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Population dynamics and bio-intensive management of sorghum midge, *Contarinia sorghicola* (Coquillett) in sorghum under southern Tamil Nadu

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ABSTRACT

Surveys on distribution of sorghum midge at southern region of Tamil Nadu during 2011 to 2014 indicated that, midge observed in all areas of three districts. Effect of abiotic factors on sorghum midge revealed that maximum, minimum temperature, wind velocity and sunshine were positive while maximum, minimum relative humidity and rainfall showed negative correlation. Among bio-intensive management strategies, *Neem* oil 3 per cent showed maximum reduction (63.36), minimum midge incidence/ 5 panicle (17.5) and maximum grain yield (2498 kg/ha) when compared to control (244 kg/ha). The highest incremental cost benefit ratio (ICBR) obtained in *Neem* seed kernel extract (NSKE) 5 per cent (1:24.7) followed by *Neem* leaf extract 5 per cent (1:22.3) treated plots.

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INTRODUCTION

Sorghum midge, *Contarinia sorghicola* (Coquillett) occurs in almost all regions of the world where sorghum is grown except Southeast Asia (Teetes *et al*., 1999 and Boyd and Bailey, 2000). It was reported from India in 1914 (Fletcher, 1914). Until the 1960's the sorghum midge was minor pest but gradually attained major pest status causing grain damage of 15.1 per cent in 1966 and 19.8 per cent in 1967 in Maharashtra, India (Jotwani, 1982). The first report of an epidemic outbreak came from Maharashtra, India in 1970 where high yielding, short duration cultivars were introduced which resulted in 40-60 per cent grain loss on local sorghums (Jotwani, 1982). AICSIP 2009-10, screened many entries of the sorghum for the incidence of sorghum midge at Kovilpatti centre and the midge spikelet damage (%) was upto 79-80 (CSV 216-R). Highest outbreak of sorghum midge upto 90 per cent (Fig.A) was at recorded from Agricultural Research Station, Kovilpatti and Tamil Nadu Agricultural University, Coimbatore during *Kharif* and post rainy season of 2010-14 (Anandhi and Sankarapandian, 2013 and Anandhi *et al*., 2015).

Fig. A : Sorghum midge affected field

Crop pest weather relationship can play a major role in determining the level of the pest incidence. The seasonal incidence of sorghum midge in India differs according to climatic conditions (Patel and Jotwani, 1986), but generally appears in Tamil Nadu with four peaks infestation in April, June, August and October (Natarajan and Chelliah, 1985). During rainy season the life cycle takes 2 weeks allowing 4-5 overlapping generations. But higher temperatures at flowering stage reduce population build up (Patel and Jotwani, 1986).

Introduction of new molecules and indiscriminate use of pesticides has eroded ecological sustainability (Anandhi *et al*., 2012). The flowering characteristics of sorghum, daily infestation by new adult sorghum midges, and the fact that only adult midges are affected by the insecticide, often result in less than adequate or desired control. The production cost/profit ratio of sorghum is not high enough to allow for much insecticide use (Teetes, 1995 and Anandhi *et al*., 2013). However, limited information is available on the survey, seasonal incidence and bio-intensive management of sorghum midge in Tamil Nadu. Hence, the present attempt was taken upto ascertain its incidence, peak activity in relation to weather parameters and bio-intensive management in sorghum ecosystem during post rainy season.

MATERIAL AND METHODS

Survey of sorghum midge :

Survey of sorghum midge was undertaken in Tamil Nadu during the *Rabi* seasons of 2011 to 2014. The survey areas comprised of - Tuticorin, Tirunelveli, Virudhunagar districts and Agricultural Research Station, Kovilpatti, where sorghum is the major crop. For each district 20 sites were selected and surveyed for midge incidence.Visual inspection sampling of the midges was done daily from 7.00 a.m to 9.00 a.m on twenty five sorghum plants when the midges are usually active and emerge during early hours. A large size plastic bag of one liter capacity was placed over the sorghum head and shaken 4-5 times to dislodge the midges, which were counted. Midge spikelet damage percentage was also calculated for the five sorghum plants.

