERMPLASM LINES FOR SHOOT FLY RESISTANCE PARAMETERS.

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ABSTRACT
Sorghum shoot fly (*Atherigona soccata* Rond.) one of the major constraints in sorghum production and host plant resistant is one of the components to control to sorghum shoot fly. The present study was carried out to assess the variability in sorghum germplasm lines for shoot fly resistant traits. The experiment was conducted in Randomized block design (RBD) with two replication on the farm of Sorghum research station, VNMKV, Parbhani during rabi 2015 with 116 sorghum germplasm lines and four checks one resistant check (IS-18551), one susceptible check (DJ-6514) and two varietal checks (SPV-1411 and PVK-801). Observations were recorded on the characters *viz.,* deadheart percentage, trichome density, leaf glossiness, seedling vigour, leaf wetness, Plumule and leaf sheath pigmentation, chlorophyll content, plant height, leaf length, leaf breadth, leaf angle, days to 50% flowering, days to maturity, 100 seed weight and grain yield per plant. The data were collected and analyzed for genotypic and phenotypic coefficient of variation (GCV and PCV), heritability and expected genetic advance. Analysis of variance showed the significant variability for all the traits studied and suggesting the presence of wide range of variation among the genotypes for all the characters. The genotypic coefficient of variation was lower than the phenotypic coefficient of variation for all the characters, indicating their importance in hybridization programme for generating variability.

INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is the fifth most important cereal crop globally after rice, maize, wheat and barley. It is predominantly cultivated in semi-arid tropics (SAT) and is the dieta ry staple of more than 500 million people in 30 countries. But the yield penalties of sorghum is very high starting from seedling stages to marketing and the maximum losses is caused due to biotic stress. Seven to eight major pests cause economic losses to this crop. Out of this sorghum shoot fly (*Atherigiona soccata* Rond.) one of the most important pest and owing to limitations like high costs and toxic hazards of chemicals.

In Maharashtra, sorghum shoot fly is one of the major constraints that limit the production and causes heavy losses up to 75.60% in grain and 68.90% in fodder. The adult fly lays white, elongated, cigar-shaped eggs single on the under surface of the leaves parallel to the midrib. After egg hatch, the larvae crawl to the plant whorl and move downward between the folds of the young leaves till they reach the growing point. They cut the growing tip resulting in deadheart formation. Sorghum shoot fly completes its life cycle in 17-21 days. Host plant resistance is one of the most effective means of keeping shoot fly population below economic threshold levels, as it does not involve any cost input by the farmers. Sharma and Nwanze (1997) suggested that resistance to shoot fly due to seedling vigour, leaf glossiness, leaf surface wetness, trichomes and chlorophyll content. But the efficacy of this mechanism was reduced under heavy shoot fly population pressure (Sing and Jotwani, 1980), Trichomes on abaxial surface (Maiti and Bidinger, 1979) and glossy leaves pale green, smooth and shining leaves (Agarwal and House, 1982), Seedling vigour (Sharma H.C., 1993) are reported to be the factors responsible for primary mechanisms of shoot fly resistance.

The number of improved varieties has been identified and developed by using landraces, but the level of resistance is low to moderate. Plant resistance to sorghum shoot fly appears to be complex character and depend on the interplay of a number of componential characters which finally sum up in the expression of resistance shoot fly (Dhillon, 2004). According to Briggs and Knowles (1967), the heritability of quantitative characters is usually high because breeding behavior can be predicted. Furthermore, high heritability coupled with genetic advance indicates that additive gene effects are operating and selection for superior genotype is possible (Arunkumar *et al.,* 2004). In the view of merge genetic information available, the present investigation was undertaken to study the variability among the traits related to shoot fly resistance in sorghum germplasm lines.

MATERIALS AND METHODS

The material used for this study was comprised Hundred and sixteen genotypes and four checks (One resistant check IS-18851, one susceptible check DJ-6514 and two varietal checks SPV-1411 and PVK-801). The material was collected from Indian Institute of Millet Research, Hyderabad and Sorghum Research Station, VNMKV, Parbhani. The experiment was conducted in the field of Sorghum Research Station, VNMKV, Parbhani during rabi 2015-2016. The experiment was conducted in randomized block design, replicated twice with a spacing 45 cm between rows and 15 cm between plants.

