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Varietal susceptibility of local and hybrid maize against *Atherigona soccata* (Diptera: Muscidae) under field conditions

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Abstract
Maize shoot fly, *Atherigona soccata* (Rondani) is one of the most serious pest in maize production. It is expensive and environmentally unsafe to manage this serious pest by using chemicals. Best approach to manage this pest is to develop host-plant resistance. Susceptibility of six maize genotypes, local (Sahiwal-2002, Agaiti-85, Neelam) and hybrid (Mon-6714, TG 46B90, Mon-6789) were checked against this pest. Hybrid genotypes TG 46B90, Mon-6714 and Mon-6789 were found moderate to highly susceptible, Neelam and Agaiti-85 were susceptible to moderately susceptible whereas, Sahiwal-2002 was highly susceptible to plant infestation, dead heart, mean eggs load per plant and mean eggs plant per plot. All the genotypes were found susceptible to moderately susceptible based on mean number of larvae and pupae. It is essential to develop pest resistant genotypes for sustainable crop production in future and emerging food security challenges.

Keywords: Resistance, infestation, genotypes, local, observation, hybrid

1. Introduction
Maize is the most important cereal crop in the world after cotton, wheat and rice, with attention to the cultivation areas and outright production [4]. The significance of maize deceit in its wide industrial applications besides as well as animal feed and human food. Green maize is consumed baked, roasted or boiled and show an important responsibility in filling the hunger gap after the dry period [6]. Maize is used broadly as the major source of calories in wild feeding and feed formulations [26]. Maize growers are relocating to specialty maize production due to higher come backs and opening chances for employment generation particularly in Pakistan [13].

The economic growth of the people of advanced countries like Pakistan is tremendously relying upon agricultural development. Agriculture backing three fourths of the country's population for its continuing employs 43.3 percent of the total labor, accounts for 18.5 percent of GDP and witness growth of 3.45 percent against 3.6 percent development rate of recent year [15].

Even though Cotton is a most important crop in Pakistan following Wheat, but its area of farming is decreasing from past years which pushed producers gone from Cotton to challenging parallel crops like Sugarcane and Maize due to pest invasion and low conjugal prices [15, 16].

Presently except for Potato, Maize is the most gainful, stable and reliable crop in Pakistan [38]. Regardless of high yielding cultivars, maize yearly production is not increasing. The major obstruction is the insect pests which devastate the maize plants. Corn crop is attacked with 141 different species of insect's pest which grounds the decrease in the yield; away from these 10 species grounds the major infestation [17]. The major pests are *Chilo partellus*, *Spodoptera exempta*, *Melanaphis sacchari*, *Chilo orichalcociliellus*, *Diuraphis noxia*, *Sesamia cretica*, *Contarinia sorghicola*, *Microtermes najdensis*, *Microcerotermes diversus*, *Epilachna similis*, *Locusta migratoria*, *Schistocerca gregaria*, *Rhopalosiphum maidis* [24], *Atherigona soccata* and numerous species of aphids.

To overcome these difficulties, diverse pesticides are utilized to control these insect pests but as these pesticides have environmental intimidation so various other control actions are needed [37]. The corn shoot fly, *A. soccata* is efficiently an important insect pest of grains, forage and maize in Africa, Mediterranean, Europe, and Asia [21]. *Atherigona soccata* damages the corn young seedling among the 1st and 4th week after appearance with laying eggs on the 3rd to 6th basal leaves.

By hatching, the legless larvae (maggot) move down between the leaf cover and cut from side to side the innermost meristematic tissues of emergent leaf resulted in arrogating of the middle shoot well common as dead heart. Leg less larvae feed the decomposed tissues of emergent point [29].

In severe conditions maize shoot fly, *A. soccata* grounds the loss up to 60 percent in the production [5]. It is familiar to see removing of maize crop because of heavy infestation of maize shoot fly. Shoot fly is most significant and dangerous pest causing damage at initial stage. Maize shoot fly grounds maximum yield losses up to 76.6% in grain and 66.6% in fodder [28]. Obvious of alteration in climate and farming systems in the globe, maize is going through due to change in progression and prevalence of shoot fly [33].

