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Population dynamics of *Chrysodeixis acuta* (Walker) and *Gesonia gemma* (Swinhoe) infesting sunflower intercropped with pigeonpea and its correlation with weather parameters

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Abstract
Investigations on seasonal incidence of semiloopers *viz*., *Chrysodeixis acuta* (Walker) and *Gesonia gemma* (Swinhoe) infesting sole sunflower and sunflower intercropped with pigeonpea were carried out on the Research Farm of Department of Agricultural Entomology, College of Agriculture, Latur (VNKMV, Parbhani) during *Kharif* 2017. The data revealed that *C. acuta* and *G. gemma* were emerged as major semiloopers on sole sunflower and sunflower intercropped with pigeonpea. The peak activity of *C. acuta* (6.0 and 8.4 larvae per quadrat) during 36th and 35th SMW, however the peak activity of *G. gemma* (2.0 and 1.0 larvae per quadrat) was registered during 33th and 34th SMW on sole sunflower and sunflower intercropped with pigeonpea, respectively. The larval population of *C. acuta* infesting sole sunflower and sunflower intercropped with pigeonpea exhibited positive correlation with rainfall, maximum temperature and beforenoon relative humidity, whereas number of rainy days showed negative correlation with larval population. The larval population of *G. gemma* infesting sole sunflower had a positive correlation with rainfall, beforenoon relative humidity, whereas number of rainy days and minimum temperature showed negative correlation with larval population. However, that rainfall exhibited significantly direct positive effect on larval population of *G. gemma* infesting sunflower intercropped with pigeonpea, whereas number of rainy days and minimum temperature showed negative correlation with larval population.

Keywords: Weather, sunflower, intercropping, pigeonpea, *Chrysodeixis acuta, Gesonia gemma*

Introduction
Sunflower, *Helianthus annus* Linnaeus (Family Compositae or Asteraceae) is one of the major oilseed crops, contains 48-53 per cent edible oil. Sunflower oil is rich in linoleic acid and vitamin E which are good for the health of heart. Besides domestic consumption, sunflower oil has also been used in industry for frying, for the production of emulsions, sauces and in margarine formulations. The high stearic-high oleic sunflower oils are utilized in variety of food formulations, including fillings, spreads, coatings and confectionary products (Salas *et al*., 2015) [14]. Sunflower is also rich in highly soluble vegetable proteins *viz*., albumins and globulins essential for human and animal health (Perez, 2015) [10].

Sunflower is cultivated on more than 70 countries on 26.20 million hectares area with 47.34 million tonnes of production and 1806.7 kg per ha of productivity (FAOSTAT, 2018) [9]. In India, the area under sunflower crop is 0.40 million hectares with 0.33 million tonnes of production and 830 kg per hectare of productivity during 2016 (FAOSTAT, 2018) [9]. In Maharashtra, sunflower is grown on an area of 0.61 lakh hectare with 27.67 thousand tonnes of production and 407 kg per hectare of productivity during 2014-2015 (Anonymous, 2015) [3].

Sunflowers attract an astounding diversity of herbivorous insects. In India, sunflower is attacked by more than fifty insect species comprising seedling pests, sucking pests, soil insects, defoliators and inflorescence pests. The defoliating insects are important (Rogers, 1992) [13] and regular pests of sunflower in Marathwada region of Maharashtra state (Bilapate and Jadhav, 1995) [7]. The defoliators estimated the loss in seed yield of 58.06 per cent per ha in a rain fed *Kharif* sunflower (Suhas *et al*., 1996) [15].

Intercropping improves diversity in an agricultural ecosystem and reduces the incidence of various insect-pests (Bhamare *et al*., 2018) [6]. The population dynamics of many sunflower insect-pests was not well studied with respect to intercropping system.

Very scanty information is available on variations in the pattern of infestation caused by insect-pests when sunflower is intercropped with pigeonpea. With this background, an attempt was made to study the population dynamics of *C. acuta* and *G. gemma* infesting sole sunflower and sunflower intercropped with pigeonpea and its correlation was worked out with prevailing weather parameters.