Five plants at random in each plot and replication were chosen and labeled for recording observations and the mean of five plants was used for statistical analysis. Observations on different morphological characteristics were recorded on these plants at different stages of crop growth. The data on the following yield and yield components and quality parameters were recorded and evaluated for shoot fly resistance characters. *i.e.* morphological characters like plant height, leaf length, leaf breadth, number of tillers per plant, days to 50% flowering, days to maturity, 100 seed weight and Shoot fly resistance characters like leaf glossiness, seedling vigour, deadheart incidence % at 14 and 28 DAE, leaf angle, Trichome density (both at adaxial and abaxial leaf surface), chlorophyll content, Plumule and leaf sheath pigmentation and leaf wetness. The mean values were used for statistical analysis. The data were analyzed statistically for genotype and phenotype coefficients of variation (Burton, 1952), Heritability (Allard, 1960) and genetic advance (Johnson *et al*., 1955).

RESULTS AND DISCUSSION

The results of analysis of variance for hundred and twenty genotypes in *rabi* sorghum observed highly significant differences among the genotypes for sixteen characters indicating presence of sufficient amount of variability among genotypes for these sixteen characters for character under study. This indicated ample scope for exploitation of all the above characters. Potdukhe *et al*. (1994) Arunkumar (2013) observed similar results for plant height, days to 50 per cent flowering and grain yield per plant. However differences between them were not of high magnitude.. Umakanth *et al*. (2002) observed similar results for plant height and days to 50 per cent flowering. It shows that presence of considerable genetic variability between all the genotypes and hence there is scope to improve all the characters by selection on making lines under study.

The data was analyzed for estimation of variability *i.e.*

Table 1: Analysis of Variance for Eighteen characters studied for resistance to *sorghum* shoot fly.

Sr. No	Characters	Source of variation		
		Treatments	Replication	Error
1	Dead hearts % at 14 DAE	107.35**	65.312	6.49
2	Dead hearts % at 28 DAE	416.28**	112.27	8.3
3	Trichome Density (Adaxial)	1630.25**	4.86	22.46
4	Trichome Density (Abaxial)	7579.35**	34.5	8.61
5	Leaf Glossiness	1.34	0.05	0.1
6	Seedling Vigour	0.822	0.85	0.11
7	Leaf Wetness	0.683	0.75	0.1
8	Plumule and Leaf sheath pigmentation	1.477*	0.37	0.07
9	Plant Height	1092.30**	36.81	10.91
10	Leaf Length	71.80**	0.17	3.1
11	Leaf Breadth	1.39*	0.08	0.06
12	Number of Tillers	0.54	0.006	0.26
13	Leaf Angle	190.95**	18.7	4.65
14	Chlorophyll content	96.50**	0.36	3.5
15	Days to 50% Flowering	95.91**	16.53	4.1
16	Days to Maturity	41.42**	81.66	4.33
17	100-seed weight (g)	0.41	0.002	0.03
18	Grain yield (g/plant)	174.04**	39.04	14.22

Table 2: Genetic Variability Parameters for Eighteen characters studied for resistance to *sorghum* shoot fly.

