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Incidence of shoot fly, *Atherigona pulla* (Wiedemann) on proso millet at different dates of sowing

Ravulapenta Sathish, M Manjunatha and K Rajashekarappa

Abstract
The investigation was carried out to know the incidence of shoot fly on proso millet during 2015-16 at Zonal Agricultural and Horticultural Sciences (ZAHRS), UAHS, Hiriyur. The shoot fly incidence was found to be higher in 15th July to 15th October sown crops. The peak incidence was observed on 15th August (23.0 % deadhearts) and 1st August (20.93 % deadhearts) sown crops whereas low incidence was on 1st May (0.59 % deadhearts) sown the crop. The higher number of eggs per plant was noticed on 15th August (2.05 eggs/plant) sown crop whereas low on 1st May (0.16 eggs/plant) sown crops Predatory coccinellids ((*Coccinella transversalis* Fabricius and *Cheilomenes sexmaculata* Fabricius) and larval parasitoids (*Halticoptera* sp. and *Trichopria* sp.) were predominant natural enemies of shoot fly observed in the proso millet ecosystem at different sowing dates. Shoot fly incidence had direct significant and negative association with the relative humidity.

Keywords: Proso millet, shoot fly, date of sowing, incidence, predatory coccinellids, parasitoids

1. Introduction
Small millets, a group of crops or minor coarse cereals, namely little millet (*Panicum sumatrense* Roxb.), kodo millet (*Paspalum scrobiculatum* L.), foxtail millet (*Setaria italica* L.), barnyard millet (*Echinochloa frumentacea* Link.) and proso millet (*Panicum miliaceum* L.) well known for drought tolerance and least water demanding for their growth and development. These crops have been traditionally the indispensable component of dry farming system. An area of 6.83 million hectares is under small millets in India with an annual production of 0.39 million tonnes [1]. These small millets are consumed as staple food and their cost of production is low compared to any cereal crop. They are cultivated in less productive soils with minimum management practices. In Karnataka, they are grown in an area of 24.0 thousand hectares with a production of 10 thousand tonnes annually, mostly in the districts of Chitradurga, Davanagere, Haveri, Tumkur, Bangalore and Kolar. The demand for small millets as a staple food has been increasing in recent years.
Although these crops have best of the attributes, its cultivation sometimes requires attention to manage insect pests. Among the insect pests harbouring small millets, shoot flies of the genus *Atherigona* are most important and destructive as they can cause substantial economic loss, particularly on little millet and proso millet at the seedling stage.
Proso millet (*Panicum miliaceum* L.) is an important indigenous crop of Indian Subcontinent. It is grown in Tamil Nadu, Karnataka, Andhra Pradesh, Orissa, Bihar, Madhya Pradesh and Maharashtra. It is locally known as Baragu. It matures very early in 70-75 days it serves as an ideal catch crop for multiple and relay cropping systems. It is well known for its drought tolerance and is one of the least water demanding crops. This crop being eco-friendly is highly suitable for sustainable agriculture. The nutritional quality of this grain is superior to fine cereals. Although this crop has best of the attributes, its cultivation sometimes requires attention to manage the only serious pest, shoot fly (*Atherigona pulla*). This pest alone can cause loss up to 80 per cent or even 100 per cent [2].
Methods currently used to manage the pest during rainy season include early sowing, increased seed rate, thinning and destroying of seedlings with deadhearts and soil application of carbofuran. Although, chemical control with granular insecticide provides good control, it is not economical because majority of the small farmers and more over for its effectiveness it requires sufficient moisture in the soil.

In rainfed agriculture, manipulation of sowing date and maintaining the sufficient soil moisture to avoid pest damage is almost not possible. Conventional methods for the control of shoot fly are neither practical nor cost effective for the small and marginal farmers. Since, the pest is restricted to seedling stage it may not be feasible for many farmers to strictly adhere to spray schedule on time, mainly due to low economic returns from these crops.

Considering seriousness of this pest, an attempt has been made to study the effect of date of sowing on the incidence of the shoot fly to predict its occurrence and to develop precise management practices against it.

