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## Impact of abiotic factors on population dynamics of lepidopteran insect-pests infesting sole soybean and soybean intercropped with pigeonpea

**VK Bhamare, SV Phatak, AS Bade and SC Kumbhar**

### Abstract

The investigations conducted at Research Farm of Department of Agricultural Entomology, College of Agriculture, Latur (VNKMV, Parbhani) during *kharif*-2015 revealed that *Aproaerema modicella*, *Achaea janata* and *Spodoptera litura* were major Lepidopteran insect-pests observed on late season soybean and soybean intercropped with pigeonpea. *A. modicella* (21.4 larvae per quadrat), *A. janata* (6.8 larvae per quadrat) and *S. litura* (6.8 larvae per quadrat) reached its peak population during 37<sup>th</sup>, 40<sup>th</sup> and 39<sup>th</sup> standard meteorological week, respectively on sole soybean. The larval population of *A. modicella* infesting sole soybean exhibited a positive correlation with before noon relative humidity while, negative correlation with rainy days and minimum temperature. *A. janata* larval population infesting sole soybean indicated a positive correlation with maximum temperature while, negative correlation with rainfall, rainy days and minimum temperature. The larval population of *S. litura* infesting sole soybean had a positive correlation with rainy days while, negative correlation with afternoon relative humidity. However, on soybean intercropped with pigeonpea peak population of *A. modicella* (18 larvae per quadrat), *A. janata* (4.8 larvae per quadrat) and *S. litura* (5.8 larvae per quadrat) was recorded during 39<sup>th</sup>, 36<sup>th</sup> and 38<sup>th</sup> standard meteorological week, respectively. *A. modicella* larval population infesting soybean intercropped with pigeonpea demonstrated a positive correlation with before noon relative humidity and maximum temperature while, negative correlation with rainfall, rainy days and minimum temperature. The larval population of *A. janata* infesting soybean intercropped with pigeonpea indicated a positive correlation with before noon relative humidity however, all other weather parameters exhibited no impact on larval population of *A. janata*. The larval population of *S. litura* infesting soybean intercropped with pigeonpea had a positive correlation with rainy days while, negative correlation with rainfall and afternoon relative humidity.

**Keywords:** *Aproaerema modicella*, *Achaea janata*, *Spodoptera litura*, population dynamics, abiotic factors, soybean intercropped with pigeonpea

### Introduction

Soybean [*Glycine max* (L.) Merrill] belongs to family Leguminaceae is well-known as wonder crop of 21<sup>st</sup> century. It is most important seed legume of world which contributes 25 percent to the global vegetable oil production. Globally, soybean was cultivated on an area of 119.09 million ha with total production of 348.12 million MT and an average yield was 2.92 MT per ha during 2016-17 (USDA, 2018) [22]. India ranked 4<sup>th</sup> in terms of global soybean area sown and 5<sup>th</sup> in terms of soybean production after USA, Brazil, Argentina and China (FAOSTAT, 2018) [4]. Soybean occupied 42 percent of India's total oilseeds and 25 percent of edible oil production (Sharma *et al.* 2014) [17]. In India, the area under soybean crop was 11.18 million ha with 10.99 million MT of total production and 980 kg per ha of an average productivity during 2016-17 (USDA, 2018) [22]. In Maharashtra, the area under soybean cultivation was 34.48 lakh ha with 29.00 lakh tones of total production, thus Maharashtra ranked second in area and production next to Madhya Pradesh with an average productivity of 841 kg per ha (SOPA, 2018) [21].

In India soybean was reported to be attacked by 273 species of insects (Rawat and Kapoor, 1968) [16] of which, 20 insect-pest species have been recorded as major pests infesting soybean (Singh and Singh, 1990) [19]. The major insect-pests observed attacking soybean are leaf minor, *Aproaerema modicella* Deventer; girdle beetle, *Obereopsis brevis* Swedenborg; stem fly, *Melanagromyza sojae* Zehnter; green semilooper, *Thysanoplusia orichalcea* Fab., *Spilarctia obliqua* Walk, *Chrysodeixis acuta* Walker and *Achaea janata* Linn; tobacco caterpillar,

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*Spodoptera litura* Fabricius; gram pod borer, *Helicoverpa armigera* Hubner; pink pod borer, *Cydia ptychora* Meyrick; jassid, *Empoasca kerri* Pruthi; whitefly, *Bemisia tabaci* Gennadius and thrips.