Materials and Methods

The non-replicated field experiment comprising one hundred and sixty quadrats (eighty quadrats of sole sunflower of 2.4 x 2.4 sq. m sizes each, eighty quadrats of sunflower intercropped with pigeonpea of 2.4 x 2.4 sq. m sizes each) was laid to investigate field life-tables and population dynamics of major insect-pests of sole sunflower and sunflower intercropped with pigeonpea at the Research Farm of Department of Agricultural Entomology, College of Agriculture, Latur (MS) during *kharif* season, 2017. The sunflower variety LSFH-171 and pigeonpea variety BDN-716 were used during the investigation. The sole sunflower and sunflower intercropped with pigeonpea was sown at the spacing of 60 x 30 cm. The field experiment was conducted under pesticide free conditions. Weekly observations on population counts on larval stage of insects were taken until crop turned yellow. Five quadrates of crop were observed twice in each meteorological week for observations on semiloopers infesting sole sunflower and sunflower intercropped with pigeonpea. The population was pooled together and average population per quadrat was calculated for each meteorological week. Average weekly meteorological data during the observation period, such as temperature, relative humidity, rainfall and number of rainy days were also recorded. The statistical analysis of data on incidence of *C. acuta***,** *G. gemma* and its relation with prevailing weather were carried out by simple correlation using excel worksheet.

Results and Discussion

Population dynamics of semiloopers infesting sole sunflower and sunflower intercropped with pigeonpea

The population dynamics of semiloopers infesting sole sunflower and sunflower intercropped with pigeonpea was studied during *kharif* season 2017. During the course of investigation the weather parameters *viz.*, minimum temperature, maximum temperature, beforenoon relative humidity, afternoon relative humidity, rainfall and number of rainy days were varied from 11.6 ºC to 22.8 ºC, 27.9 ºC to 31.7 ºC, 73 to 100 per cent, 29 to 82 per cent, 0.00 to 184.0 mm and 0 to 4 days, respectively. The data pertaining to population of semiloopers infesting sunflower intercropped with pigeonpea in relation to weather parameters during *kharif* season 2017 are presented in Table 1-6.

Chrysodeixis acuta (Walker) on sole sunflower

The first incidence of *C. acuta* on sole sunflower was recorded in 30th SMW (1.8 larvae per quadrat) with its peak population level (6.0 larvae per quadrat) in 36th SMW. At maximum level of pest population the prevailing weather factors *viz.*, rainfall, number of rainy days, maximum temperature, minimum temperature, beforenoon relative humidity and afternoon relative humidity were 4.0 mm, 1 day, 30.9 ºC, 22.0 ºC, 98 and 61 per cent, respectively (Table 1).

Chrysodeixis acuta (Walker) on sunflower intercropped with pigeonpea

The first incidence of *C. acuta* on sunflower intercropped with pigeonpea was recorded in 30th SMW (2.2 larvae per quadrat) with its peak population level (8.4 larvae per quadrat) in 35th SMW. At maximum level of pest population the prevailing weather factors *viz.*, rainfall, number of rainy days, maximum temperature, minimum temperature, beforenoon relative humidity and afternoon relative humidity were 22.0 mm, 2 days, 29.9 ºC, 22.8 ºC, 97 and 74 per cent, respectively (Table 2).

These results are in harmony with the findings of Brahman *et al*. (2018) [8] who revealed that the incidence of *C. acuta* was observed during the 31st SMW (0.33 larvae per mrl) and maximum population was observed during 36th SMW (1.00 larvae per mrl). Ahirwar *et al*. (2015) [2] observed the first incidence of green semilooper (*C. acuta*) immediately after seedling stage when the crop age was about 25 days. The semilooper was present on the soybean during the entire cropping season from 25 days crop stage and remained available up to maturity of crop i.e. first week of October. Further Ahirwar *et al*. (2014) [1] the first incidence of *C. acuta* larvae was noticed during 31st SMW (3.99 larvae per mrl) and the peak larval population was during 34th SMW (9.97 larvae per mrl). Raghuvanshi *et al*. (2014) [12] evidenced that the infestation of green semilooper started in the last week of the July, at 21 DAS (0.2 larva per plant) and the population was gradually increased up to third week of August (1 larva per plant) at 49 DAS.

