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Impact of abiotic factors on population dynamics of *Thysanoplusia orichalcea* (Fabricius) and *Mocis undata* (Fabricius) infesting sole sunflower and sunflower intercropped with pigeonpea

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Abstract
The investigations conducted at Research Farm of Department of Agricultural Entomology, College of Agriculture, Latur (VNKMV, Parbhani) during *kharif*-2017 revealed that *Thysanoplusia orichalcea* (Fabricius) and *Mocis undata* (Fabricius) were major semilooper pests observed on sunflower and sunflower intercropped with pigeonpea. The peak population of *T. orichalcea* was exhibited on sole sunflower and sunflower intercropped with pigeonpea during 35th (3.2 larvae per quadrat) and 34th SMW (2.6 larvae per quadrat), respectively. The larval population *T. orichalcea* infesting sole sunflower indicated a positive correlation with rainfall, maximum temperature and beforenoon relative humidity, whereas number of rainy days showed negative correlation with larval population. *T. orichalcea* larval population infesting sunflower intercropped with pigeonpea demonstrated a positive correlation with rainfall and afternoon relative humidity while, negative correlation with number of rainy days. The population of *M. undata* reached to its peak on sole sunflower and sunflower intercropped with pigeonpea during 33th (1.6 larvae per quadrat) and 31st SMW (1.0 larva per quadrat), respectively. The larval population of *M. undata* infesting sole sunflower indicated a positive correlation with rainfall and beforenoon relative humidity, whereas number of rainy days, minimum temperature and afternoon relative humidity showed negative correlation with larval population. The larval population of *M. undata* infesting sunflower intercropped with pigeonpea evidenced a positive correlation with rainy days and minimum temperature while, negative correlation with rainfall, beforenoon and afternoon relative humidity.

Keywords: *Thysanoplusia orichalcea*, *Mocis undata*, population dynamics, abiotic factors

Introduction
Sunflower, *Helianthus annus* Linnaeus (Family Compositae or Asteraceae) is photo-insensitive crop, grown across the globe primarily for its seeds, oil and meal. It is not only cultivated as an ornamental plant but also fulfills the demand of feed and fuel. The sunflower oil is high in unsaturated fatty acids, vitamin E and plant sterols and; low in saturated fatty acids (Bonos *et al*., 2011) [5]. Sunflower is well known for its phytoremediation potential as efficiently remove pollutants from soil and water (Luqueno *et al*., 2014) [13]. Worldwide, sunflower is cultivated over an area of more than 26.20 million hectares in about 70 countries with 47.34 million tonnes of production and 1806.7 kg per ha of productivity during 2016 (FAOSTAT, 2018) [6]. In India, sunflower is cultivated on an area of 0.40 million hectares with 0.33 million tonnes of production and 830 kg per hectare of productivity during 2016 (FAOSTAT, 2018) [6]. 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) [1].

Sunflower is referred as high-risk crop because of potential losses from insects, diseases, weeds and birds (Knodel *et al*., 2015) [12]. In India sunflower is damaged by more than fifty insect-pests. Among them, defoliating semiloopers play significant role in vegetative stage of crop. *Thysanoplusia orichalcea* (Fabricius) and *Mocis undata* (Fabricius) are reported as regular and key pests of sunflower in Marathwada region of Maharashtra state. The loss in seed yield due to defoliators was estimated to the tune of 58.06 per cent per ha in a rain fed *Kharif* sunflower (Suhas *et al*., 1996) [17].

Intercropping improves diversity in an agricultural ecosystem and reduces the incidence of various insect-pests (Bhamare *et al*., 2018) [3]. All combinations of crops will not suppress insect-pests hence determination of right intercrop combination is essential. The successful use of intercropping to manage insect-pests depends on a thorough knowledge of how distinct crop characteristics and combinations will influence the behaviour of insect-pest (Seni, 2018) [16]. Moreover, scanty information is available on the population dynamics of insect-pests when sunflower is intercropped with pigeonpea. With this background, an attempt was made to study the impact of abiotic factors on population dynamics of *Thysanoplusia orichalcea* (Fabricius) and *Mocis undata* (Fabricius) infesting sole sunflower and sunflower intercropped with pigeonpea.

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 *T. orichalcea* and *M. undata* and its relation with abiotic factors 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 major insect-pests 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 18.0 ºC to 22.3 ºC, 28.1 ºC to 33.5 ºC, 42 to 88 per cent, 41 to 67 per cent, 0 to 104.0 mm and 0 to 4 days, respectively. The data pertaining to the population of *T. orichalcea* and *M. undata* infesting sole sunflower and sunflower intercropped with pigeonpea in relation to weather parameters during *kharif* season 2017 are presented in Table 1-2

Thysanoplusia orichalcea (Fabricius) on sole sunflower

The first incidence of *T. orichalcea* on sole sunflower was recorded in 34th SMW (1.0 larva per quadrat) with its peak population level (3.2 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.