The global climate change signifies increase in average temperature, change in the rainfall pattern and enormous climatic events. These seasonal and long term variations would influence the fauna, flora and population dynamics of insect-pests. The weather parameters are known to have direct impact on population dynamics of insect-pests through inflection of developmental rates, survival, fecundity, voltinism and dispersal (Karuppaiah and Sujayanad, 2012)<sup>[10]</sup>. Diversifying cropping systems by increasing the spatial and temporal heterogeneity of agricultural mosaics has been proposed as a practicable option to surmount the negative effects of modern agriculture (Burel *et al.* 2013)<sup>[2]</sup>. Intercropping may be a realistic application of ecological ideals based on biodiversity, biotic interactions and other natural regulation mechanisms permitting efficient insect-pest management with low reliance on off-farm inputs (Shennan, 2008)<sup>[18]</sup>; (Malezieux *et al.* 2009)<sup>[12]</sup>. Some intercrops offer advantages in terms of reducing incidence of insect-pests and diseases and often produces higher and more stable yields than their sole crop components (Vandermeer, 1989)<sup>[23]</sup>. In Marathwada region of Maharashtra soybean is commonly intercropped with pigeonpea. The great variability of responses to insect-pests in this intercrop system is therefore needs to be understood.

Keeping in view the above facts, the present investigation was framed to study the impact of abiotic factors on population dynamics of Lepidopteran insect-pests infesting sole soybean and soybean intercropped with pigeonpea.

### Materials and Methods

The non-replicated field experiment on population dynamics of insect-pests infesting sole soybean and soybean intercropped with pigeonpea was conducted at the Research Farm of Department of Entomology, College of Agriculture, Latur (MS) during *kharif* 2015. The soybean variety MAUS-81 was sown at the spacing of 45 x 5 cm in 120 quadrats. Out of these, 60 quadrats were intercropped with pigeonpea variety, BSMR-853 with spacing of 45 x 20 cm. The field experiment was conducted under pesticide free conditions. Weekly observations on population counts on larval stage of insects were taken from last week of August to second week of November when crop turned yellow. Five quadrates of crop were observed twice in each meteorological week for observations on insect-pests infesting sole soybean and soybean intercropped with pigeonpea. For this purpose the population thus counted was pooled together and average population per plant 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 population of *Aproaerema modicella*, *Achaea janata*, *Spodoptera litura* and weather parameters were worked out by simple correlation.

### Results and Discussion

#### Population dynamics of Lepidopteran insect-pests infesting sole soybean and soybean intercropped with pigeonpea

The population dynamics of major insect-pests infesting sole soybean and soybean intercropped with pigeonpea was

studied during *kharif* season 2015. During the course of investigation the weather parameters *viz.*, minimum temperature, maximum temperature, before noon relative humidity, afternoon relative humidity, rainfall and number of rainy days were varied from 18.0 °C to 22.3 °C, 28.1 °C to 33.5 °C, 42 to 88 percent, 41 to 67 percent, 0 to 104.0 mm and 0 to 4 days, respectively. The data pertaining to the major insect-pests population infesting sole soybean and soybean intercropped with pigeonpea in relation to weather parameters during *kharif* season 2015 are presented in Table 1-2 and depicted graphically in Fig. 1-2.

#### *Aproaerema modicella* (Deventer) on sole soybean

The first incidence of *A. modicella* on sole soybean was recorded in 35<sup>th</sup> standard meteorological week (2.8 larvae per quadrat) with its peak population level (21.4 larvae per quadrat) in 37<sup>th</sup> standard meteorological week. At maximum level of population of *A. modicella* the prevailing weather factors *viz.*, rainfall, number of rainy days, maximum temperature, minimum temperature, before noon relative humidity and afternoon relative humidity were 104 mm, 4 day, 28.1 °C, 21.1 °C, 88 percent and 67 percent, respectively (Table 1).