Population dynamics of sorghum midge :

Field experiments were conducted at Agricultural Research Station, Kovilpatti, Tamil Nadu Agricultural University, Tamil Nadu during 2011-2014 under rainfed in natural condition. The variety K-8 was sown in the 43rd standard week coinciding with third week of October to monitor the pest population. Recommended package of practices were followed to raise the crop except plant protection. Number of midges/ panicle was counted after bagging the panicles with 1 lit capacity polythene bags. It was recorded daily and expressed as mean midges/ panicle/ week. The data on maximum and minimum temperatures, maximum and minimum relative humidity, rainfall, sunshine hours and wind velocity were obtained from the weather station located near the experimental. The data on mean midge population/ panicle/ week was correlated with weather parameter to work out the inter-relationship between the pest population and weather parameters. The data was statistically analyzed using MSTAT software and't' test applied to test the significance. Regression equations were also worked out.

Bio-intensive management of sorghum midge :

Field experiments were conducted with eight treatments, replicated thrice at Agricultural Research Station, Kovilpatti during 2011 to 2014 with the plot size of 8 rows of 4m length. The treatment includes indigenous plant extracts of *Neem* (*Azadirachta indica*) seed kernel extract 5 per cent, *Neem* leaf (*Azadirachta indica*) extract 5 per cent, *Neem oil* (*Azadirachta indica*) 3 per cent, pungam *(Pongamia pinnata)* oil 5 per cent, wild *Tulsi* (*Ocimum tenuiflorum*) leaf extract 5 per cent and mexican poppy *(Argemone mexicana*) leaf extract 5 per cent, carbaryl 10D @ 10kg/acre and one untreated control. All the treatments were imposed on need based at two times on 3rd and 18th day after panicle emergence. Care was taken to avoid drifting of the spray solution and to give a thorough coverage of ear head. Plain water was sprayed in untreated control plots. Observations on the number of sorghum adult midges at one day before, 3, 5 and 7 days after each application were recorded on five randomly selected ear heads in each plot. The yield in each plot was recorded and expressed as kilogram per hectare. The mean values after $\sqrt{x+0.5}$ transformations were subjected to statistical analysis to test significance as per analysis of variance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under the following heads:

Population fluctuation :

Sorghum is grown in these areas as rainfed condition. The midge per cent incidences of spikelet at different districts are illustrated in Fig 1. The midge per cent incidence in milky stage of panicle during 2011-14 ranged between 40.0 -50.0, 15.0 -50.0, 2.0 -28.0 and 85.1- 96.0 at Tuticorin, Tirunelveli, Virudhunagar and Agricultural Research Station, Kovilpatti, respectively. The midge per cent incidences were highest in Tuticorin district and very severe outbreak (96 %) was recorded at Agricultural Research Station, Kovilpatti (upto 96 %).

Seasonal occurrence of sorghum midge :

The influence of weather factors on the incidence of midge were calculated on K-8 sorghum and the pooled

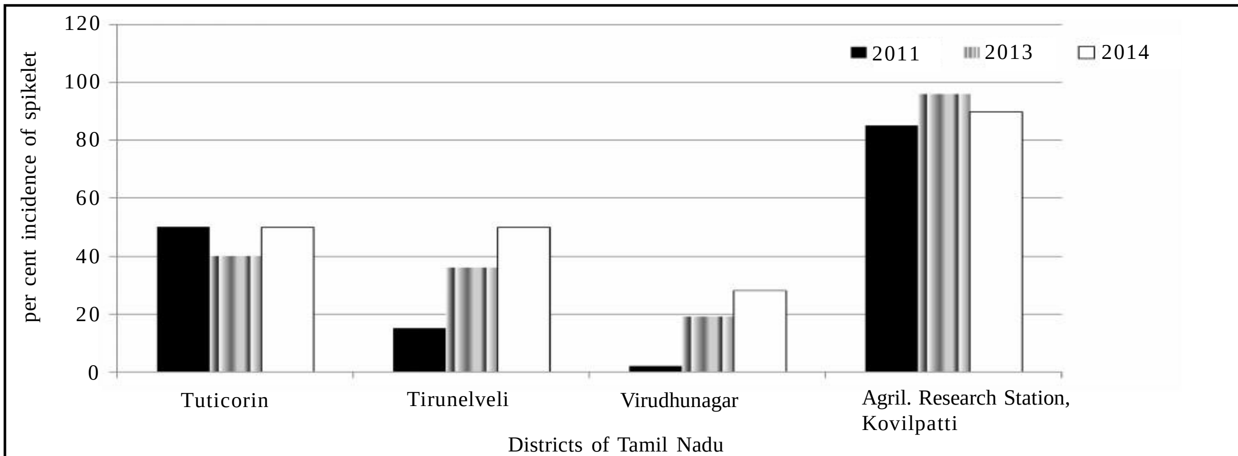

Fig. 1 : Incidence of sorghum midge on sorghum in three districts of Tamil Nadu during 2011-14