For the approach of pest management use the susceptible cultivars which are environmentally secure, socially suitable and economically possible. There are numerous plant attributes, which are dependable for host plant confrontation. The plant constituents may manipulate negatively as well as positively on herbivore and their natural opponents [20, 1]. These attributes may be segregated into biochemical and morphological. Morphological attributes are most significant in host plant resistance [27]. In corn crop these attributes are dependable for suitability of a cultivar for feeding, development and oviposition.

Scientist observed that cultivar DK-6525 was most susceptible against insect pests particularly maize shoot fly, *A. soccata* the genotype named Sahiwal-2002 was most susceptible [2]. The ecologically and economically sound management performs will be required to conflict the prevalence of shoot fly in maize. Comparable type of work performed by few investigators [7, 25, 35, 9].

The use of susceptible varieties is economically feasible, environmentally safe and socially suitable approach of insect pest management. Susceptible material can be utilized in breeding programs in host plant resistance evaluation or directly in cultivar testing proceeding to recommendation. Such type of facts is not enough in our country consequently; an examination to learn the resistance mechanism of a little selected hybrid and local cultivars against shoot fly, *A. soccata* in maize was carried out, so that we can recommend shoot fly resistance cultivars to farmer for cultivation in this zone. This may be successfully utilized for forewarning farmers.

2. Materials and Methods

2.1 Experimental site

Current research was conducted at the Post Graduate Entomological Research Farm of the University of Agriculture Faisalabad, Pakistan during the autumn period (Aug-Nov) 2017 for checking the comparative susceptibility of different local and hybrid maize genotypes against insect pest such as maize shoot fly, *A. soccata* (Rondani) in field conditions. A field of maximum shoot fly incidence recorded was preferred which has been prevailed under corn cultivation for last many decades.

2.2 Research design and material

RCBD design was used to execute the research experiment. There were six treatments and every treatment replicated three times. Size of complete experiment area was 142.87ft^2 with plant to plant distance 25.4 cm, row to row distance 75 cm which was divided into 18 sub-plots each with an area of 15 x 22.86 (11.43ft). Standard cultural agricultural practices were ratified in field thoroughly during the maize sowing period. The experimented area was left open for normal infestations of maize shoot fly, *A. soccata* (Rondani). The whole experiment was comprising six local (Sahiwal-2002, Agaiti-85, Neelam) and hybrid (Mon-6714, Mon-6789, TG 46B90) genotypes. Data was recorded on weekly basis from germination to till 42 DAS.

2.3 Plant infestation (%)

Data regarding maize shoot fly, *A. soccata* (Rondani) infestation were observed by counting the total number of damaged plants from each plot at weekly interval. Plant infestation was recorded by using the following formula.

$$\text{Infestation (\%)} = \frac{\text{No. of infested plants}}{\text{Total no. of plants}} \times 100$$

2.4 Dead heart incidence (%)

Total number of maize plants in each plot was counted and the number of maize plants showing dead heart formation was calculated and convinced into % dead heart by applying specified formula [33].

$$\text{Dead heart (\%)} = \frac{\text{No. of plants with deadheart}}{\text{Total no. of plants}} \times 100$$

2.5 Number of larvae and pupae

At 5th and 6th week after sowing maize plants were observed for number of pupae/plots of maize shoot fly. Five plants were randomly selected from each plot and dissected for to check the pupae presence. In case of larvae observation data were taken from initial stage (Germination stage) 2nd to till 6th week after sowing. Data were recorded and calculate the percentage of pupae and larvae/plot [12].

2.6 Oviposition

All the cultivated genotypes were observed for oviposition rate of maize shoot fly, *A. soccata* (Rondani). Observations were reported on mean number of plants with eggs and total mean number eggs/plant after 2nd week of sowing. The data on number of eggs were performed as number of eggs/5 plants randomly selected and plants with eggs in terms of percentage of total number of plants. In case of number of eggs/plants, eggs plants were brought to entomology laboratory and eggs/plant were counted under microscope. Oviposition data were analyzed by using the methodology of Dhillon *et al*. [12].