#### *Aproaerema modicella* (Deventer) on soybean intercropped with pigeonpea

The first incidence of *A. modicella* on soybean intercropped with pigeonpea was recorded in 35<sup>th</sup> standard meteorological week (3.4 larvae per quadrat) with its peak population level (18 larvae per quadrat) in 39<sup>th</sup> standard meteorological week. At maximum level of population of *A. modicella* the prevailing weather factors *viz.*, rainfall, number of rainy days, maximum temperature, minimum temperature, before noon relative humidity and afternoon relative humidity were 0.0 mm, 0 day, 30.7 °C, 21.5 °C, 67 percent, 55 percent, respectively (Table 2).

These results fall in the line of observations made by Ghadage *et al.* (2015)<sup>[9]</sup> who revealed that the larval population of leaf miner on soybean commenced from last week of July (1.30 larvae per plant) and attained its peak (8.56 larvae per plant) during first week of September. Chattopadhyay *et al.* (2002)<sup>[3]</sup> revealed that July to September was peak period for the incidence of soybean leaf miner. Dry weather condition along with lower relative humidity (morning < 80 percent and increase in maximum temperature (32 °C for Parbhani) under clear sky condition were found to be favorable for the multiplication of the pest.

#### *Achaea janata* (Linnaeus) on sole soybean

The first incidence of *A. janata* on sole soybean was recorded in 35<sup>th</sup> meteorological week (0.4 larvae per quadrat) with its peak population level (6.8 larvae per quadrat) in 40<sup>th</sup> meteorological week. At maximum level of pest population the prevailing weather factors *viz.*, rainfall, number of rainy days, maximum temperature, minimum temperature, before noon relative humidity and afternoon relative humidity were 15 mm, 3 days, 31.2 °C, 19.5 °C, 64 and 55 percent, respectively (Table 1).

#### *Achaea janata* (Linnaeus) on soybean intercropped with pigeonpea

The first incidence of *A. janata* on soybean intercropped with pigeonpea was recorded in 35<sup>th</sup> meteorological week (1.4 larvae per quadrat) with its peak population level (4.8 larvae

per quadrat) in 36<sup>th</sup> meteorological week. At maximum level of pest population the prevailing weather factors viz., rainfall, number of rainy days, maximum temperature, minimum temperature, before noon relative humidity and afternoon relative humidity were 46 mm, 2 days, 31.7 °C, 21.5 °C, 71 and 50 percent respectively (Table 2).

These results are more or less similar with the findings of Gaur (2014) [8] who noticed incidence of larval population of *A. janata* on castor in 32<sup>nd</sup> SW. The mean level of population was 0.4 and 0.5 larva per plant during first and second year, respectively. The maximum population of *A. janata* was recorded in 37<sup>th</sup> SW when temperature ranged between 22.5-36.8 °C during 2012 (4.6 larvae per plant) and between 25.0-33.6 °C during 2013 (6.0 larvae per plant). According to Yadav *et al.* (2014) [24] green semilooper was first recorded in 33<sup>rd</sup> SMW in August with its peak activity (2.30 larvae per mrl) during 35<sup>th</sup> SMW.

***Spodoptera litura* (Fabricius) on sole soybean crop**

The first incidence of *S. litura* on sole soybean was observed to be 0.8 larva per quadrat in 35<sup>th</sup> standard meteorological week. The highest larval population to the extent of 6.8 larvae per quadrat was recorded on sole soybean in 39<sup>th</sup> standard meteorological week. At maximum level of pest population the prevailing weather factors viz., rainfall, number of rainy days, maximum temperature, minimum temperature, before noon relative humidity and afternoon relative humidity were 0

mm, 0 days, 30.7 °C, 21.5 °C, 67 and 55 percent, respectively (Table 1).