Thysanoplusia orichalcea (Fabricius) on sunflower intercropped with pigeonpea

The first incidence of *T. orichalcea* on sunflower intercropped with pigeonpea was recorded in 33th SMW (0.8 larva per quadrat) with its peak population level (2.6 larvae 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 accordance with the findings of (Basit *et al*., 2016) [2] who revealed that *T. orichalcea* was found in sunflower ecosystem but in small numbers. (Jat *et al*., 2017) [11] evidenced that *T. orichalcea* was recorded at its peak in the last week of January on cabbage (4th SMW).

Mocis undata (Fabricius) on sole sunflower

The first incidence of *M. undata* on sole sunflower was recorded in 31th SMW (0.6 larva per quadrat) with its peak population level (1.6 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).

Mocis undata (Fabricius) on sunflower intercropped with pigeonpea

The first incidence of *M. undata* on sunflower intercropped with pigeonpea was recorded in 31th SMW (1.0 larva per quadrat) with its peak population level (1.0 larva per quadrat) in 31th 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 0.0 mm, 0 days, 30.9 ºC, 22.3 ºC, 92 and 51 per cent, respectively (Table 2).

The results of present investigation are in agreement with the findings of (Pratheepa *et al*., 2014) [15] who reported severe incidence of *M. undata* on soybean in the state of Maharashtra between 2009 and 2012. Similarly (Gujrati 1971) [10], (Gangrade 1974) [7], (Gangrade 1976) [8] and (Bhattacharya and Rathore 1977) [4] reported incidence of *M. undata*.

Table 1: Population dynamics of *T. orichalcea* and *M. undata* 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	*T. orichalcea*	*M. undata*
July	30	3.0	1	22.0	30.0	95	56	-	-
Aug.	31	0.0	0	22.3	30.9	92	51	-	0.6
	32	4.0	1	22.8	29.7	94	54	-	0.8
	33	21.0	2	22.1	28.3	98	58	-	1.6
	34	184.0	4	21.5	27.9	100	74	1	0.8
Sept.	35	22.0	2	22.8	29.9	97	74	3.2	-
	36	4.0	1	22.0	30.9	98	61	2.4	-
	37	137.0	4	21.6	30.3	100	70	-	-
	38	20.0	2	21.9	28.6	100	74	-	-
	39	8.0	1	21.6	31.7	100	82	-	-
Oct.	40	0.0	0	22.6	31.5	90	74	-	-

Table 2: Population fluctuations of *T. orichalcea* and *M. undata* on 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	*T. orichalcea*	*M. undata*
July	30	3.0	1	22.0	30.0	95	56	-	-
Aug.	31	0.0	0	22.3	30.9	92	51	-	1
	32	4.0	1	22.8	29.7	94	54	-	0.2
	33	21.0	2	22.1	28.3	98	58	0.8	-
	34	184.0	4	21.5	27.9	100	74	2.6	-
Sept.	35	22.0	2	22.8	29.9	97	74	1.6	-
	36	4.0	1	22.0	30.9	98	61	0.6	-

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

***Thysanoplusia orichalcea* (Fabricius) on sole sunflower**

The results in respect of simple correlation between larval population of *T. orichalcea* infesting sole sunflower and weather parameters during *kharif* 2017 are tabulated in Table 3. The data on correlation coefficient indicated that rainfall (0.8526*), maximum temperature (1.3280*) and beforenoon relative humidity (1.3739*) exhibited significantly direct positive effect on larval population of *T. orichalcea* infesting sole sunflower, whereas number of rainy days (-0.7941*) showed negative correlation with larval population.

***Thysanoplusia orichalcea* (Fabricius) on sunflower intercropped with pigeonpea**

The results in respect of simple correlation between larval population of *T. orichalcea* infesting sunflower intercropped with pigeonpea and weather parameters during *kharif* 2017 are tabulated in Table 4. The data on correlation coefficient revealed that rainfall (0.7735*) and afternoon relative humidity (0.7787*) exhibited significantly direct positive effect on larval population of *T. orichalcea* infesting sunflower intercropped with pigeonpea, whereas number of rainy days (-0.9144*) showed negative correlation with larval population.

The trend of results found in present studies coincides with the studies of (Jat *et al*., 2017) [11] who evidenced that temperature, relative humidity, extent and distribution of rainfall influenced the infestation and stabilization of *T. orichalcea* population. (Patel and Thakur 2005) [14] observed that maximum and minimum temperature of 28.1 and 12 ºC were suitable for multiplication of *T. orichalcea.*

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

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (ºC)	Minimum temperature (ºC)	Beforenoon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	0.8526*	0.7810	-0.4845	-0.3831	0.4538	0.3379
Number of rainy days	-0.7275	-0.7941*	0.3885	0.4388	-0.5548	-0.4028
Maximum temperature (ºC)	-0.7546	-0.6496	1.3280*	0.0721	-0.9146	-0.6228
Minimum temperature (ºC)	-0.1952	-0.2401	0.0236	0.4344	-0.1116	-0.0084
Before noon relative humidity (%)	0.7313	0.9598	-0.9462	-0.3528	1.3739*	1.1400
Afternoon relative humidity (%)	-0.1154	-0.1474	0.1378	0.0056	-0.2416	-0.2912
Correlation coefficient (r)	-0.209	-0.090	0.447	0.215	0.005	0.148
Simple regression coefficient (bi)	1.5725	-7.2113	3.4338	4.2194	5.7130	-3.2731