2.7 Statistical analysis

Applying statistical software, Excel and GENSTAT, Analyses of variance, all collected data were analyzed. Means were calculated by using Least Significant Differences (LSD).

3. Results and Discussions

3.1 Percent infestation

Data in Table. 1 compile the mean percentage infestation of shoot fly, *A. soccata* (Rondani) in local and hybrid maize genotypes which are usually sown at Entomological Post Graduate Research Farm, University of Agriculture Faisalabad, Pakistan. To check the susceptibility of maize genotypes research were carried out in peak season of shoot fly *A. soccata* incidence (autumn season) during the year 2017. Results showed that mean percent infestation of shoot fly was considerably different on all maize genotypes in week

1 and week 2. After week 3 mean incidence of shoot fly was non-significantly higher (28.10 %) on Sahiwal-2002 and TG 46B90 (11.14 %) and lower (8.62 %) on Neelam and Mon-6789 (8.7%).

After week 5 mean percent infestation of shoot fly, was significantly higher (9.7%), (7.9 %) and (6.07%) / plant on genotypes, Neelam, Sahiwal-2002 and Mon-6714 respectively. In week 4 mean percent infestation of shoot fly, *A. soccata* was significantly higher (6.62%), (6.51%) on Sahiwal-2002 and Agaiti-85 while lower on (2.9%) TG 46B90.

The overall mean percent infestation of shoot fly, *A. soccata* were found statistically non-significant on all tested local and hybrid maize genotypes. Present study concludes that infestation percentage of this insect pest higher in May month. The dissimilarity in the current and previous studies may be due to differences in the time of cultivated maize and Agro-climatic change. According to Spark and Yate [36] the change in the climatic status has very much influenced the agricultural system beside with the insect pest. In current study percent infestation of shoot fly, *A. soccata* on all maize genotypes were higher than that reported by some previous scientists like Mensah and Madden [23]; Sparks and Yates [36]; Dhillon *et al.* [11], which may be due to the verity that host plant susceptibility has participated its role in restraining insect pest population.

3.2 Dead heart observation

Observations related to percent dead heart formation are presented in Table 1. The percent dead heart formation was found higher (53.3%), (40.6%), (38%) on Sahiwal-2002, Agaiti-85 and Neelam, while lower percent dead heart was recorded on Mon-6714, Mon-6789 and TG 46B90 after 2 weeks of sowing. After 3 week of sowing dead heart formation were observed significantly higher as compared to other weeks with (69.3%), (68%), (46%) on local genotypes Sahiwal-2002, Agaiti-85 and Neelam while (38.6%), (28.6%), (21.3%) on hybrid cultivars Mon-6714, Mon-6789 and TG 46B90 respectively Table 1.

Balikai [8] reported that maize shoot fly, *A. soccata* population began to increase in July, reached its highest peak in August and declined thereafter with a slight peak in October which again declined confirming the present findings. Raigar *et al.* [30] reported that maize shoot fly, *A. soccata* dead hearts increased rapidly during first week of August 47.63 per cent and thereafter the infestation continues to increase and became constant after third week of August.

Table 1: Mean weekly infestation (%), dead heart formation (%) of shoot fly, *A. soccata*

Genotypes	Infestation Percentage (Mean value) Dead heart percentage (Mean value)									
	week II	week III	week IV	week V	week VI	week II	week III	week IV	week V	week VI
Sahiwal-2002	8.98a	28.10a	6.62a	7.9ab	2.78a	53.3a	69.3a	34.6ab	40.6a	51.3a
Agaiti-85	11.28a	8.9a	6.51a	5.33cd	4.72a	40.6ab	68.0a	0.00b	29.3abc	28.0b
Neelam	13.52a	8.62a	3.13b	9.7a	4.37a	38.0b	46.0b	45.3ab	38.0ab	24.0b
Mon-6714	7.56a	9.4a	4.15ab	6.07bc	3.93a	28.0b	38.6bc	28.6ab	36.6abc	6.66c
Mon-6789	7.93a	8.7a	3.11b	5.09cd	3.69a	32.0b	28.6cd	110.0a	26.0bc	23.3b
TG 46B90	11.85a	11.14a	2.97b	3.17d	2.04a	29.3b	21.3d	24.0ab	23.3c	22.0b
Std Error	2.96	9.15	1.14	0.99	1.92	6.5	6.02	48.2	6.53	5.73
C.V %	35.60	89.74	31.63	19.48	65.70	21.75	16.29	145.98	24.77	27.12
R.E (RCB)	0.89	0.99	1.3*	1.2***	1.04	1.02*	0.9**	0.99**	0.88**	1.23**

