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Influence of ambient weather on the incidence of major insect-pests of sole soybean and soybean intercropped with pigeonpea

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Abstract
Investigations were carried out during *Kharif* 2015 at Research Farm of Department of Agricultural Entomology, College of Agriculture, Latur (VNKMV, Parbhani) on the influence of ambient weather on seasonal incidence of *Helicoverpa armigera*, *Cydia ptychora* and *Obereopsis brevis* infesting sole soybean and soybean intercropped with pigeonpea. The data revealed that *Helicoverpa armigera*, *Cydia ptychora* and *Obereopsis brevis* were emerged as major insect-pests on late season soybean and soybean intercropped with pigeonpea. The peak activity of *H. armigera* (6.4 larvae per quadrat), *C. ptychora* (3.4 larvae per quadrat) and *O. brevis* (3.8 grubs per quadrat) was registered during 42nd, 43rd and 38th standard meteorological week, respectively on sole soybean. The larval population of *H. armigera* infesting sole soybean exhibited a positive correlation with minimum temperature, before noon relative humidity and afternoon relative humidity. *C. ptychora* larval population infesting sole soybean indicated a positive correlation with rainfall while, negative correlation with before noon relative humidity. The grub population of *O. brevis* infesting sole soybean had a positive correlation with maximum temperature, minimum temperature, before noon relative humidity and afternoon relative humidity. However, on soybean intercropped with pigeonpea the peak population of *H. armigera* (8.2 larvae per quadrat), *C. ptychora* (3.6 larvae per quadrat) and *O. brevis* (2.4 grubs per quadrat) was recorded during 42nd, 45th and 38th standard meteorological week, respectively *H. armigera* larval population infesting soybean intercropped with pigeonpea demonstrated a positive correlation with minimum temperature and afternoon relative humidity. The larval population of *C. ptychora* infesting soybean intercropped with pigeonpea indicated a positive correlation with rainfall whereas before noon relative humidity exhibited negative impact on larval population of *C. ptychora*. The grub population of *O. brevis* infesting soybean intercropped with pigeonpea had a positive correlation with maximum temperature, before noon relative humidity and afternoon relative humidity.

Keywords: Weather, soybean, intercropping, pigeonpea, *Helicoverpa armigera*, *Cydia ptychora*, *Obereopsis brevis*,

Introduction
Soybean [*Glycine max* (L.) Merrill], a golden bean of 21st century belongs to family Leguminaceae is world's most important seed legume which revealed unprecedented growths in terms of both area and production. It is principal source of proteins, fats, carbohydrates, amino acids, vitamins and minerals. Soybean not only supplies food for humans and animals, but it also improves the soil fertility by fixing atmospheric nitrogen. The practicability of growing soybean crop with minimum input or management leads to the rapid increase in area and production (Sharma *et al*. 2014) [18].

Soybean was cultivated worldwide 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) [24]. India ranked 4th in terms of global soybean area sown and 5th in terms of soybean production after USA, Brazil, Argentina and China (FAOSTAT, 2018) [6]. Soybean contributed 42 per cent of India's total oilseeds and 25 per cent of edible oil production (Sharma *et al*. 2014)
[18]. In India, the area under soybean 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) [24]. 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].

Soybean is attacked by more than 20 insect-pests in Maharashtra, amongst major pests 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, *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.

Intercropping is an approach to improve diversity in an agricultural ecosystem. It is pursued with various objectives such as maintaining ecological balance, more efficient utilization of resources, increasing the quantity and quality of farm produce, and lowering the damage from insect-pests, plant diseases and weeds. Intercropping and staggered sowing offers a source of diversity and stabilizes the crop production environment by discouraging pest species while improving crop performance (Steiner 1984) [22]; (Tingey and Lamont 1988) [23]; (Sastawa and Odo 1999) [17]; (Odo and Futuless 2000) [15]. Insect-pest situations are more dynamic in intercropping systems than in sole crops (Bhatnagar and Davies 1981) [4]; (Jervis 1997) [12]. In dry land farming soybean is commonly intercropped with pigeonpea. Hence, it is necessary to study the impact of intercropping system on incidence of insect-pests compared to sole cropping.