Sr. No.	Characters	Range		MEAN	^{2}(g) (Genotypic variance)	^{2}(p) (Phenotypic variance)	GCV (%)	PCV (%)	h^2b.s.(%)	GA	GA as % of mean
		Minimum	Maximum								
1	Deadheart % 14 DAE	8.3	38.4	22.47	50.431	56.9256	31.6043	33.5777	88.59	13.7693	61.2785
2	Deadheart % 28 DAE	17.9	68.55	39.8357	203.972	212.2761	35.8519	36.5745	96.09	28.8395	72.396
3	Trichome Density (adaxial)	0	277.5	121.3833	8148.906	8171.369	74.3688	74.4712	99.73	185.7031	152.9889
4	Trichome Density (abaxial)	0	194	55.1625	3785.37	3793.984	111.5348	111.6616	99.77	126.5983	229.5007
5	Leaf Glossiness	1.5	5	2.9938	0.622	0.7256	26.3444	28.4531	85.73	1.5043	50.2475
6	Seedling Vigour	1.75	5	3.1388	0.3518	0.4711	18.8973	21.8671	74.68	1.0559	33.6415
7	Leaf Wetness	2	4.75	3.1771	0.2909	0.3927	16.9762	19.7245	74.07	0.9562	30.0983
8	Plumule and Leafsheath Pigmentation	1	3	1.9938	0.699	0.7788	41.9347	44.2644	89.75	1.6317	81.8391
9	Plant Height (cm)	67.5	198	130.3833	540.6956	551.6131	17.8342	18.0134	98.02	47.4245	36.3731
10	Leaf Length (cm)	38.95	70.45	54.3425	34.3499	37.4549	10.7851	11.262	91.71	11.5622	21.2764
11	Leaf Breadth (cm)	3.2	7.9	5.4942	0.6628	0.7308	14.8177	15.5593	90.69	1.5971	29.0696
12	Number of Tillers	0.3	2.4	1.38	0.1389	0.4088	27.0094	46.3336	33.98	0.4476	32.434
13	Leaf angle (degree)	37	84.5	56.3125	93.1482	97.8019	17.1389	17.5618	95.24	19.403	34.4559
14	Chlorophyll content	34	63.4	45.185	46.4991	50.0087	15.0914	15.6505	92.98	13.5453	29.9775
15	Days to 50% flowering	64	96	77.2458	45.9077	50.0082	8.7714	9.1547	91.8	13.3731	17.3124
16	Days to Maturity	108.5	138	123.475	18.5442	22.8831	3.4876	3.8742	81.04	7.9858	6.4675
17	100-seed weight (g)	1.45	3.9	2.4433	0.1922	0.2262	17.9417	19.4644	84.97	0.8324	34.0684
18	Grain yield (g/plant)	6.4	52.85	21.0017	79.9107	94.1354	42.5646	46.1979	84.89	16.9666	80.7871

phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability, genetic advance and genetic advance as per cent of mean.

Genotypic and phenotypic co-efficient of variation

High estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were observed for the traits deadheart percent at 14 (31.60 and 33.57) and 28 (35.85 and 36.57) DAE, trichome density adaxial (74.36 and 74.47) and abaxial (111.53 and 111.66), Plumule and leaf sheath pigmentation (41.93 and 44.26), number of tillers (27.00 and 46.33) and grain yield per plant (42.56 and 46.19). The result also revealed that the medium GCV and PCV for the trait leaf glossiness (26.34 and 28.45), seedling vigour (21.89 and 21,86), leaf wetness (16.97 and 19.72), plant height (17.83, and 18.01), leaf length (10.78 and 11.26), leaf breadth (14.81 and 15.55), leaf angle (17.13 and 17.56), chlorophyll content (15.09 and 15.65) and 100 seed weight (17.94 and 19.46), where as lowest GCV and PCV was observed for the trait days to 50% flowering (8.77 and 9.15)and days to maturity (3.48 and 3.87). The present study also revealed that all the characters under study exhibited a higher genotypic coefficient of variation than the phenotypic coefficient of variation. Riyazaddin *et al.* (2016) also reported the PCV percentage of leaf glossiness, leaf sheath pigmentation, and trichome density was higher than the GCV. It clearly showed that environmental effect was more for expression of all the characters under study. Similar results were revealed by Arunkumar (2013) for plant height, days to 50% flowering, 100 seed weight and yield per plant. The PCV was higher than GCV for all the characters studied showing that all the traits were highly influenced by environment. However differences between them were not of high magnitude. These findings also agree with the findings of Ahemad *et al.* (2012), Gloria Buraw *et al.* (2012) and Ranjith *et al.* (2015).