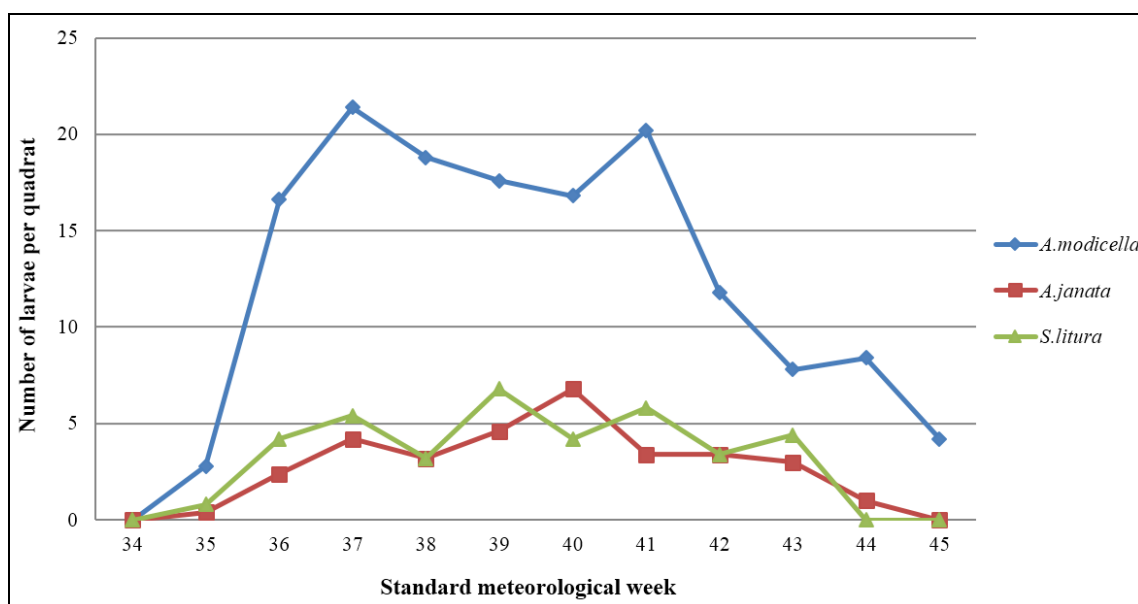
***Spodoptera litura* (Fabricius) on soybean intercropped with pigeonpea**

The first incidence of *S. litura* on soybean intercropped with pigeonpea was observed to be 1.4 larvae per quadrat in 35<sup>th</sup> standard meteorological week. The highest larval population to the extent of 5.8 larvae per quadrat was recorded on in 38<sup>th</sup> standard meteorological week. At maximum level of pest population the prevailing weather factors viz., rainfall, number of rainy days, maximum temperature, minimum temperature, before noon relative humidity and afternoon relative humidity were 26 mm, 2 days, 29.6 °C, 21.6 °C, 73 and 65 percent, respectively (Table 2).

The results are in close agreement with the findings of Ahirwar *et al.* (2014) [1] who observed that first incidence of larval population of *S. litura* on soybean was recorded in 31<sup>st</sup> SW (1.24 larvae per mrl) with its peak during the 37<sup>th</sup> SW (9.38 larvae per mrl). Raghuvanshi *et al.* (2014) [14] noticed first incidence of tobacco caterpillar larvae on soybean at 42 DAS, in the third week of August, (0.10 larva per plant) with its peak population at 56 DAS (0.30 larva per plant). Gaur *et al.* (2015) [7] revealed that the population of *S. litura* on soybean was nil up to 35 DAS (32 SMW) while, peak population was recorded at 42 DAS (33 SMW).

**Table 1:** Population dynamics of *A. modicella*, *A. janata* and *S. litura* on sole soybean in relation to weather parameters during kharif 2015