2. Materials and Methods

In order to study the incidence of shoot fly on proso millet a field trial was carried out during 2015-16 at Zonal Agricultural and Horticultural Sciences (ZAHRS), UAHS, Hiriyur. GPUP-21 variety of proso millet was selected for sowing. The crop was sown in an area of 27 m^2 area with three subplots of 3 m X 3 m (9 m^2 area) in size. The seeds were sown by adopting a spacing of 30 cm between the rows. The crop was sown sequentially at fortnightly intervals starting from 1st day of May' 2015 to till the 15th day of December' 2015. A total of 16 sowings were accommodated during this period. All the recommended agronomical practices (except plant protection measures) were adopted on time. The crops were allowed for natural infestation by shoot fly without taking any control measures.

2.1 Egg count per plant

The egg laying habit by shoot fly *i.e*. white, elongated, cigar shaped eggs laid singly on the under surface of the leaves, parallel to the midrib was confirmed. In each plot 5 plants were randomly selected. Number of shoot fly eggs was counted from each plant and total number of eggs on five plants (sum of eggs in 5 randomly selected plants) was taken and average was calculated to represent the number of eggs per plant.

2.2 Deadheart incidence (%)

Number of plants with deadhearts caused by shoot fly per plot was recorded. Total number of plants was also counted and per cent deadhearts was computed and expressed as percentages by the following formula.

$$\text{Deadheart incidence (\%)} = \frac{\text{Number of plants with deadhearts/plot}}{\text{Total number of plants/plot}} \text{ X } 100$$

2.3 Natural enemies

Predators: The total number present on 5 plants were taken and then average number of coccinellids per plant, number of chrysopids per plant and number of spiders per plant were calculated.

Parasitoids: The larvae (10 plants with deadhearts) were collected from the field and reared in the laboratory and parasitoids emerged from the larvae were counted and got identified by Dr. Ankita Gupta, Scientist, Division of Insect Systematics, *National Bureau of Agricultural Insect Resources,* Bengaluru-560 065. The per cent parasitism was worked out from the observations made.

The meteorological data were collected from observatory in Zonal Agricultural and Horticultural Research Station (ZAHRS) farm, Hiriyur which is near to the experimental plot. The correlation analysis was done to understand the relationship between various weather parameters viz., temperature, relative humidity and rain fall with the number of eggs and per cent deadheart.

3. Results and discussion

3.1 Number of eggs per plant

Significantly the mean number of eggs (14, 21 and 28 DAE) was significantly highest in 15th August (2.05 eggs/ plant) and 15th July (1.80 eggs/ plant) sown crops which were on par with 15th October (1.76 eggs/ plant) sown crop. Significantly lowest number of eggs was recorded in 1st May (0.16 eggs/ plant) and 15th May (0.31 eggs/ plant) sown crops (Table 1). These findings are in agreement with Karibasavaraja [3] and Shekarappa and Ramegowda [4] who noticed highest number of shoot fly eggs during the 2nd week of August (3.2 eggs/ plant) and 3rd week of July (4.5eggs /plant), respectively, but on sorghum.

3.2 Per cent deadheart

The mean per cent deadheart (14, 21 and 28 DAE) was significantly highest in 15th August (23.0 %) sown crop which was on par with 1st August (20.93 %), 15th July (20.89 %) and 15th September (20.44 %) sown crops. Significantly very low mean percent deadheart was noticed in 1st May (0.59 %), 15th May (2.63 %) and 1st June (3.04 %) sown crops (Table 2). The early sown crops (during May) recorded very low infestation. The present findings are in accordance with Deepthi [5] who noticed peak incidence (62 % deadhearts) of sorghum shoot fly during the 1st week of August.

3.3 Natural enemy population

Predatory coccinellids and larval parasitoids were predominant natural enemies of shoot fly observed in the proso millet ecosystem at different sowing dates. In the present investigation, predatory coccinellids (*Coccinella transversalis* Fabricius and *Cheilomenes sexmaculata* Fabricius) and larval parasitoids (*Halticoptera* sp. and *Trichopria* sp.) were predominant natural enemies in proso millet ecosystem at different sowing dates.

Significantly highest mean number of predatory coccinellids (14, 21 and 28 DAE) per plant was noticed in 1st November (1.39/ plant) which was on par with the 1st October (1.34/ plant) sown crops on proso millet, whereas lowest in 1st May (0.29/ plant) sown crop (Table 3).

The activity of larval parasitoids was observed during peak incidence of shoot fly *i.e*. from 15th July to 15th October sown crops in proso millet with the range of 1.0 to 4.0 per cent (Table 4). This increase in parasitism can be attributed to the increase in the number of shoot fly maggots (incidence) during that particular season.