Means in the columns having same letters are not differed significantly. While means in the columns followed by different letters are significantly different at 5 % level of significance (LSD test)

-Means of three replicates, *Significant, **, *** highly significant (0.05%).

In 4-week, dead heart formation observed significantly higher in genotypes Sahiwal-2002, Neelam, and Mon-6789 with (34.6%), (45.3%) and (110%) while lower on Mon-6714, TG 46B90 with mean percent dead heart (28.6%) and (24%) respectively. Local genotype Agaiti-85 was observed with (0%) dead heart formation in 4 weeks after sowing. The dead heart formation increased from starting August month and decreased gradually after October month. In week 5 and 6 dead heart formation was significantly higher and both weeks recorded less number of dead hearts as compared to previous weeks, which uphold the earlier findings of Keerthi *et al.* [19]; Kumar *et al.* [22] who reported (32.30%), (49.67%), (39.04%), (63.50%) and (18.03%) dead heart in summer season while (2.35%), (9.37%), (20.61%), (20.35%), (26.18%) dead heart in the month of March (2.66%) in the month of April, while recorded 0 % dead heart in the months of May-June respectively.

3.3 Number of eggs / plant observation

Data regarding to oviposition rate of shoot fly, *A. soccata* at different weeks interval showed in Table 2. In week 2 maximum eggs (3.2) was observed on genotype Sahiwal-2002 while none of the eggs found on hybrid genotype Mon-6789. Same level of oviposition rate was found on Neelam (2.6) and Mon-6714 (2.6) while Agaiti-85 and TG 46B90 was showed (1.7) and (2.8) mean number of eggs / plants respectively. After week 3 oviposition rate was increased on all genotypes as compared to week 2. Current findings are in agreement with Karibasavaraja [18]; Shekarappa and Ramegowda [34] who observed highest number of shoot fly, *A. soccata* eggs during the 2nd week of August (3.2) eggsnivplant and 3rd week of July (4.5) eggs /plant on sorghum genotypes. After week 5 all the genotypes showed moderate type of mean number of eggs load / plant which are non-significantly different. After week 6 all the genotypes observed less mean number of shoot fly *A. soccata* eggs/ pant as compared to previous weeks. These are above observations are in confirmation with the findings of Karibasavaraja and Balikai [18] who concluded that oviposition by shoot fly, *A. soccata* reached peaks on 33rd standard week and minimized gradually on 44th standard week. Similarly, Balikai [8] observed that shoot fly intensity began to boost in July, attained its highest peak in August month and declined thereafter with an insignificant peak in October month which again became lower agreement with the present findings.

3.4 Number of eggs plants / plot observation

In present research mean number of shoot fly, *A. soccata* eggs plant / plot were also recorded to make the research more

useful, interesting, precise and effective. Both week 4 and 5 were noticed with peak shoot fly egg plants as compared to other weeks.

Genotypic and environment interactions were found significant for mean number of shoot fly egg plants and overall resistance score. Nonetheless, the mean sum of square for environment effects was comparatively higher than the genotypic fallout, implying that environment has a significant bearing on the appearance of resistance to *A. soccata*. Current findings are correlated with the previous research conducted by Riyazaddin *et al.* [32] who reported work on many genotypes for checking the eggs plant and found maximum eggs plant during his research.