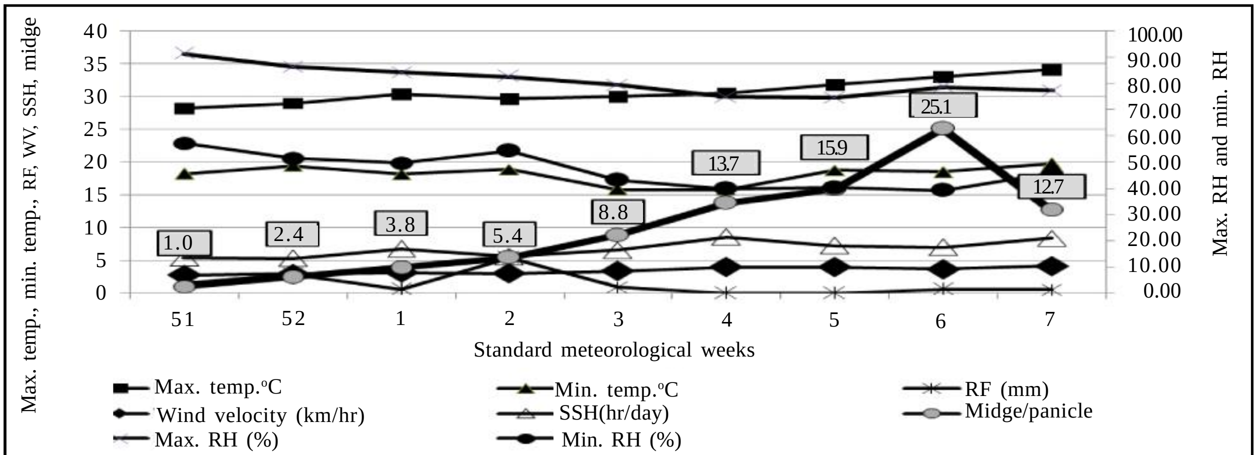

Fig. 2 : Correlation between sorghum midge and weather parameters during seed maturation stage (Pooled data of 3 years)

data showed that infestation of the midge during *Rabi*, 2011-14 commenced during the last week of December (51 SMW) and continued upto second week of February (7 SMW) (Fig. 2). Initially, the infestation was recorded to be 1.0 to 3.8 midges/5 panicle which increased gradually and reached to maximum 25.1 midges/5 panicle at 33.0 °C maximum, 18.5 °C minimum temperature, 78.7 and 39.3 per cent maximum and minimum relative humidity, 3.6 km/hr wind velocity and 6.9 hr/day sunshine hours in the first week of February (6 SMW) in the late sown sorghum varieties.

The seasonal incidence of sorghum midge in India differs according to climatic conditions (Patel and Jotwani, 1986). The damage by sorghum midge was significantly higher in the late-planted (October- last week) sorghum varieties than in the early planted (first week - October) sorghum hybrids. This observation was contrary to the findings of Castro *et al*. (2000) wherein late planted hybrids of sorghum showed significantly lesser incidence of sorghum midge. Peak midge density was observed during the second fortnight of October in the rainy season and February, March in the post-rainy season (Sharma and Vidyasagar, 1992).

Correlation studies :

Abiotic factors, *viz*., maximum temperature, humidity, wind velocity and sunshine hours are suggested as causes for population fluctuation of sorghum midge. The pooled correlation co-efficients (r) of midge population during 2011-14 with weather parameters are given in Table 1. The maximum, minimum relative humidity and total rainfall had negative association with midge population (r= -0.52, -0.67 and -0.13, respectively), while it there was positive relationship between maximum, minimum temperature, wind velocity and sunshine (r = 0.53, 0.17, 0.55 and 0.39) with midge infestation.

The above findings are in agreement with the reports of Natarajan and Chelliah, 1985; Patel and Jotwani, 1986 and Sharma and Vidyasagar, 1992 who also observed negative significant correlation with minimum relative humidity and positive significant correlation with temperature. The present results are contradictory to the findings of Pendleton and Teetes (1994) who noticed that wind velocity plays a negative role in the movement of the flies. This might be due to the differences in the climatic conditions and cultivars used. Fisher and Teetes (1982) also concluded that rainfall played an important role in the population dynamics of the midge.