Moreover, seasonal and long term changes consequenced due to climate change would affect the flora, fauna and population dynamics of insect-pests. The ambient weather is known to have direct impact on population dynamics of insects through modulation of developmental rates, survival, fecundity, voltinism and dispersal (Karuppaiah and Sujayanad, 2012) [13]. In this context, the present study was planned to investigate the influence of ambient weather on population dynamics of major 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 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 in 1:1 ratio. 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 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 incidence of *H. armigera*, *C. ptychora*, *O. brevis* and its relation with ambient weather were carried out by simple correlation using excel worksheet.

Results and Discussion

Population dynamics of major insect-pests infesting 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 ^{0}C to 22.3 ^{0}C, 28.1 ^{0}C to 33.5 ^{0}C, 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 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.

Helicoverpa armigera (Hubner) on sole soybean

The first incidence of *H. armigera* on sole soybean was recorded in 40th standard meteorological week (1.4 larvae per quadrat) with its peak population level (6.4 larvae per quadrat) in 42nd 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, 32.8 ^{0}C, 18.0 ^{0}C, 60 and 48 per cent, respectively (Table 1).

Helicoverpa armigera (Hubner) on soybean intercropped with pigeonpea

The first incidence of *H. armigera* on soybean intercropped with pigeonpea was recorded in 40th standard meteorological week (2.4 larvae per quadrat) with its peak population level (8.2 larvae per quadrat) in 42nd 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, 32.8^{0}C, 18.0^{0}C, 60 and 48 per cent, respectively (Table 2).

These findings do find the support from the work of Singh and Singh (1996) [20] who revealed that larvae of *H. armigera* on *Rabi* soybean was appeared in the 1st week of March at the pod filling stage of the crop (1.07 larvae per meter row length) with its peak during 3rd week of March. According to Bapatla *et al*. (2017) [3] pigeonpea was proved the most effective intercrops because of their phenology, repellent chemicals, and physical barriers and also because they were not the natural hosts of the defoliators and did not compete with soybean. The incidence of the defoliators and the extent of damage to soybean leaves were the lowest.

Cydia ptychora (Meyrick) on sole soybean

The first incidence of *C. ptychora* on sole soybean was recorded in 43th standard meteorological week (3.4 larvae per quadrat) with its peak population level. 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, 33.5 ^{0}C, 18.6 ^{0}C, 60 and 41 per cent, respectively (Table 1).

Cydia ptychora (Meyrick) on soybean intercropped with pigeonpea

The first incidence of *C. ptychora* on soybean intercropped with pigeonpea was recorded in 43th standard meteorological week (3.2 larvae per quadrat) with its peak population level of 3.6 larvae per quadrat in 45th 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, 32.0 ^{0}C, 18.2 ^{0}C, 42 and 56 per cent, respectively (Table 2).

The present finding gets the support from the results of Vinod and Patil (2016a) [26] who found that soybean remained vulnerable to pod borer (*C. ptychora*) from 34th MSW to 42nd MSW which followed an increasing trend from 1.10 to 15.20 pod borer larvae per plant with its peak population (10.20 and 9.10 larvae per plant during 2013-14 and 2014-15, respectively) during 42nd MSW. Vinod and Patil (2016b) [25] depicted that the crop sown during the first fortnight of June escaped the high incidence of pink pod borer whereas, the crop sown during the last week of July noticed higher incidence. These results endorse the results of present findings.

***Obereopsis brevis* (Swedenborg) on sole soybean**

The first incidence of *O. brevis* on sole soybean was recorded in 35th standard meteorological week (1.2 grubs per quadrat). The population of *O. brevis* on sole soybean varied from 0.8 to 3.8 grubs per quadrat. The highest level of population (3.8 grubs per quadrat) was observed in 38th 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 26.0 mm, 2 days, 29.6 ^{0}C, 21.6 ^{0}C, 73 and 65 per cent, respectively (Table 1).

***Obereopsis brevis* (Swedenborg) on soybean intercropped with pigeonpea**

The first incidence of *O. brevis* on soybean intercropped with pigeonpea was recorded in 35th standard meteorological week (0.6 grub per quadrat). The population of *O. brevis* on soybean intercropped with pigeonpea varied from 0.6 to 2.4 grubs per quadrat. The highest level of population (2.4 grubs per quadrat) was observed in 38th 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 26.0 mm, 2 days, 29.6 ^{0}C, 21.6 ^{0}C, 73 and 65 per cent, respectively (Table 2).