3.4 Correlation of shoot fly incidence with abiotic and biotic factors at different dates of sowing

Morning relative humidity (r=-0.43), evening relative humidity (r=-0.31) and predatory coccinellid population had direct significant and negative association with the number of eggs per plant and per cent deadheart by shoot fly in proso

millet ecosystem (Table 5). If the relative humidity is more than 60 per cent it favours shoot fly incidence but when it drops below 60 per cent exhibits negative effect on shoot fly incidence. This might have affected the physiology, development, longevity and oviposition of shoot fly. The present findings are in similar with the Pavana Kumar *et al*. [6] who reported, relative humidity had negative correlation with shoot fly incidence.

Table 1: Effects of date of sowing on oviposition by shoot fly, *A. pulla* in proso millet during 2015-16

Date of sowing	Number of eggs/ plant			
	14 DAE	21 DAE	28 DAE	Mean
01-05-2015	0.07 (0.75)^{i}	0.13 (0.79)^{i}	0.27 (0.87)^{h}	0.16^{j}
15-05-2015	0.27 (0.87)^{hi}	0.40 (0.94)^{hi}	0.27 (0.87)^{h}	0.31^{ij}
01-06-2015	0.33 (0.91)^{ghi}	0.47 (0.98)^{hi}	0.53 (1.01)^{gh}	0.44^{hij}
15-06-2015	0.47 (0.98)^{fgh}	0.67 (1.08)^{gh}	0.60 (1.05)^{fgh}	0.58^{ghi}
01-07-2015	0.60 (1.05)^{efg}	0.73 (1.11)^{gh}	0.80 (1.13)^{efg}	0.71^{fgh}
15-07-2015	2.27 (1.66)^{a}	1.67 (1.47)^{bc}	1.47 (1.40)^{ab}	1.80^{ab}
01-08-2015	1.80 (1.52)^{b}	1.20 (1.30)^{def}	1.27 (1.33)^{abcd}	1.42^{bc}
15-08-2015	2.27 (1.66)^{a}	2.27 (1.66)^{a}	1.60 (1.45)^{a}	2.05^{a}
01-09-2015	1.27 (1.33)^{c}	1.47 (1.40)^{cd}	1.33 (1.35)^{abc}	1.36^{c}
15-09-2015	1.13 (1.28)^{c}	1.47 (1.40)^{cd}	1.07 (1.25)^{bcde}	1.22^{cde}
01-10-2015	1.27 (1.33)^{c}	1.33 (1.35)^{cde}	1.20 (1.30)^{abcde}	1.27^{cd}
15-10-2015	1.93 (1.56)^{b}	2.07 (1.60)^{ab}	1.27 (1.31)^{abcd}	1.76^{abc}
01-11-2015	1.13 (1.27)^{c}	0.93 (1.19)^{efg}	0.87 (1.17)^{defg}	0.98^{def}
15-11-2015	0.73 (1.10)^{ef}	0.93 (1.19)^{efg}	1.00 (1.22)^{cdef}	0.89^{efg}
01-12-2015	0.80 (1.14)^{de}	0.80 (1.13)^{fgh}	0.60 (1.04)^{fgh}	0.73^{fgh}
15-12-2015	1.07 (1.25)^{cd}	0.73 (1.11)^{gh}	0.87 (1.16)^{defg}	0.89^{efg}
S.Em ±	0.05	0.06	0.07	
CD @ 0.05	0.14	0.19	0.20	
CV%	6.62	9.00	9.69	
F test	*	*	*	

Figures in the parentheses are √x+0.5 transformed values; DAE= Days after emergence.
Means in the columns followed by the same alphabet do not differ significantly by DMRT (P=0.05)

Table 2: Effects of date of sowing on deadhearts caused by shoot fly, *A. pulla* in proso millet during 2015-16