Table 2: Oviposition preference of females shoot fly, *Atherigona soccata*

Genotypes	Number of eggs / plant (Mean value) Number of eggs plants / plot (Mean value)									
	week II	week III	week IV	week V	week VI	week II	week III	week IV	week V	week VI
Sahiwal-2002	3.2a	3.06bc	3.5cd	2.7a	1.4a	0.42a	0.67a	1.86b	1.46b	0.20ab
Agaiti-85	1.7b	5.7a	6.1a	2.4a	0.4a	0.32a	0.25b	2.86a	1.4b	0.14bc
Neelam	2.6ab	1.6c	5.1b	1.7ab	0.6a	0.48a	0.58a	2.03b	2.06a	0.27ab
Mon-6714	2.6ab	4.0 ab	2.4e	2.4a	0.8a	0.30a	0.24b	1.26c	1.16b	0.35a
Mon-6789	0.00c	2.06bc	2.8de	2.0ab	0.2a	0.31a	0.25b	1.2c	1.26b	0.13bc
TG 46B90	2.8a	1.8c	4.1c	1.2b	0.0a	0.26a	0.14b	1.23c	1.43b	0.00c
Std Error	0.85	0.92	0.37	0.48	1.06	0.10	0.04	0.13	0.25	0.08
C.V %	48.23	37.24	11.45	28.11	220.77	35.69	17.05	9.22	21.38	56.02
R.E (RCB)	1.03**	1.09**	0.86**	1.09*	0.98	0.88	1.17**	1.47**	0.88*	1.70**

Means in the columns having same letters are not differed significantly. While means in the columns followed by different letters are significantly different at 5 % level of significance (LSD test)

- Means of three replicates, *Significant, ** highly significant (0.05%).

3.5 Mean larvae observation

All genotypes showed non-significant larvae observation as presented in Table 3. Maximum larvae population was observed in 2 weeks after sowing. Maximum larvae / plant was observed in local genotype Sahiwal-2002, while lowest larvae / plant was observed in hybrid genotype Mon-6789 (0.1). After week 3 all the genotypes show lower non-significant relations between the means and show same number of larvae infestation Table 3.

Maximum larvae were found in the month of August while lowest in month of October. After week 6 Lowest larvae infestation was observed with (0.26), (0.33), (0.20), (0.20), (0.1) and (0.08) 0n Sahiwal-2002, Agaiti-85, Neelam, Mon-6714, Mon6789 and TG 46B90 respectively.

A little research workout has been taken to check the susceptibility of shoot fly, *A. soccata* against maize cultivars under field conditioned but the study of Alex *et al.* [3] shows some comparison about current research findings. They conduct their research on sorghum genotypes to check the population abundance of shoot fly, *A. soccata*. Their results showed that shoot fly, *A. soccata* population were higher on wild cultivars then on local one. The study of Raina and Kibuka [31] also somewhat relates with current research findings, who conducted their research on shoot fly, *A. soccata* to check the oviposition and survival on intercropped maize and sorghum genotypes. They conclude that shoot fly, *A. soccata* larvae feeds on both host plants but caused very little damage (6%) to maize crop then sorghum.

3.6 Mean pupae observation

During current experiment all parameters regarding to shoot fly, *A. soccata* resistance or susceptibility were observed to make the research more effective and accurate. Data regarding to pupae observation was checked after 5 and 6 weeks of sowing. Pupation frequently takes place in the bottom of the dead shoot, but sometimes within soil. In current finding all the genotypes showed same number of mean pupae / plants after 5 and 6 weeks of sowing respectively Table 3.