These results fall in the line of observations made by Ahirwar *et al*. (2015a) [1] who recorded that the girdle beetle made its first appearance on the soybean in the IInd week of September (0.3 damaged plants per m row). The peak activity of girdle beetle (1.0 damaged plants per m row) observed during Ist week of October. Gaur *et al*. (2015) [8] noticed that incidence of *O. brevis* started at 70 DAS (37 SMW) with its peak activity at 84 DAS (39 SMW). However, Yadav *et al*. (2015b) [27] reported that the infestation of girdle beetle was started in Ist week of August at 28 DAG (0.60 per cent plant infestation). The infestation caused by grub of girdle beetle gradually increased and reaches 13.0 per cent with 38.5 per cent stem tunneling. Thus the present findings agree with these reports.

Table 1: Population of *H. armigera*, *C. ptychora* and *O. brevis* on sole soybean in relation to weather parameters during *kharif* 2015

Month	Standard meteoro-logical weeks	Rainfall (mm)	Number of rainy days	Temperature		Relative Humidity (%)		Mean number of larvae per quadrat		
				Min	Max	Before noon	After noon	*H. armigera*	*C. ptychora*	*O. brevis*
Aug	34	24.5	2	29.4	21.3	69	62	-	-	0
Sept	35	14.0	1	30.8	22.3	72	52	-	-	1.2
	36	46.0	2	31.7	21.5	71	50	-	-	2.2
	37	104.0	4	28.1	21.1	88	67	-	-	1.4
	38	26.0	2	29.6	21.6	73	65	-	-	3.8
	39	0.0	0	30.7	21.5	67	55	-	-	0.8
Oct	40	15.0	3	31.2	19.5	64	55	1.4	-	1.2
	41	17.0	1	31.8	18.3	65	46	3.8	0	-
	42	0.0	0	32.8	18.0	60	48	6.4	0	-
	43	0.0	0	33.5	18.6	60	41	6	3.4	-
Nov	44	0.0	0	31.9	18.9	52	52	4.6	2	-
	45	0.0	0	32.0	18.2	42	56	2.4	2.4	-

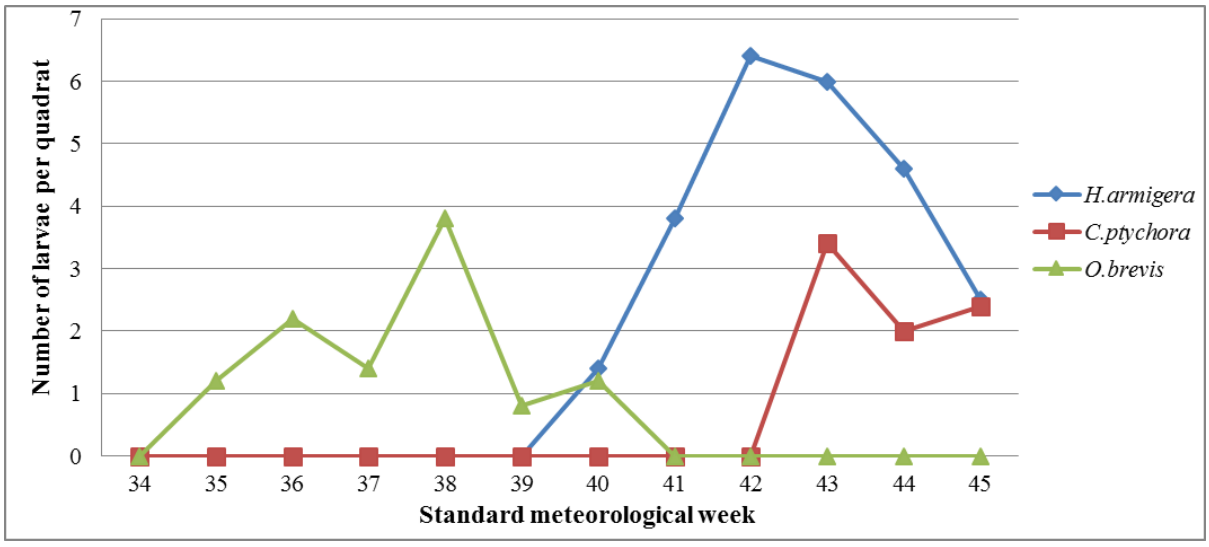

Fig 1: Population dynamics of *H. armigera*, *C. ptychora* and *O. brevis* on sole soybean in relation to weather parameters

Table 2: Population of *H. armigera*, *C. ptychora* and *O. brevis* on soybean intercropped with pigeonpea in relation to weather parameters during *kharif* 2015