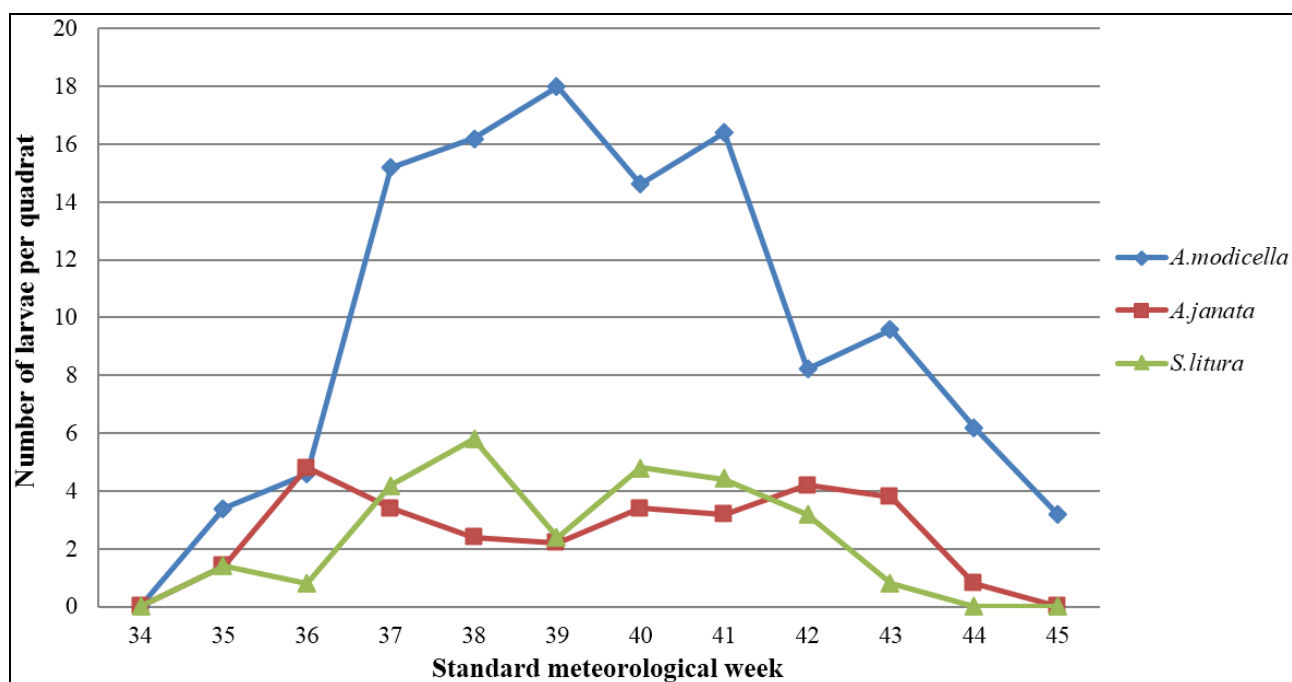
Month	Standard meteorological weeks	Rainfall (mm)	Number of rainy days	Temperature		Relative Humidity (%)		Mean number of larvae per quadrat		
				Min	Max	Before noon	After noon	<i>A. modicella</i>	<i>A. janata</i>	<i>S. litura</i>
Aug	34	24.5	2	29.4	21.3	69	62	-	-	-
Sept	35	14.0	1	30.8	22.3	72	52	2.8	0.4	0.8
	36	46.0	2	31.7	21.5	71	50	16.6	2.4	4.2
	37	104.0	4	28.1	21.1	88	67	21.4	4.2	5.4
	38	26.0	2	29.6	21.6	73	65	19.8	3.2	3.2
	39	0.0	0	30.7	21.5	67	55	17.6	4.6	6.8
Oct	40	15.0	3	31.2	19.5	64	55	16.8	6.8	4.2
	41	17.0	1	31.8	18.3	65	46	20.2	3.4	5.8
	42	0.0	0	32.8	18.0	60	48	11.8	3.4	3.4
	43	0.0	0	33.5	18.6	60	41	7.8	3	4.4
Nov	44	0.0	0	31.9	18.9	52	52	8.4	1	-
	45	0.0	0	32.0	18.2	42	56	3.8	-	-



**Fig 1:** Population dynamics of *A. modicella*, *A. janata* and *S. litura* on sole soybean in relation to weather parameters ~ 432 ~

**Table 2:** Population fluctuations of *A. modicella*, *A. janata* and *S. litura* on soybean intercropped with pigeonpea in relation to weather parameters during *kharif* 2015

Month	Standard meteorological weeks	Rainfall (mm)	Number of rainy days	Temperature		Relative Humidity (%)		Mean number of larvae per quadrat		
				Min	Max	Before noon	After noon	<i>A. modicella</i>	<i>A. janata</i>	<i>S. litura</i>
Aug	34	24.5	2	29.4	21.3	69	62	-	-	-
Sept	35	14.0	1	30.8	22.3	72	52	3.4	1.4	1.4
	36	46.0	2	31.7	21.5	71	50	4.6	4.8	0.8
	37	104.0	4	28.1	21.1	88	67	15.2	3.4	4.2
	38	26.0	2	29.6	21.6	73	65	16.2	2.4	5.8
	39	0.0	0	30.7	21.5	67	55	18	2.2	2.4
Oct	40	15.0	3	31.2	19.5	64	55	14.6	3.4	4.8
	41	17.0	1	31.8	18.3	65	46	16.4	3.2	4.4
	42	0.0	0	32.8	18.0	60	48	8.2	4.2	3.2
	43	0.0	0	33.5	18.6	60	41	9.6	3.8	0.8
Nov	44	0.0	0	31.9	18.9	52	52	6.2	0.8	-
	45	0.0	0	32.0	18.2	42	56	3.2	-	-