Under field conditions shoot fly, *A. soccata* take significantly fewer days to reach the pupa stage. There was no difference among cultivars in pupa weight under field conditions. Newly formed pupae were light brown in color and slowly turned to dark brown with age. Examination under field conditions explained that, in exceptional cases, pupation also took place inside the basal stalk of maize. In current study, no indication of diapauses was observed; all pupae and larvae, which were observed in the field, completed their cycle without disruption. Similar type of experiment was conducted by Karibasavaraja *et al.* [18] who checked the comparative biology of shoot fly, *A. soccata* on susceptible and resistant sorghum cultivars. They checked the significant difference between susceptible and resistant cultivars with related to larval, pupal and adult developmental parameters. They found 58.4% pupation on susceptible cultivars then resistant cultivars 30.2%. Goftishu *et al.* [14] performed an experiment to check the pupal biology of barley shoot fly, *Delia flavibasis* on susceptible and resistant cultivars of barley under both field and laboratory conditions. There findings concludes that barley shoot fly, *Dalia flavibasis* showed significant differences in their prepupal and pupal stage as well as in pupal weight. Current findings are also accordance with Dhillon *et al.* [10] who conducted a research to find out the different mechanisms of resistance in sorghum against shoot fly, *A. soccata*. Their research concludes that pupal period varied among resistant and susceptible group of sorghum lines, while in case of mean pupal mortality shoot fly, *A. soccata* showed remarkable changes on resistant (13.4-18.4) and susceptible (9.6-10.3) sorghum lines respectively.

Table 3: Mean larvae and pupae population of shoot fly, *A. soccata*

Genotypes	Larvae population (Mean value) Pupae population (Mean value)						
	week II	week III	week IV	week V	week II	week III	week IV
Sahiwal-2002	4.0a	0.33a	0.8a	0.74a	0.26a	0.0667a	0.3333a
Agaiti-85	2.36bc	0.54a	0.53ab	0.59ab	0.33a	0.0000a	0.0667b
Neelam	3.1ab	0.20a	0.40ab	0.54bc	0.20a	0.2000a	0.1400ab
Mon-6714	1.73c	0.22a	0.13ab	0.51bc	0.20a	0.2667a	0.1333ab
Mon-6789	1.4c	0.20a	0.06b	0.34cd	0.1a	0.0000a	0.2000ab
TG 46B90	1.33c	0.13a	0.26ab	0.26d	0.08a	0.2000a	0.0000b
Std Error	0.49	0.19	0.29	0.09	0.16	0.1624	0.1029
C.V %	26.28	85.72	100.08	22.10	101.28	161.72	86.60
R.E (RCB)	0.87**	0.89	0.98*	0.95***	1.22	0.95	0.97*

Means in the columns having same letters are not differed significantly. While means in the columns followed by different letters are significantly different at 5 % level of significance (LSD test)
-Means of three replicates, *Significant, **highly significant (0.05%)

4. Conclusion

Ecological perceptions of varietal response are revealing of capabilities that in what way individual pests perform. The overall mean populations of maize shoot fly, *A. soccata* were found statistically non-significant on the six tested local and hybrid maize genotypes. However, highest overall mean % infestation of shoot fly, *A. soccata* was recorded (28.1%) on Sahiwal-2002 while lower (2.04) on TG 46B90. In case of dead heart formation highest dead heart were observed in Mon-6789 (110%) while lowest (0%) was observed in Agaiti-85. Oviposition rate of shoot fly, *A. soccata* were found significantly different and maximum egg lying was recorded (6.1) on Sahiwal-2002 and lowest (0) on TG 46B90 while mean number of eggs plant / plot was found highest (2.86) on Agaiti-85 and lowest was (0) on TG 46B90 respectively. In case of mean larvae and pupae incidence all the genotypes were found non-significant toward shoot fly, *A. soccata* larvae and pupae. If we talk about overall comparison of local and hybrid cultivars hybrid cultivars were found more susceptible to shoot fly, *A. soccata* infestation as compared to local lines. On the basis of above stated information, hybrid tested maize genotypes were recommended for cultivation during autumn season. Maize should be sown earlier in autumn for lower infestation of insect pest. There is a much less investigation has been carried out on maize crop against shoot fly, *A. soccata* especially examination of their larvae and pupae, with the developing of this pest status in maize there is great need to investigate the damage parameters of shoot fly, *A. soccata* in maize crop.