Date of sowing	Deadheart per cent			
	14 DAE	21 DAE	28 DAE	Mean
01-05-2015	0.22 (1.56)^{f}	0.67 (4.58)^{f}	0.89 (5.33)^{i}	0.59^{f}
15-05-2015	1.22 (6.34)^{f}	3.22 (9.78)^{f}	3.44 (10.10)^{i}	2.63^{f}
01-06-2015	1.44 (6.86)^{f}	3.56 (10.40)^{f}	4.11 (11.27)^{i}	3.04^{f}
15-06-2015	7.56 (15.92)^{cde}	12.22 (20.38)^{c}	16.00 (23.56)^{de}	11.93^{c}
01-07-2015	10.22 (18.55)^{c}	11.67 (19.86)^{c}	12.11 (20.35)^{fg}	11.33^{cd}
15-07-2015	14.78 (22.59)^{b}	19.89 (26.46)^{ab}	28.00 (31.95)^{a}	20.89^{ab}
01-08-2015	15.67 (23.26)^{b}	18.89 (25.69)^{b}	28.22 (32.10)^{a}	20.93^{ab}

15-08-2015	19.44 (26.13)^{a}	22.78 (28.51)^{a}	26.78 (31.17)^{ab}	23.00^{a}
01-09-2015	14.11 (22.01)^{b}	19.33 (26.07)^{b}	23.89 (29.25)^{bc}	19.11^{b}
15-09-2015	17.22 (24.52)^{ab}	19.22 (25.99)^{b}	24.89 (29.90)^{abc}	20.44^{ab}
01-10-2015	16.78 (24.14)^{ab}	18.23 (25.27)^{b}	18.67 (25.55)^{d}	17.89^{b}
15-10-2015	15.56 (23.21)^{b}	17.00 (24.34)^{b}	23.00 (28.57)^{c}	18.52^{b}
01-11-2015	10.33 (18.63)^{c}	12.22 (20.24)^{c}	13.56 (21.58)^{ef}	12.04^{c}
15-11-2015	8.44 (16.71)^{cd}	10.67 (18.93)^{cd}	14.67 (22.49)^{ef}	11.26^{cd}
01-12-2015	5.11 (13.03)^{e}	7.22 (15.53)^{e}	8.33 (16.68)^{h}	6.89^{e}
15-12-2015	6.11 (14.06)^{de}	8.23 (16.03)^{de}	9.23 (17.59)^{gh}	7.86^{de}
S.Em ±	1.18	1.09	1.07	
CD @ 0.05	3.53	3.26	3.21	
CV%	11.75	9.48	8.31	
F test	*	*	*	

Figures in the parentheses are *arc* sine transformed values; DAE= Days after emergence.
Means in the columns followed by the same alphabet do not differ significantly by DMRT (P=0.05)

Table 3: Effects of date of sowing on predatory coccinellids population in proso millet ecosystem during 2015-16

Date of sowing	Number of coccinellids/plant			
	14 DAE	21 DAE	28 DAE	Mean
01-05-2015	0.20 (0.82)^{f}	0.33 (0.88)^{fg}	0.33 (0.95)^{f}	0.29^{f}
15-05-2015	0.57 (1.02)^{e}	0.47 (0.95)^{ef}	0.60 (1.02)^{ef}	0.54^{ef}
01-06-2015	0.60 (1.02)^{e}	0.73 (1.07)^{de}	0.73 (1.08)^{de}	0.69^{def}
15-06-2015	0.97 (1.20)^{cd}	1.00 (1.17)^{cd}	1.07 (1.22)^{bc}	1.01^{abcde}
01-07-2015	0.77 (1.12)^{de}	0.13 (0.79)^{fg}	0.80 (1.10)^{cde}	0.57^{def}
15-07-2015	0.77 (1.12)^{de}	1.00 (1.20)^{cd}	0.80 (1.10)^{cde}	0.86^{bcde}
01-08-2015	1.37 (1.36)^{ab}	1.27 (1.30)^{bc}	1.27 (1.30)^{ab}	1.30^{abc}
15-08-2015	0.73 (1.08)^{de}	1.60 (1.44)^{a}	1.27 (1.30)^{ab}	1.20^{abc}
01-09-2015	1.57 (1.43)^{a}	0.33 (0.88)^{fg}	1.00 (1.19)^{bcd}	0.97^{abcde}
15-09-2015	1.17 (1.29)^{bc}	1.20 (1.28)^{c}	0.80 (1.10)^{cde}	1.06^{abcd}
01-10-2015	0.97 (1.20)^{cd}	1.53 (1.41)^{ab}	1.53 (1.40)^{a}	1.34^{ab}
15-10-2015	1.17 (1.29)^{bc}	1.20 (1.28)^{c}	0.60 (1.01)^{ef}	0.99^{abcde}
01-11-2015	1.57 (1.43)^{a}	1.60 (1.44)^{a}	1.00 (1.18)^{bcd}	1.39^{a}
15-11-2015	0.77 (1.12)^{de}	0.60 (1.01)^{ef}	1.07 (1.22)^{bc}	0.81^{cde}
01-12-2015	0.73 (1.08)^{de}	1.60 (1.44)^{a}	1.27 (1.30)^{ab}	1.20^{abc}
15-12-2015	0.80 (1.12)^{de}	1.00 (1.20)^{cd}	0.80 (1.10)^{cde}	0.87^{bcde}
S.Em ±	0.05	0.05	0.04	
CD @ 0.05	0.16	0.15	0.12	
CV%	7.74	7.34	5.84	
F test	*	*	*	