Heritability

In the present study results indicated that heritability estimates were high for the traits viz., trichome density on adaxial (99.73) and abaxial (99.77) leaf surface, deadheart percent 14 (88.59) and 24 (96.09), leaf glossiness (85.73), seedling vigour (74.68), leaf wetness (74.07), Plumule and leaf sheath pigmentation (89.75), plant height (98.02), leaf length (91.71), leaf breadth (90.69), leaf angle (95.24) , chlorophyll content (92.98), days to 50% flowering (91.80), days to maturity (81.04), grain yield per plant (84.89), 100 seed weight (84.97), except number of tillers (33.98). Similar observations were made by Kalpande *et al.* (2014), Ranjith *et al.* (2015) and Sonone *et al.* (2015). These findings are closely associated with the findings of Dhedhi *et al.* (2016), They revealed that high heritability coupled with high to moderate genetic advance expressed as percentage of mean was observed for harvest index, grain yield per plant, dry fodder yield per plant, days to 50% flowering and plant height which showed that these traits were controlled by additive gene effects and phenotypic selection were for these traits were likely to be effective. These findings are also agreement with the study of Riyazaddin *et al.* (2016), they revealed that shoot fly deadheart, leaf glossiness, leaf sheath pigmentation, seedling vigour, and trichome density on the adaxial and abaxial leaf surfaces exhibited high broadscense heritability and genetic advance, This indicating that these traits had high genetic heritability. The coefficient of variation indicates only the extent of variability existing for various characters, but does not give any information regarding the heritable proportion of it. Hence, amount of heritability permits greater effectiveness of selection by separating out the environmental influence from the total variability and to indicate accuracy with which a genotype can be identified phenotypically. If heritability is 100 per cent, the phenotypic performance will be a perfect indication of genotypic performance ($6^2ph = 6^2g$). The GCV along with heritability estimates would provide a better picture of the amount of genetic advance expected by phenotypic selection (Burton, 1952). Shinde *et al.* (1979) and Dhutmal *et al.* (2015) revealed, If the heritability is due to additive effect, it would be associated with high genetic gain and if with non -additive, the genetic gain will be low (Panse 1957).

Genetic Advance

High heritability with moderate genetic advance as per cent of mean was recorded for seedling vigour, leaf wetness, leaf length, number of tillers, leaf angle and 100 seed weight. Similar results were obtained by Ranjith *et al.* (2015) and Sonone *et al.*(2015). The results indicate that these characters were less influenced by environment but governed by additive and non-additive gene action. The present study indicated that the character leaf length, leaf breadth, chlorophyll content, days to 50 per cent flowering and 100 seed weight showed high heritability but low genetic advance as per cent of mean, thereby indicating that expression of these characters may be due to non-additive gene action.

The genetic advance expressed as percentage of mean is the product of genotypic coefficient of variation, the square root of heritability ratio and selection intensity. Johnson *et al.* (1955) suggested that heritability estimates in conjunction with genetic advance were reliable in predicting the resultant effect from selecting the best individuals. Yield being a complex character is influenced by many factors. In the present study, high heritability coupled with high genetic advance as per cent mean was observed for deadheart percent (14 and 28 DAE), trichomes density (Adaxial and Abaxial), leaf glossiness. Plumule and leaf sheath pigmentation, plant height, grain yield per plant and suggesting that these traits are under the control of additive gene action and can be improved through simple selection procedure, Rana *et al.* (2016) observed that the magnitude of GCV, PCV, heritability and genetic advance as percentage of mean were recorded high for various characters like leaf: stem ratio, number of leaves per plant, green fodder yield per plant, stem girth and dry matter yield per plant in sorghum. Similar results were reported by Bello *et al.*(2007), Deeplakshmi and Ganeshmurthy (2007) and Shinde *et al.* (2010), This indicates the lesser influence of environments in expression of characters and prevalence of additive gene action in their inheritance, since are amenable for simple selection.

The overall result indicated that there is adequate genetic variability present in the material used. Hence, variability studies and heritability analysis suggested that dead heart %, trichomes both at the adaxial and an abaxial side of leaf surfaces, leaf glossiness, Plumule and leaf sheath pigmentation and leaf wetness can be used as marker traits to select for resistance to shoot fly (*Atherigona soccata* Rond.). Therefore the emphasis is to be paid on above -mentioned characters for improving the productivity during selection. Moreover these traits are also having high heritability and genetic advance on grain yield also.

REFERENCES

Agarwal, B. L. and House, L. R. 1982. Breeding for pest resistance in sorghum. In Sorghum in the eighties. *Proceedings of the International Symposium on Sorghum, 2-7 Nov. 1981, ICRISAT, Patancheru, Andhra Pradesh, India.* pp. 435-446.

Ahmed M., E. I. Naim, M. Ibrahim, Ibrahim Mohammad, E. Abdel Rahman, A. Elishiekh Ibrahim. 2012. Evaluation of some local sorghum (*Sorghum bicolor* (L.) Moench) genotypes in rain-fed. *International J. Plant Research.* **2(1):** 15-20.

Allard, R. W., 1960. Principles of Plant Breeding. *J. Wiley and Sons, Inc., New York.* pp. 84-85.