Gesonia gemma (Swinhoe) on sole sunflower

The first incidence of *G. gemma* on sole sunflower was recorded in 32th SMW (0.6 larva per quadrat) with its peak population level (2.0 larvae per quadrat) in 33th SMW. At maximum level of pest population the prevailing weather factors *viz.*, rainfall, number of rainy days, maximum temperature, minimum temperature, beforenoon relative humidity and afternoon relative humidity were 21.0 mm, 2 days, 28.3 ºC, 22.1 ºC, 98 and 58 per cent, respectively (Table 1).

Gesonia gemma (Swinhoe) on sunflower intercropped pigeonpea

The first incidence of *G. gemma* on sunflower intercropped pigeonpea was recorded in 32th SMW (0.6 larva per quadrat) with its peak population level (1.0 larva per quadrat) in 34th SMW. At maximum level of pest population the prevailing weather factors *viz.*, rainfall, number of rainy days, maximum temperature, minimum temperature, beforenoon relative humidity and afternoon relative humidity were 184.0 mm, 4 days, 27.9 ºC, 21.5 ºC, 100 and 74 per cent, respectively (Table 2).

The results of present investigation are in agreement with the findings of Antony and Pratheepa (2017) [4] who reported that *G. gemma* was emerged as a serious threat to the soybean crop. Pratheepa *et al.* (2014) [11] reported severe incidence of *G. gemma* on soybean in the state of Maharashtra between 2009 and 2012. Bele *et al*. (2018) [5] revealed that incidence of *G. gemma* was statistically at par in soybean verities. Date of arrival of monsoon and sowing date of crop, not correlated with the incidence *G. gemma*. The larval incidence of *G. gemma* was less when population appearance late in the season.

Table 1: Population of *C. acuta*, and *G. gemma* on sole sunflower in relation to weather parameters during *kharif* 2017

Month	Standard meteoro-logical weeks	Rainfall (mm)	Number of rainy days	Temperature (ºC)		Relative Humidity (%)		Mean number of larvae per quadrat	
				Min	Max	Before noon	After noon	*C. acuta*	*G. gemma*
July	29	34.0	3	22.5	28.6	97	55	-	-
	30	3.0	1	22.0	30.0	95	56	1.8	-
Aug.	31	0.0	0	22.3	30.9	92	51	0.4	-
	32	4.0	1	22.8	29.7	94	54	1.0	0.6
	33	21.0	2	22.1	28.3	98	58	3.4	2.0
	34	184.0	4	21.5	27.9	100	74	5.4	1.0
Sept.	35	22.0	2	22.8	29.9	97	74	2.6	0.6
	36	4.0	1	22.0	30.9	98	61	6.0	-
	37	137.0	4	21.6	30.3	100	70	5.0	-
	38	20.0	2	21.9	28.6	100	74	3.2	-
	39	8.0	1	21.6	31.7	100	82	4.4	-
Oct.	40	0.0	0	22.6	31.5	90	74	1.6	-
	41	101.0	3	21.1	30.5	100	66	0.4	-

Table 2: Population of *C. acuta*, and *G. gemma* on sole sunflower intercropped with pigeonpea in relation to weather parameters during *kharif* 2017

Month	Standard meteoro-logical weeks	Rainfall (mm)	Number of rainy days	Temperature (ºC)		Relative Humidity (%)		Mean number of larvae per quadrat	
				Min	Max	Before noon	After noon	*C. acuta*	*G. gemma*
July	29	34.0	3	22.5	28.6	97	55	-	-
	30	3.0	1	22.0	30.0	95	56	2.2	-
Aug.	31	0.0	0	22.3	30.9	92	51	1.6	-
	32	4.0	1	22.8	29.7	94	54	0.8	0.6
	33	21.0	2	22.1	28.3	98	58	2.0	0.4
	34	184.0	4	21.5	27.9	100	74	3.0	1.0
Sept.	35	22.0	2	22.8	29.9	97	74	4.8	-
	36	4.0	1	22.0	30.9	98	61	5.0	-
	37	137.0	4	21.6	30.3	100	70	3.0	-
	38	20.0	2	21.9	28.6	100	74	4.8	-
	39	8.0	1	21.6	31.7	100	82	3.4	-
Oct.	40	0.0	0	22.6	31.5	90	74	2.2	-
	41	101.0	3	21.1	30.5	100	66	0.4	-