Regression studies :

Since the interaction of climatic factors is complex, the multiple regression analysis was worked out between independent weather factors for the dependent factor (midge population) (Table 1). The co-efficient determination (R^2) between weather parameters and midge population was significant (57.02 %) during the above years of study (2011 to 2014). The regression equations fitted between weather factors (X) and midge population (Y) is given below:

$$Y = 42.43 + 0.53^{**} x_1 + 0.17 x_2 - 0.52^{**} x_3 - 0.67^{**} x_4 + 0.13 x_5 - 0.55^{**} x_6 + 0.39^{*} x_7$$

where, x_1= Maximum temperature (°C); x_2= Minimum temperature (°C); x_3= Maximum relative humidity (%); x_4= Minimum relative humidity (%); x_5= Rainfall (mm); x_6= Wind velocity (Km/hr); x_7= Sunshine (hrs/ day).

About 57.02 per cent of the variation in midge population was contributed by weather parameters considered. The results indicated that when effect of other factors are kept constant an increase of 1°C of

Table 1 : Correlation and multiple regressions between midge population and weather parameters (Pooled data of 3 years)

Weather parameter	Correlation co-efficient (r)	Multiple regression co-efficients	Standard error	't' value	R^2
Intercept		42.43			
X_1 = Max. temperature (° C)	0.53**	-0.06	0.65	-0.09	0.5702*
X_2 = Min. temperature (° C)	0.17	0.33	0.71	0.46	
X_3 = Max. RH (%)	-0.52**	-0.24	0.13	-1.79	
X_4 = Min. RH (%)	-0.67**	-0.42	0.22	-1.86	
X_5 = Rainfall (mm)	-0.13	-0.01	0.45	-0.02	
X_6 = Wind velocity (km /hr)	0.55**	2.48	3.73	0.66	
X_7 = Sunshine (hr/day)	0.39*	-0.84	1.59	-0.52	

* and ** indicate significance of values at P=0.05 and 0.01, respectively

maximum temperature, 1 km/h increase in wind velocity and 1hr increase in sunshine hours/ day would lead to increase of midge population by 0.53, 0.55 and 0.39 numbers, respectively. A decrease of 1 per cent reduction in maximum and minimum relative humidity would lead to reduction in midge population to the tune of 0.52 and 0.67, respectively. Rest of the variation is attributable to factors not considered.

The multiple regression co-efficient analysis clearly indicated that the population build up was dependent on abiotic factors. The co-efficient determination between weather parameters and midge population was highly significant over the above years of study showing the importance of these parameters in influencing the abundance of sorghum midge. Baxendale *et al*. (1984a) developed two mathematical model that the onset and duration of adult sorghum midge emergence after the winter diapause as a function of soil temperature and rainfall and second the length of the life cycles of the following generations of sorghum midges as a function of ambient (air) temperature Baxendale *et al*. (1984b).

Bio-intensive midge management :

Midge percentage reduction over control :

The data on the efficacy of different bio-intensive management strategies on sorghum midge during *Rabi* 2011-2014 are presented in Table 2 and Fig. 3. The pooled observations of pre-treatment count indicated that the midge population/ 5 ear heads varied between 31.50 and 39.3. The results revealed that all the treatments were

Table 2: Effect of different BIPM- practices against the population of sorghum midge, *C. sorghicola,* grain yield of sorghum and incremental cost benefit ratio (ICBR) (Pooled analysis of 3 years)

Treatments	PTC	Adult midges/ 5 panicle (mean no.) 7 DAT*	Grain yield (kg/ha)	Increase yield over control	ICBR	B.C ratio
T_1	35.0 (5.9)	18.0 (4.2)**	2215	1971	24.7	2.1
T_2	35.7 (5.9)	20.3 (4.4)	1542	1298	22.3	1.5
T_3	35.9 (5.9)	17.5 (4.1)	2498	2254	9.3	2.0
T_4	34.8 (5.9)	21.9 (4.6)	1115	871	3.0	0.9
T_5	33.7 (5.6)	24.9 (4.9)	898	655	11.3	0.9
T_6	39.3 (6.17)	23.1 (4.9)	673	429	8.1	0.6
T_7	31.5 (5.6)	7.1 (2.5)	3284	3040	3.1	1.6
T_8	34.4 (5.8)	43.2 (6.5)	244	-	-	0.2
C.D. (P=0.05)	0.5	2.6	137.9			

*DAT – Days after treatment; ** Figures in parenthesis are $\sqrt{x+0.5}$ transformed values

(T_1- NSKE 5% ; T_2- NLE 5%; T_3- *Neem* oil 3%; T_4-Pungam oil 5%; T_5- Wild *Tulsi* leaf extract 5%;T_6- Mexican poppy leaf extract 5%; T_7- Carbaryl 10D @ 10kg/ac; T_8-control)