**Fig 2:** Population dynamics of *A. modicella*, *A. janata* and *S. litura* on soybean intercropped with pigeonpea in relation to weather parameters

**Correlation between incidence of Lepidopteran insect-pests of sole soybean and soybean intercropped with pigeonpea with weather parameters and weather parameters**

***Aproaerema modicella* (Deventer) on sole soybean**

The results in respect of simple correlations between larval population of *A. modicella* infesting sole soybean and weather parameters during *kharif* season 2015 are presented in Table 3. The data on correlation coefficient revealed that rainy days (-1.0295\*) and minimum temperature (-0.6177\*) showed significantly direct negative effect on larval population of *A. modicella* infesting sole soybean, whereas before noon relative humidity (0.6668\*) showed significantly direct positive effect.

***Aproaerema modicella* (Deventer) on soybean intercropped with pigeonpea**

The results in respect of simple correlations between larval population of *A. modicella* infesting soybean intercropped with pigeonpea and weather parameters during *kharif* season

2015 are presented in Table 4. The data on correlation coefficient revealed that rainfall (-0.7156\*), rainy days (-1.1945\*) and minimum temperature (-1.4398\*) showed significantly negative effect on larval population of *A. modicella* infesting soybean intercropped with pigeonpea, whereas before noon relative humidity (0.5450\*) and maximum temperature (0.7319\*) showed significantly direct positive effect.

The trend of results found in present studies coincides with the studies of Mukesh Kumar *et al.* (2008) [13] who revealed that leaf miner was negatively correlated with minimum temperature however, exhibited positive correlation with maximum temp., R.H. and rainfall. According to Gadad *et al.* (2013) [5] leaf miner incidence on groundnut indicated a negative and significant relationship with morning relative humidity. However, minimum temperature (r = -0.535), morning relative humidity (r=-0.820) and evening relative humidity (r=-0.755) showed significant and negative relationship with leaf miner incidence.

**Table 3:** Simple regression coefficients, path analysis showing direct and indirect effects of weather parameters on larval population of *A. modicella* infesting sole soybean during *kharif* 2015

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (°C)	Minimum temperature (°C)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	-0.0261	-0.0220	0.0189	-0.0116	-0.0207	-0.0152
Number of rainy days	-0.8685	-1.0295*	0.7669	-0.4822	-0.7715	-0.6603
Maximum temperature (°C)	-0.1565	-0.1609	0.2160	-0.1506	-0.1567	-0.1982
Minimum temperature (°C)	-0.2741	-0.2893	0.4307	-0.6177*	-0.4377	-0.3383
Before noon relative humidity (%)	0.5259	0.4997	-0.4837	0.4722	0.6668*	0.3134
Afternoon relative humidity (%)	0.2547	0.2799	-0.4004	0.2390	0.2051	0.4364
Correlation coefficient (r)	0.4557	0.4256	-0.2348	0.0576	0.4733	0.1490
Simple regression coefficient (bi)	49.4800	49.5600	23.8300	34.6800	-38.2100	22.4800

\* = 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 *A. modicella* infesting soybean intercropped with pigeonpea during *kharif* 2015