Aruna C., Padmaja P. G. 2009. Evaluation of genetic potential of shoot fly resistant sources in sorghum [*Sorghum bicolor* (L.) Moench]. *J. Agriculture Science.* **147:** 71-80.

Arunkumar B., Biradar B. D. and P. M. Salimath 2004. Genetic Variability and Character Association Studies in Rabi Sorghum. *Karnataka J. Agriculture Scienc.* **17(3):** 471-475.

Arunkumar, B. 2013. Genetic variability, character association and path Analysis studies in sorghum (*sorghum bicolor* L. Moench). *The Bioscan, An International Quarterly J. life Science.* **8(4):** 1485-1488, (Supplement on Genetics & Plant Breeding).

Ashok Kumar, A., Reddy, B. V. S., Sharma, H. C. and Ramaiah, B., 2008. Shoot fly (*Atherigona soccata*) resistance in improved grain sorghum hybrids. *J. SAT Agricultural Research.* **6:**

Bello D., Kadams, A. M., Simon, S. Y. and Mash, D. S. 2007. Studies on Genetic Variability in Cultivated Sorghum (*Sorghum bicolor* L. Moench) Cultivars of Adamawa State Nigeria. *American-Eurasian J.Culture & Environmental Science.* **2(3):** 297-302.

Borad, P. K. and Mittal, V. P. 1983. Assessment of losses caused hq pest complex on sorghum hybrids CSH-5. Pagcs 271-288 in Proceedings of the National Seminar on Crop Losses Due to Insect Pests, 7-9 January 1983, Hyderabad. A.P.. India (Krishnamurthy Rao. B.II. and Murty. K.S.R.K., eds.). *Indian Journal of Entomology* **Vol. 11** (Special Issue). Hyderabad. Andhra Pradesh. India: Entonlological Society of India.

Briggs, F. N. and Knowles, P. F. 1967. *Introduction to Plant Breeding.* Champman-Reinhold, Inc., U.S.A. p. 104.

Burton, G. W. 1952. Quantitative inheritance in grasses. proc. 6th interaction. *Grassland.Cong J.* **(1)**: 227-283.

Chavan, S. K., Mahajan, R. C., Sangita, U. Fatak. 2010. Genetic variability studies in sorghum. *Karnataka J. Agriculture Science.* **23(2) :** (322-323).

Dhedhi, K. K. Ansodariya V. V., Chaudhari N. N., Sanghani J. M. and Sorathiya J. S. 2016. Genetic variation among forage pearl millet Genotypes for fodder yield and its component traits under rainfed conditions of gujarat. *The Bioscan.* **11(1):** 45-48. 2016.

Dhillion,M. K., 2004. Effccts of cytoplasmic male-sterility on expression of resistance to sorghum shoot fly. Ph. D. Thesis submitted to CCS Haryana Agricultural University, Hissar India.

Dhutmal R. R., Kalpande H. V. and More A. W. 2015. Genetic variability and heritability studies in *rabi* sorghum drought Tolerant genotypes. *Annals of Plant and Soil Research.* **17(4):** 391-394.

Doggett, H., Starks, K. J. and Eberhart, S. A. 1970. Breeding for resistance to the sorghum shoot fly. *Crop Science.* **10:** 528-531.

Gloria Burow, Cleve, D. Franks, Zhanguo Xin, John J. Burke. 2012. Genetic diversity in a collection of Chinese sorghum landraces assessed by microsattelites. *American J. crop science.* **3:** 1722-1729.

Johnson, R. E., Robinson, H. W. and Comstock, H. F. 1955. Estimates of genetic and environmental variability in Soybean. *Agronomy J.* **47:** 314-318.

Jotwani, M. G. and Davies, J. C. 1980. Insect resistance studies in sorghum at International Institutes and National Programs with special reference to India. pp 224-236. In Proceedings of the short course in host plant resistance (ed M K Harris). Texas A & M University, College Station, Texas, USA.

Kalpande, H. V., Chavan, S. K., More, A. W., Patil, V. S. and Unche P. B. 2014. Character association, genetic variability and component analysis in sweet sorghum [*Sorghum bicolor* (L. Moench)]. *J. Crop and Weed.* **10(2):**108-110.

Maiti, R. K., and Bidinger, F. R. 1979. A simple approach to identification of shoot fly resistance in sorghum. *Indian I.P.I. Protec.* **7:** 135-140.