Month	Standard meteoro-logical weeks	Rainfall (mm)	Number of rainy days	Temperature		Relative Humidity (%)		Mean number of larvae per quadrat		
				Min	Max	Before noon	After noon	*H. armigera*	*C. ptychora*	*O. brevis*
Aug	34	24.5	2	29.4	21.3	69	62	-	-	0
Sept	35	14.0	1	30.8	22.3	72	52	-	-	0.6
	36	46.0	2	31.7	21.5	71	50	-	-	1.4
	37	104.0	4	28.1	21.1	88	67	-	-	1.4
	38	26.0	2	29.6	21.6	73	65	-	-	2.4
	39	0.0	0	30.7	21.5	67	55	-	-	0.6
Oct	40	15.0	3	31.2	19.5	64	55	2.4	-	1.2
	41	17.0	1	31.8	18.3	65	46	7.4	-	-
	42	0.0	0	32.8	18.0	60	48	8.2	-	-
	43	0.0	0	33.5	18.6	60	41	5.8	3.2	-
Nov	44	0.0	0	31.9	18.9	52	52	6.6	2.8	-
	45	0.0	0	32.0	18.2	42	56	2.4	3.6	-

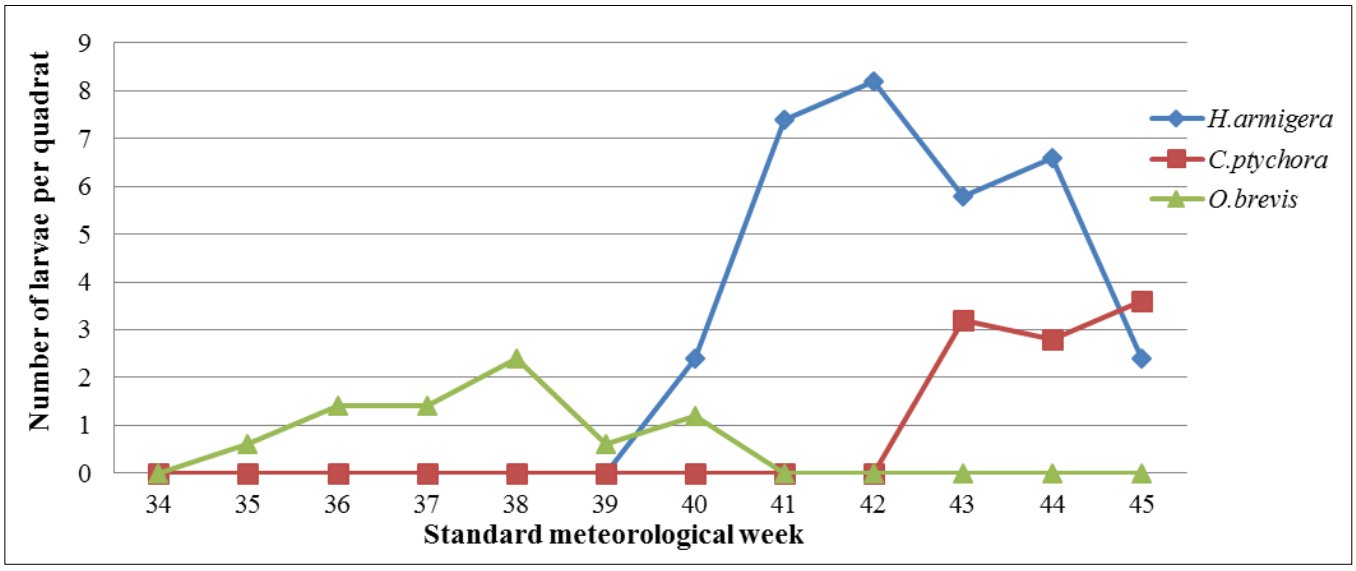

Fig 2: Population dynamics of *H. armigera*, *C. ptychora* and *O. brevis* on soybean intercropped with pigeonpea in relation to weather parameters

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

***Helicoverpa armigera* (Hubner) on sole soybean**

The results in respect of simple correlations between larval population of *H. armigera* infesting sole soybean and weather parameters during *kharif* 2015 are presented in Table 3. The data presented on correlation indicated that there was significant positive correlation between larval population of *H. armigera* infesting sole soybean and weather parameters *viz*., minimum temperature (2.3738*), before noon relative humidity (0.6052*) and afternoon relative humidity (0.8740*).