Figures in the parentheses are √x+0.5 transformed values; DAE= Days after emergence.
Means in the columns followed by the same alphabet do not differ significantly by DMRT (P=0.05)

Table 4: Population dynamics of larval parasitoids on *A. pulla* at different dates of sowing during 2015-16

Date of sowing	*Per cent parasitism			
	14 DAE	21 DAE	28 DAE	Mean
01-05-2015	0.00	0.00	0.00	0.00
15-05-2015	0.00	0.00	0.00	0.00
01-06-2015	0.00	0.00	0.00	0.00
15-06-2015	0.00	0.00	0.00	0.00
01-07-2015	0.00	0.00	0.00	0.00
15-07-2015	1.00	3.00	0.00	1.33
01-08-2015	1.00	0.00	8.00	3.00
15-08-2015	4.00	6.00	2.00	4.00
01-09-2015	0.00	2.00	1.00	1.00
15-09-2015	2.00	1.00	1.00	1.33
01-10-2015	1.00	3.00	0.00	1.33
15-10-2015	1.00	1.00	4.00	2.00
01-11-2015	0.00	0.00	0.00	0.00
15-11-2015	0.00	0.00	0.00	0.00
01-12-2015	0.00	0.00	0.00	0.00
15-12-2015	0.00	0.00	0.00	0.00

*Mean of 10 deadheart plants

Table 5: Correlation of shoot fly, *A. pulla* with abiotic and biotic factors at different dates of sowing during 2015-16

Factors	Proso millet	
	Eggs/ plant	Deadheart (%)
Maximum temperature (^{0}C)	-0.13	-0.09
Minimum temperature (^{0}C)	0.06	0.17
Morning relative humidity (%)	-0.43*	-0.35*
Evening relative humidity (%)	-0.31*	-0.26*
Rainfall (mm)	0.043	0.14
Predatory coccinellids	0.46*	-0.44*
Larval parasitoids	-	0.61**

** Significant @ 0.01 *Significant @ 0.05

4. Conclusion

From the results it was concluded that, proso millet sown during the 1st May to 15th July was best among all sowing dates with least number of eggs and per cent deadheart. Therefore, early sowing dates (late May to early July) are

recommended as principal components of integrated proso millet shoot fly management.

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6. References

1. ANONYMOUS, Pocket book on Agriculture Statistics, Government of India, Ministry of Agriculture, Directorate of economics and Statistics, Department of Agriculture and Co-operation, Govt. of India, 2016.
2. Jagadish PS, Murali PR, Seetharam A. Evaluation of germplasm lines and cultural practice on the incidence of little millet shoot fly, *Atherigona pulla* Wiede. Environ. Edu. Res. 1995, 45-47.
3. Karibasavaraja LR. Bio-ecology and management of sorghum shoot fly, *Atherigona soccata* Rondani, M. Sc. (Agri.) Thesis, University of Agricultural Sciences, Dharwad (India), 2003.
4. Shekarappa, Ramegowda GK. Monitoring natural enemies of sorghum pest. Insect Environment. 2005; 11:33-34.
5. Deepthi J. Studies on the management of pests of sweet sorghum with special reference to stem borer, *Chilo partellus* (Swinhoe). M. Sc. (Agri.) Thesis, Uni University of Agricultural Sciences, Dharwad (India). 2007, 50.
6. Pavana Kumar ST, Srinath Reddy AB, Minakshi M, Adam K, Mazumdar D, Shekharappa. Impact of weather parameters on shoot fly (*Atherigona soccata* Rondani) of sorghum in *kharif* season. The Ecoscan. 2015; 9(1, 2):99-104.