Correlation between incidence of semiloopers infesting sole sunflower and sunflower intercropped with pigeonpea with weather parameters

***Chrysodeixis acuta* (Walker) on sole sunflower**

The results in respect of simple correlation between larval population of *C. acuta* infesting sole sunflower and weather parameters during *kharif* 2017 are tabulated in Table 3. The data presented on correlation coefficient indicated that rainfall (1.4605*), maximum temperature (0.7353*) and beforenoon relative humidity (1.5163*) exhibited significantly direct positive effect on larval population of *C. acuta* infesting sole sunflower, whereas number of rainy days (-1.7360*) showed negative correlation with larval population.

***Chrysodeixis acuta* (Walker) on sunflower intercropped with pigeonpea**

The results in respect of simple correlation between larval population of *C. acuta* infesting sunflower intercropped with pigeonpea and weather parameters during *kharif* 2017 are tabulated in Table 4. The data presented on correlation coefficient indicated that rainfall (0.7861*) and maximum temperature (1.1028*) and beforenoon relative humidity (1.2871*) exhibited significantly direct positive effect on larval population of *C. acuta* infesting sunflower intercropped with pigeonpea, whereas number of rainy days (-1.1283*) showed negative correlation with larval population. The similar trend in results was obtained by Brahman *et al.* (2018) [8] who noticed that *C. acuta* population exhibited a significant positive correlation with evening and average relative humidity. While, the other variables were not found significantly correlated with larval population. Bele *et al*. (2018) [5] found that larval population of *C. acuta* was positively correlated with relative humidity.

Table 3: Simple regression coefficients, path analysis showing direct and indirect effects of weather parameters on larval population of *C. acuta* infesting sole sunflower during *kharif* 2017

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (ºC)	Minimum temperature (ºC)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	1.4605*	1.2693	-0.9096	-0.5630	0.8243	0.4497
Number of rainy days	-1.5087	-1.7360*	0.8735	1.0265	-1.2880	-0.3938
Maximum temperature (ºC)	-0.4580	-0.3700	0.7353*	-0.0006	-0.5186	-0.2494
Minimum temperature (ºC)	-0.0092	-0.0142	-0.0000	0.0240	-0.0087	0.0041
Before noon relative humidity (%)	0.8558	1.1250	-1.0695	-0.5480	1.5163*	0.6426
Afternoon relative humidity (%)	0.0164	0.0121	-0.0180	0.0091	0.0226	0.0532

Correlation coefficient (r)	0.357	0.286	-0.388	-0.052	0.548	0.507
Simple regression coefficient (bi)	4.9635	-2.6327	2.8459	3.9589	9.2523	1.0849

***** = Significant at 5 %. Diagonal elements are direct effects while off-diagonal elements are indirect effects

Table 4: Simple regression coefficients, path analysis showing direct and indirect effects of weather parameters on larval population of *C. acuta* infesting sunflower intercropped with pigeonpea during *kharif* 2017

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (ºC)	Minimum temperature (ºC)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	0.7861*	0.6832	-0.4896	-0.3031	0.4437	0.2421
Number of rainy days	-0.9806	-1.1283*	0.5677	0.6672	-0.8371	-0.2560
Maximum temperature (ºC)	-0.6869	-0.5549	1.1028*	-0.0009	-0.7778	-0.3740
Minimum temperature (ºC)	-0.0394	-0.0604	-0.0000	0.1021	-0.0369	0.0175
Before noon relative humidity (%)	0.7264	0.9549	-0.9078	-0.4651	1.2871*	0.5455
Afternoon relative humidity (%)	0.1082	0.0797	-0.1191	0.0601	0.1489	0.3513
Correlation coefficient (r)	-0.086	-0.026	0.154	0.060	0.228	0.526
Simple regression coefficient (bi)	2.9566	-1.8926	4.7207	1.8636	8.6860	7.9193

***** = Significant at 5 %. Diagonal elements are direct effects while off-diagonal elements are indirect effects

Gesonia gemma (Swinhoe) on sole sunflower

The results in respect of simple correlation between larval population of *G. gemma* infesting sole sunflower and weather parameters during *kharif* 2017 are tabulated in Table 5. The data presented on correlation coefficient indicated that rainfall (0.8331*) and beforenoon relative humidity (0.5886*) exhibited significantly direct positive effect on larval population of *G. gemma* infesting sole sunflower, whereas number of rainy days (-1.1424*) and minimum temperature (-0.7269*) showed negative correlation with larval population.