* = 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 *T. orichalcea* 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)	0.7735*	0.7140	-0.5495	-0.3596	0.5036	0.5191
Number of rainy days	-0.8441	-0.9144*	0.6139	0.5937	-0.5995	-0.7552
Maximum temperature (ºC)	-0.0360	-0.0340	0.0506	0.0288	-0.0144	-0.0270
Minimum temperature (ºC)	0.2109	0.2945	-0.2577	-0.4536	-0.0303	0.2801
Before noon relative humidity (%)	0.2379	0.2391	-0.1039	0.0244	0.3654	0.1410
Afternoon relative humidity (%)	0.5225	0.6431	-0.4162	-0.4808	0.3004	0.7787*
Correlation coefficient (r)	0.865	0.942	-0.663	-0.647	0.526	0.937*
Simple regression coefficient (bi)	1.0656	-7.0973	4.0246	-2.8947	1.1053	8.5633

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

***Mocis undata* (Fabricius) on sole sunflower**

The results in respect of simple correlation between larval population of *M. undata* infesting sole sunflower and weather parameters during *kharif* 2017 are tabulated in Table 5.The data presented on correlation coefficient indicated that rainfall (1.0900*) and beforenoon relative humidity (0.8834*) exhibited significantly direct positive effect on larval population of *M. undata* infesting sole sunflower, whereas number of rainy days (-1.3130*), minimum temperature (-0.6033*) and afternoon relative humidity (-0.7423*) showed negative correlation with larval population.

***Mocis undata* (Fabricius) on sunflower intercropped with pigeonpea**

The results in respect of simple correlation between larval population of *M. undata* infesting sunflower intercropped with pigeonpea and weather parameters during *kharif* 2017 are tabulated in Table 6. The partitioning of correlation coefficient revealed that number of rainy days (4.7787*) and minimum temperature (1.3743*) exhibited significantly direct positive effect on larval population of *M. undata* infesting sunflower intercropped with pigeonpea, whereas afternoon rainfall (-1.8232*), beforenoon relative humidity (-2.0302*) and afternoon relative humidity (-1.2581*) showed negative correlation with larval population.

The present findings are in accordance with the results of (Pratheepa *et al.*, 2014) [15] who reported that among all the abiotic factors minimum temperature (25 to 25.5 ºC) played a major role on incidence of *M. undata*. (Gauns *et al*., 2014) [9] revealed that the semilooper population showed negative correlation with rainfall.

Table 5: Simple regression coefficients, path analysis showing direct and indirect effects of weather parameters on larval population of *M. undata* 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)	1.0900*	0.9985	-0.6194	-0.4898	0.5802	0.4321
Number of rainy days	-1.2028	-1.3130*	0.6423	0.7256	-0.9173	-0.6646
Maximum temperature (ºC)	-0.2387	-0.2054	0.4200	0.0228	-0.2892	-0.1987
Minimum temperature (ºC)	0.2711	0.3334	-0.0327	-0.6033*	0.1549	0.0117
Before noon relative humidity (%)	0.4702	0.6171	-0.6084	-0.2269	0.8834*	0.7330
Afternoon relative humidity (%)	-0.2942	-0.3757	0.3511	0.0144	-0.6159	-0.7423*
Correlation coefficient (r)	0.096	0.055	0.153	-0.557	-0.204	-0.429
Simple regression coefficient (bi)	9.3055	-5.5188	5.0263	-2.7124	1.7001	-3.8614

***** = 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 *M. undata* 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)	-1.8232*	-1.6831	1.2953	0.8476	-1.1869	-1.2235
Number of rainy days	4.4114	4.7787*	-3.2082	-3.1024	3.1276	3.9466
Maximum temperature (ºC)	-0.0547	-0.0517	0.0770	0.0438	-0.0219	-0.0412
Minimum temperature (ºC)	-0.6389	-0.8922	0.7809	1.3743*	0.0917	-0.8486
Before noon relative humidity (%)	-1.3217	-1.3287	0.5772	-0.1355	-2.0302*	-0.7832
Afternoon relative humidity (%)	-0.8443	-1.0390	0.6724	0.7769	-0.4854	-1.2581*
Correlation coefficient (r)	-0.271	-0.216	0.195	-0.195	-0.505	-0.208
Simple regression coefficient (bi)	-1.6774	2.4769	4.0890	5.8572	-4.1016	-9.2401

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

Conclusion

Thus it can be concluded that *T. orichalcea* and *M. undata* were emerged as major semiloopers pests on sole sunflower and sunflower intercropped with pigeonpea. The larval population of semiloopers was found to be significantly reduced when sunflower intercropped with pigeonpea in comparison with sole sunflower. This might be due to dilution of host plants, habitat and chemical effects produced in intercropping system compared to sole cropping.

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