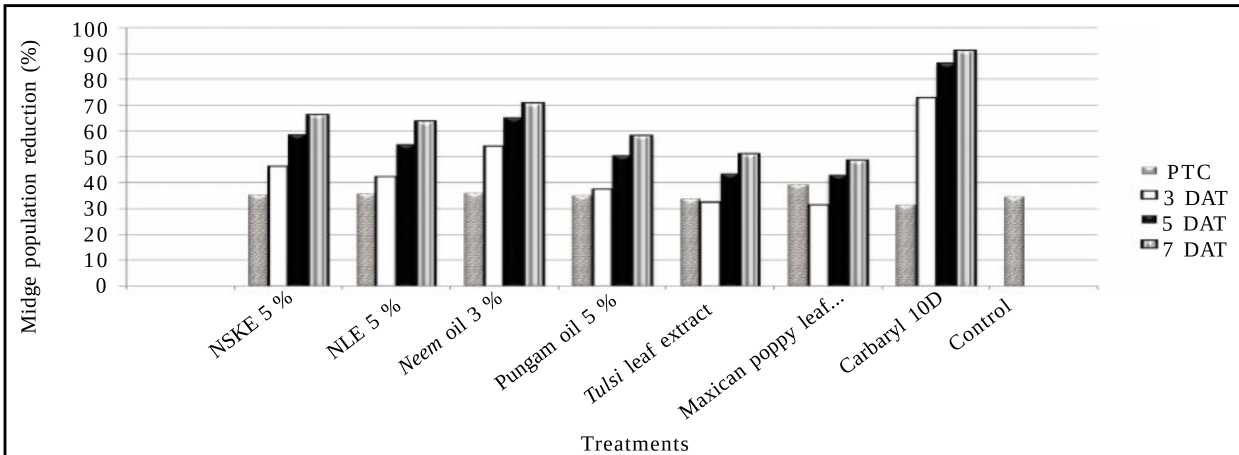

Fig. 3 : Effect of botanicals against sorghum midge, *C. sorghicola* in *Rabi* season (2010-14), Kovilpatti, Tamil Nadu

effective in reducing the midge incidence when compared to control. On the third day after treatment (DAT) the check carbaryl 10D @10kg/acre recorded the maximum reduction in midge population over control (72.7) followed by *Neem* oil 3 per cent (54.1%) which was on par with NSKE 5 per cent (46.3%) and *Neem* leaf extract 5 per cent (42.3%). Similar trend was observed on 5 and 7 DAT (Fig. 3). The results of the pooled data of Table 2 indicated that neem oil 3 per cent (17.5) showed minimum midge incidence/ 5 panicle on the seven day after treatment as compared to the check Carbaryl 10D @ 10kg/acre (7.1).

Sorghum grain yield :

The highest sorghum grain yield was recorded in the check carbaryl 10D @ 10kg/ac (3284 kg/ha) which was significantly superior over control (244 kg/ha). Due to the severe incidence of midge the yield was very low in control plots. Among the treatments, maximum grain yield was observed in *Neem* oil 3 per cent sprayed plots (2498 kg/ha) which was at par with NSKE 5 per cent treated plots (2215 kg/ha) (Table 2).

Incremental cost benefit ratio (*ICBR*) :

The highest ICBR (1:24.68) was obtained in NSKE 5 per cent treated plots followed by *Neem* leaf extract 5 per cent (1:22.30) treated plots. The highest cost benefit ratio was also recorded in NSKE 5 per cent (1:2.05) followed by neem oil 3 per cent (1:2.01) treated plots.

Among bio-intensive management strategies, *Neem* oil 3 per cent registered the maximum reduction, minimum midge incidence/ 5 panicle and maximum grain yield when compared to control. However, the highest ICBR obtained in NSKE 5 per cent followed by *Neem* leaf extract 5 per cent treated plots. An additional yield, net return and incremental cost benefit ratio indicating the *Neem* based pest management practices found to be more economical over control. The overall effectiveness of chemical insecticides against sorghum midge remains questionable in dryland condition. Hence, particular attention should be given to naturally occurring plant-derived pesticides such as *Neem* products. Franzmann *et al*. (2008) also reported that the practical application of biopesticides has led to a massive reduction in the use of synthetic insecticides for the management of major pests of sorghum in Australia. He also reported that these changes have produced immediate economic, environmental and social benefits. The present finding remain as such without discussion as none of the workers in past have attempted to work out the economics of BIPM for sorghum midge.

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