Mohammed Riyazaddin., Polavarapub Kavi kishor., Are Ashok Kumar, Belum V. S. Reddy, Rajendra S . Munghate and Hari C. Sharma. 2015. Mechanisms and diversity of resistance to sorghum shoot fly, *Atherigona soccata. Plant Breeding ISSN* (ISSN: 0179-9541, ISSN: 1439-0523) **Panse V. G. 1957.** Genetics of quantitative characters in relation to plant breeding. *Indian J. Genetics and Plant Breeding* **.17:** 318-328.

Potadukhe, N. R., Shekhar, V. B., Thote, S. G., Wanjari, S. S. and Ingle, R. W. 1994. Estimation of genetic parameters, correlation coefficients and path analysis in grain sorghum (*Sorghum bicolor* (L.). *Crop Research.* (Hissar). **7(3):** 402-406.

Prabhakar. 2003. Genetic variability and correlation studies in F_2 populations of rabi sorghum. *J. Maharashtra agriculture University.* **28(2):**202-203.

Rana, H. R., Prajapati, K. N., Suthar K. J. And Kher H. R. 2016. Study of variability, correlation and path analysis in forage sorghum [sorghum bicolor (l.) Moench]. *The Bioscan.* **11(1):** 259-263, 2016 (supplement on agronomy).

Ranjit, P., Ghorade, R. B. and Kalpande, V. V. V. 2015. Screening for shoot fly resistance in sorghum(*sorghum bicolor* L.Moench). *J. Innovative Agrculture.* **2(1):** 23-28.

Riyazaddin Mohammed., Ashok Kumar Are., Rajendra Sudhakar Munghate., Ramaiah Bhavanasi1., Kavi Kishor B.Polavarapu and Hari Chand Sharma. 2016. Inheritance to resistance sorghum shoot fly, *Atherigona soccata* in sorghum (*Sorghum bicolor* (L) Moench. *Frontiers in plant sciences.* 07 (543). 01-18. *IISN.* 1664-462.

Riyazaddin Mohammed., Rajendra S. Munghat, Ashok Kumar Are, Kavi Kishor B. Polavarapu, Belum V. S. Reddy, Hari C. Sharma. 2016. Components of resistance to sorghum shoot fly, *Atherigona Soccata. Euphytica.* **207:** 419-438.

Sharma, H. C., Faujdar Singh and Nwanze, K. F. (eds.). 1997. Plant resistance to insects in sorghum. International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, Andhra Pradesh, India.

Sharma, H. C. 1993. Host plant resistance to insects in sorghum and its role in integrated pest management. *Crop Protection.* **12:** 11-34.

Shekharappa. 2007. Evaluation of sorghum varieties against shoot fly (*Atherigona soccata* Rondani). *Karnataka J. Agriculture Science.* **20(3):** (651-652).

Shinde, D. G., Biradar, B. D., Salimath, P. M., Kamatar, M. Y., Hundekar, A. R. and Deshpande, S. K. 2010. Studies on genetic variability among the derived lines of B x B, B x R and R x R crosses for yield attributing traits in rabi sorghum (*Sorghum bicolor* (L.) MOENCH). *Electronic J. Plant Breeding.* **1(4):** 695-705.

Shinde, V. K., Nerkar, Y. S. and Katepallewar, B. N. 1979. Studies on genetic variability in winter sorghum selection. Sorghum Newsletter, 22.

Singh, S. P. and Jotwani, M. G. 1980. Mechanism of resismnce in sorghum to shoot fly. II. Antibiosis, *Indian .I. Ent*. **42:** 353-357.

Sonone, C. V., Thakare, S. V., Aware, S. A. and Ghorade, R. B. 2015. Evaluation of Shoot Fly Tolerance Derived Lines in Sorghum. *International J. Current Microbiology Applied Science.* **4(12):** 166-177.

Umakanth, A. V., Madhusudhana, R., Latha, K. M., Rafia, S. M. and Kiran, V. S. S. 2004. Analysis of genetic variation and trait interrelationship in sorghum. *National J. Plant Improvement*. **6(2):**104-107.

Wiseman, B. R. and Morrison, W. P. 1981. Components for management of field corn and grain sorghum insects and mites in the United States. United States Department of Agriculture - Agricultural Research Service 9USDAARS), ARM 5-18. Washington, D.C., U.S.A.: Government Printing Press. p.18.