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6. References

1. Afzal M, Bashir MH. Influence of certain leaf characters of some summer vegetables with incidence of predatory mites of the family Cunaxidae. Pakistan Journal of Botany. 2007; 39(1):205-209.
2. Afzal M, Nazir Z, Bashir MH, Khan BS. Analysis of host plant resistance in some genotypes of maize against *Chilo Partellus* (Swinhoe) (Pyralidae: Lepidoptera). Pakistan Journal of Botany. 2009; 41(1):421-428.
3. Alex GL, Delobel, Unnithan GC. The status of sorghum *Arundinaceum as* a host of *Atherigona soccata* (Rondani), (Diptera: Muscidae) in Kenya. International Journal of Tropical Insect Science. 1981; 2(1):67-71.
4. Anonymous (2013-14) Directorate of Economics and Statistics. Department of Agriculture and Cooperation:
5. Atwal AS. Agricultural Pest of India and South Asia. In: Kalyani Publishers Ludhiana India, 1976, 159-165.
6. Balikai RA, Venkatesh H. Influence of weather factors on the incidence of sorghum shoot fly, *Atherigona soccata* (Rondani) in Rabi. Insect Environment. 2001; 7(2):123.
7. Balikai RA. Bio-ecology and management of sorghum shoot fly, *Atherigona soccata* (Rondani). International Journal of Agriculture Science. 2006; 2(2):644-646.
8. Balikai RA. Seasonal incidence of sorghum shoot fly in northern dry zone of Karnataka. Karnataka Journal of Agriculture Science. 2000; 13(2):457-458.
9. Daware DG, Ambilwade PP, Kamble RJ, Bhosle BB. Bio–efficacy of insecticides against sorghum shoot fly, *Atherigona soccata* (Rondani). Indian Journal of Entomology. 2011; 73(3):227-229.
10. Dhillon MK, Hari CS, Jagdish SN, Ram S, Pampapathy G. Influence of cytoplasmic male sterility on expression of different mechanisms of resistance in sorghum to *Atherigona soccata* (Diptera: Muscidae). Journal of Economic Entomology. 2006; 99(4):1452-1461.
11. Dhillon MK, Sharma HC, Reddy BVS, Singh R, Naresh JS. Inheritance of resistance to sorghum shoot fly, *Atherigona soccata*. Crop Sciences. 2006; 46(3):1377-1383.
12. Dhillon MK, Sharma HC, Singh R, Naresh JS. Mechanisms of resistance to shoot fly, *Atherigona soccata* in sorghum. Euphytica. 2005; 144(3):301-312.
13. Durga KK, Anaka V, Varma S, Sreelatha D, Reddy AY. Influence of planting methods, spacing and fertilization on yield and quality of sweet corn. Maize Journal. 2012; 1(2):121-123.
14. Goftishu M, Tefera T, Getu E. Biology of barley shoot fly Delia flavibasis Stein (Diptera: Anthomyiidae) on resistant and susceptible barley cultivars. Journal of Pest Science. 2009; 82(1):67-71.
15. Government of Pakistan. Economic Survey of Pakistan 2016-17. Ministry of Finance. Islamabad Pakistan. 2017; 29.
16. Horvath DP, Llewellyn D, Clay SA. Heterologous hybridization of cotton microarrays with velvetleaf (*Abutilon theophrasti*) reveals physiological responses due to corn competition. Weed Science. 2007; 55(6):546-557.