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (°C)	Minimum temperature (°C)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	-0.7156*	-0.6037	0.5184	-0.3176	-0.5678	-0.4177
Number of rainy days	-1.0077	-1.1945*	0.8898	-0.5594	-0.8951	-0.7661
Maximum temperature (°C)	-0.5302	-0.5452	0.7319*	-0.5104	-0.5310	-0.6716
Minimum temperature (°C)	-0.6390	-0.6743	1.0039	-1.4398*	-1.0196	-0.7885
Before noon relative humidity (%)	0.4324	0.4084	-0.3953	0.3859	0.5450*	0.2561
Afternoon relative humidity (%)	-0.1288	-0.1415	0.2024	-0.1208	-0.1037	-0.2206
Correlation coefficient (r)	0.1874	0.2313	-0.1970	-0.0085	0.3563	0.1181
Simple regression coefficient (bi)	44.1600	41.5300	17.4000	51.4700	-14.9700	22.3400

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

#### *Achaea janata* (Linnaeus) on sole soybean

The results in respect of simple correlations between larval population of *A. janata* infesting sole soybean and weather parameters during *kharif* season 2015 are presented in Table 5. The partitioning of correlation coefficient revealed that maximum temperature (0.6191\*) showed direct positive effect on larval population of *A. janata* infesting sole soybean whereas rainfall (-0.8792\*), rainy days (-1.3583\*) and minimum temperature (-1.1609\*) showed negative effect.

#### *Achaea janata* (Linnaeus) on soybean intercropped with pigeonpea

The data in respect of simple correlations between larval population of *A. janata* infesting soybean intercropped with pigeonpea and abiotic factors during *kharif* 2015 are presented in Table 6. The partitioning of correlation

coefficient revealed that before noon relative humidity (0.9252\*) showed direct positive effect on larval population of *A. janata* infesting soybean intercropped with pigeonpea. However, all other weather parameters exhibited no correlation with *A. janata* larval population.

The present findings are in accordance with the results of Madhuri *et al.* (2006) [11] who revealed that semilooper population of *A. janata* was negatively and significantly correlated with minimum temperature however, positively and significantly correlated with morning relative humidity. Gaur (2014) [8] noticed that castor semilooper exhibited significant and positive correlation with maximum temperature (0.750 and 0.651) and minimum temperature (0.480 and 0.553) while for morning RH (-0.552 and -0.696) the correlation was negative.

**Table 5:** Simple regression coefficients, path analysis showing direct and indirect effects of weather parameters on larval population of *A. janata* infesting sole soybean during *kharif* 2015

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (°C)	Minimum temperature (°C)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	-0.8792*	-0.7418	0.6369	-0.3902	-0.6976	-0.5132
Number of rainy days	-1.1460	-1.3583*	1.0118	-0.6362	-1.0180	-0.8712
Maximum temperature (°C)	-0.4485	-0.4612	0.6191*	-0.4317	-0.4491	-0.5680
Minimum temperature (°C)	-0.5152	-0.5437	0.8095	-1.1609*	-0.8221	-0.6358
Before noon relative humidity (%)	0.3129	0.2955	-0.2861	0.2793	0.3944	0.1854
Afternoon relative humidity (%)	0.2149	0.2361	-0.3378	0.2076	0.1730	0.3681
Correlation coefficient (r)	0.1917	0.3799	-0.0549	-0.0621	0.3408	-0.0029
Simple regression coefficient (bi)	12.1400	98.8900	25.1100	21.4600	-65.0900	13.7100

\* = 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 *A. janata* infesting soybean intercropped with pigeonpea during *kharif* 2015

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (°C)	Minimum temperature (°C)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	0.1124	0.0948	-0.0814	0.0499	0.0892	0.0656
Number of rainy days	-0.2892	-0.3428	0.2554	-0.1606	-0.2569	-0.2199
Maximum temperature (°C)	-0.0472	-0.0485	0.0651	-0.0454	-0.0472	-0.0598
Minimum temperature (°C)	-0.0245	-0.0258	0.0384	-0.0551	0.0390	-0.0302
Before noon relative humidity (%)	0.7341	0.6934	-0.6712	0.6552	0.9252*	0.4349
Afternoon relative humidity (%)	0.1533	0.1685	-0.2410	0.1439	0.1235	0.2627
Correlation coefficient (r)	0.2893	0.2407	0.2419	-0.0841	0.3890	-0.3660
Simple regression coefficient (bi)	10.7300	10.5400	-27.7100	20.7600	-55.3300	33.0700

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

### *Spodoptera litura* (Fabricius) on sole soybean

The results in respect of simple correlation between larval population of *S. litura* infesting sole soybean and weather parameters during *kharif* 2015 are tabulated in Table 7. The data presented on correlation coefficient indicated that rainy days (0.7697\*) exhibited significantly direct positive effect on larval population of *S. litura* infesting sole soybean, whereas afternoon relative humidity (-0.9292\*) showed negative correlation with larval population.