Gesonia gemma (Swinhoe) on sunflower intercropped with pigeonpea

The results in respect of simple correlation between larval population of *G. gemma* infesting sunflower intercropped with pigeonpea and weather parameters during *kharif* 2017 are tabulated in Table 6. The data presented on correlation coefficient indicated that rainfall (0.7896*) exhibited significantly direct positive effect on larval population of *G. gemma* infesting sunflower intercropped with pigeonpea, whereas number of rainy days (-0.7946*) and minimum temperature (-0.7493*) showed negative correlation with larval population. The analogous results were obtained by Bele *et al*. (2018) [5] who evidenced that larval population of *G. gemma* was negatively correlated with minimum temperature. According to Antony and Pratheepa (2017) [4] the grey semi-looper, *G. gemma* was emerged as a serious threat to the soybean crop and reported that maximum temperature and humidity with less number of rainy days influenced the population of *G. gemma* in Maharashtra.

Table 5: Simple regression coefficients, path analysis showing direct and indirect effects of weather parameters on larval population of *G. gemma* infesting sole sunflower during *kharif* 2017

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (ºC)	Minimum temperature (ºC)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	0.8331*	0.7240	-0.5198	-0.3212	0.4702	0.2565
Number of rainy days	-0.9928	-1.1424*	0.5748	0.6755	-0.8476	-0.2592
Maximum temperature (ºC)	-0.2726	-0.2202	0.4376	-0.0003	-0.3087	-0.1484
Minimum temperature (ºC)	0.2802	0.4298	0.0006	-0.7269*	0.2627	-0.1244
Before noon relative humidity (%)	0.3322	0.4367	-0.4151	-0.2127	0.5886*	0.2494
Afternoon relative humidity (%)	-0.0239	-0.0176	0.0263	-0.0133	-0.0329	-0.0775
Correlation coefficient (r)	0.156	0.210	0.105	0.599	0.132	0.104
Simple regression coefficient (bi)	8.3775	-5.1235	5.0088	-3.5485	1.0620	-4.6734

***** = Significant at 5 %. Diagonal elements are direct effects while off-diagonal elements are indirect effects

Table 6: Simple regression coefficients, path analysis showing direct and indirect effects of weather parameters on larval population of *G. gemma* infesting sunflower intercropped with pigeonpea during *kharif* 2017

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (ºC)	Minimum temperature (ºC)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	0.7896*	0.6862	-0.4918	-0.3044	0.4456	0.2431
Number of rainy days	-0.6906	-0.7946*	0.3998	0.4699	-0.5896	-0.1803
Maximum temperature (ºC)	0.2128	0.1719	-0.3416	0.0003	0.2410	0.1159
Minimum temperature (ºC)	0.2889	0.4431	0.0006	-0.7493*	0.2708	-0.1282
Before noon relative humidity (%)	-0.0706	-0.0928	0.0882	0.0452	-0.1250	-0.0530
Afternoon relative humidity (%)	0.0928	0.0683	-0.1021	0.0515	0.1277	0.3012
Correlation coefficient (r)	0.623	0.482	0.447	0.487	0.370	0.299
Simple regression coefficient (bi)	4.6098	-2.0691	-2.2702	-2.1237	-1.3098	1.0542

***** = Significant at 5 %. Diagonal elements are direct effects while off-diagonal elements are indirect effect

Conclusion

Thus it can be concluded that *C. acuta* and *G. gemma* were emerged as major semiloopers on sole sunflower and sunflower intercropped with pigeonpea. The population of *C. acuta* was more in sunflower intercropped with pigeonpea however, the population of *G. gemma* was significantly reduced when sunflower intercropped with pigeonpea. This might be resulted due to dilution of host plants, presence of physical barrier, habitat and chemical effects produced in intercropping system compared to sole cropping.

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