17. Jafari KH, Jalali SK. Identification and analysis of host plant resistance in leading maize genotypes against spotted stem borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae). Pakistan Journal of Biological Science. 2007; 10(11):1885-1895.
18. Karibasavaraja LR, Balikai RA, Deshpande VP. Comparative biology of shoot fly, *Atherigona soccata* (Rondani), on susceptible and resistant cultivars of sorghum. Agriculture Science Digest. 2007; 27(3):204-206.
19. Keerthi MC, Somasekhar, Prabhuraj A, Bheemanna M, Krishnamurthy D. Effect of weather parameter on seasonal incidence of sorghum shoot fly, *Atherigona soccata* (Rondani), (Diptera: Muscidae). Journal of Entomology and Zoology Studies. 2017; 5(5):1684–1687.
20. Krips OE, Kleijn PW, Willems PEL, Gols GJZ, Dicke M. Leaf hairs influence searching efficiency and predation rate of the predatory mite *Phytoseiulus persimilis* (Acari: Phytoseiidae). Ecology and Evolution of the Acari. 1999; 23(1):119-131.
21. Kumar DA, Channaveerswami AS. Pre and post emergence control measures for shoot fly incidence and its influence on seed yield of little millet (*Panicum sumatrense*). Journal of Experimental Zoology. 2015; 18(2):811-814.
22. Kumar S, Singh DV, Sachan SK, Singh G, Singh G. Studies on pest complex and seasonal incidence of shoot fly, *Atherigona soccata* (Rondani) on maize in western. Progressive Agriculture. 2016; 16(1):120-124.
23. Mensah LM, Madden AR. Shoot fly on sweet maize. Maize Abstract. 1999; 1(2):373.
24. Moharram IA, Gashem MY, Morshed AE, Mezgage M. Collection and classification of insect and their natural enemies on cereal crops in Yemen. Arabic Journal of Plant Protection. 1996; 14(2):47-53.
25. Mudigoudra S, Shekharappa, Balikai RA. Evaluation of plant products in combination with cow urine and panchagavya against sorghum shoot fly, *Atherigona soccata* (Rondani). Karnataka Journal of Agriculture Science. 2009; 22(3):618-620.
26. Oladejo JA, Adetunji MO. Economic analysis of maize production in Oyo state of Nigeria. Agricultural Science Research Journal. 2012; 2(2):77-83.
27. Parvez A, Ihsan-ul-haq, Ashfaq M. Some studies on the physico–morphological characters contributing toward resistance in some maize cultivars against stem borer. Pakistan Journal of Agriculture Science. 2000; 37(1):178-180.
28. Pawar VM, Jadhav GD, Kadam BS. Compatibility of oncol 50SP with different fungicides on sorghum (C53541) against shoot fly, *Atherigona soccata* (Rondani). Pesticides. 1984; 18(4):89-10.
29. Ponnaiya BWX. Studies in the genus Sorghum II. The cause of resistance in sorghum to the insect pest, *Atherigona soccata*. CIMMYT. 1951; 21(1):203-217.
30. Raiger RA, Ameta OP, Sharma KC, Rana BS. Incidence of shoot infesting insects' pests of sorghum. Indian Journal of Applied Entomology. 2002; 16(2):47-50.
31. Raina AK, Kibuka JG. Oviposition and survival of sorghum shoot fly, on intercropped maize and sorghum. Entomologia Experimentalis et Applicata. 1983; 34(1):107-110.
32. Riyazaddin M, Polavarapu B, Kishor K, Kumar AA, Reddy BVS, Rajendra, Munghate S, *et al*. Mechanisms and diversity of resistance to sorghum shoot fly, *Atherigona soccata*. Plant Breeding. 2015; 134(3):423-436.
33. Sathish R, Manjunatha M, Rajashekarappa K. Effect of Organic Amendments, Botanicals and Insecticides against Little Millet Shoot Fly, *Atherigona pulla* (Wiedemann). International Journal of Current Microbiology and Applied Sciences. 2017; 6(10):2196-2203.
34. Shekarappa GK, Rramegowda. Monitoring natural enemies of sorghum pest. Insect Environment. 2005; 11(2):33-34.
35. Siddique SS, Arif M, Babu R, Yadav U, Bisht S, Hooda KS. Assessment of some newer insecticides against Sorghum shoot fly, *Atherigona soccata* (Rondani). Journal of Experimental Zoology. 2011; 14(1):301-302.
36. Sparks TH, Yates TJ. The effect of spring temperature on the appearance dates of shoot flies. Ecography. 1997; 20(4):368-374.
37. Tandi BI, Bajiya RS. Management of shoot fly and stem borer in pearl millet. Indian Journal of Applied Entomology. 2013; 27(1):73-75.
38. Tariq M, Iqbal H. Maize in Pakistan-An Overview (Review Article). Agriculture and Natural Resources. 2010; 44(1):757-763.