### *Spodoptera litura* (Fabricius) on soybean intercropped with pigeonpea

The results in respect of simple correlation between larval population of *S. litura* infesting soybean intercropped with pigeonpea and weather parameters during *kharif* 2015 are tabulated in Table 8. The data presented on correlation coefficient revealed that rainfall (-1.0466\*) and afternoon relative humidity (-1.1275\*) exhibited significantly negative correlation with larval population of *S. litura* infesting

soybean intercropped with pigeonpea, whereas number of rainy days (0.8397\*) noticed positive correlation with larval population of *S. litura*.

These results are in accordance with the findings of Gadhiya *et al.* (2014)<sup>[6]</sup> who observed that larval population of *S. litura* showed significant positive correlation with maximum, minimum and mean temperature, morning, evening and mean vapour pressure deficit and evaporation. However, significantly negative association with morning, evening and mean relative humidity. Singh *et al.* (2014)<sup>[20]</sup> observed that minimum temperature had negative correlation with number of *S. litura* moths trapped during first year and positive significant correlation during second year. The maximum temperature had highly significant positive correlation and relative humidity had highly significant negative correlation. Ramesh Babu *et al.* (2015)<sup>[15]</sup> confirmed that the fluctuations in the male moth catches of *S. litura* per pheromone trap in soybean were mainly due to maximum temperature, rainfall, sunshine and wind speed.

**Table 7:** Simple regression coefficients, path analysis showing direct and indirect effect of weather parameters on larval population of *S. litura* infesting sole soybean during *kharif* 2015

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (°C)	Minimum temperature (°C)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	-0.1819	-0.1535	0.1318	-0.0807	-0.1443	-0.1062
Number of rainy days	0.6493	0.7697*	-0.5734	0.3605	0.5768	0.4937
Maximum temperature (°C)	0.2692	0.2769	-0.3717	0.2592	0.2696	0.3410
Minimum temperature (°C)	0.1046	0.1103	-0.1643	0.2356	0.1668	0.1290
Before noon relative humidity (%)	0.0756	0.0714	-0.0691	0.0675	0.0953	0.0448
Afternoon relative humidity (%)	-0.5423	-0.5960	0.8526	-0.5089	-0.4367	-0.9292*
Correlation coefficient (r)	0.2836	0.2172	0.0390	0.0449	0.4631	-0.1422
Simple regression coefficient (bi)	13.5600	13.4900	25.5900	91.6900	-15.9900	28.0000

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

**Table 8:** Simple regression coefficients, path analysis showing direct and indirect effects of weather parameters on larval population of *S. litura* infesting soybean intercropped with pigeonpea during *kharif* 2015

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (°C)	Minimum temperature (°C)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	-1.0466*	-0.8829	0.7581-	0.4645	-0.8304	-0.6108
Number of rainy days	0.7084	0.8397*	-0.6255	0.3933	0.6293	0.5386
Maximum temperature (°C)	0.2758	0.2836	-0.3807	0.2655	0.2762	0.3493
Minimum temperature (°C)	0.0548	0.0578	-0.0861	0.1234	0.0874	0.0676
Before noon relative humidity (%)	0.0987	0.0932	-0.0902	0.0881	0.1243	0.0584
Afternoon relative humidity (%)	-0.6581	-0.7232	1.0345	-0.6175	-0.5300	-1.1275*
Correlation coefficient (r)	0.3178	0.4929	-0.3415	0.0714	0.4932	0.2949
Simple regression coefficient (bi)	92.9300	68.1500	85.1200	22.7600	-17.8900	-10.1500

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

### Conclusion

Thus it can be concluded that *A. modicella*, *A. janata* and *S. litura* were emerged as major Lepidopteran insect-pests on

late season sole soybean and soybean intercropped with pigeonpea. The larval population of Lepidopteran pests was found to be significantly reduced when soybean intercropped

with pigeonpea in comparison with sole soybean. This might be 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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