***Helicoverpa armigera* (Hubner) on soybean intercropped with pigeonpea**

The results in respect of simple correlations between larval population of *H. armigera* infesting soybean intercropped with pigeonpea and weather parameters during *kharif* 2015 are presented in Table 4. The data indicated that there was significant positive correlation between larval population of *H. armigera* infesting soybean intercropped with pigeonpea and weather parameters *viz*., minimum temperature (2.2483*) and afternoon relative humidity (0.8678*) which showed direct positive effect on larval population of *H. armigera*.

The results obtained are in close agreement with the findings Brahman *et al.* (2018) [5] and Jat *et al.* (2017) [11] who reported that larval population of *H. armigera* exhibited significant positive correlation with minimum temperature.

Gadhiya *et al.* (2014) [7] revealed that larval population of *H. armigera* on groundnut revealed significant positive correlation with maximum, minimum and mean temperature, morning, evening and mean vapour pressure deficit and evaporation. Indira Kumar (2014) [9] showed that minimum temperature and evaporation exhibited significant positive correlation (r = 0.85 and r = 0.90, respectively) with tomato fruit borer larval population. These results endorse the results of the present findings.

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

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (^{0}C)	Minimum temperature (^{0}C)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	-0.0773	-0.0652	0.0560	-0.0343	-0.0613	-0.0451
Number of rainy days	-0.1166	-0.1382	0.1029	-0.0647	-0.1035	-0.0886
Maximum temperature (^{0}C)	-0.2125	-0.2186	0.2934	-0.2046	-0.2128	-0.2692
Minimum temperature (^{0}C)	1.0535	1.1118	-1.6552	2.3738*	1.6811	1.3001
Before noon relative humidity (%)	0.4802	0.4536	-0.4390	0.4286	0.6052*	0.2845
Afternoon relative humidity (%)	0.5101	0.5606	-0.8019	0.4787	0.4108	0.8740*
Correlation coefficient (r)	0.5059	-0.6049	0.7916	-0.8788	-0.5806	-0.7111*
Simple regression coefficient (bi)	14.6200	17.2700	-19.4300	14.7700	51.8800	73.1400

***** = 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 *H. armigera* infesting soybean intercropped with pigeonpea during *kharif* 2015

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (0C)	Minimum temperature (0C)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	-0.3272	-0.2760	0.2370	-0.1452	-0.2596	-0.1910
Number of rainy days	-0.1095	-0.1297	0.0966	-0.0608	-0.0972	-0.0832
Maximum temperature (0C)	-0.3278	-0.3371	0.4526	-0.3156	-0.3283	-0.4152
Minimum temperature (0C)	0.9978	1.0530	-1.5677	2.2483*	1.5923	1.2314
Before noon relative humidity (%)	0.3441	0.3250	-0.3146	0.3072	0.4337	0.2039
Afternoon relative humidity (%)	0.5665	0.5566	-0.7962	0.4753	0.4079	0.8678*
Correlation coefficient (r)	-0.4868	-0.5071	0.7133	-0.9020	-0.5743	-0.6206*
Simple regression coefficient (bi)	13.1400	14.6200	-15.3400	13.4000	47.5900	57.9100

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

***Cydia ptychora* (Meyrick) on sole soybean**

The results in respect of simple correlations between larval population of *C. ptychora* infesting sole soybean and weather parameters during *kharif* season 2015 are tabulated in Table 5. The partitioning of correlation coefficient revealed that rainfall (0.7697*) showed significantly direct positive effect on larval population of *C. ptychora* infesting sole soybean, whereas before noon relative humidity (-0.9292*) showed significantly direct negative effect.

***Cydia ptychora* (Meyrick) on soybean intercropped with pigeonpea**

The results in respect of simple correlations between larval population of *C. ptychora* infesting soybean intercropped with pigeonpea and weather parameters during *kharif* season 2015 are tabulated in Table 6. The partitioning of correlation coefficient revealed that rainfall (0.8397*) showed significantly direct positive effect on larval population of *C. ptychora* infesting soybean intercropped with pigeonpea, whereas before noon relative humidity (-1.1275*) showed significantly direct negative effect.

These findings coincides with the results of Vinod and Patil (2016a)[26] who indicated a highly significant and positive relationship (r = 0.77**) between maximum temperature and incidence of pod borer *C. ptychora* during 2013-14 whereas, morning relative humidity showed a significant and negative correlation (r =-0.64**) with pod borer incidence during the year 2014-15.

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

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (^{0}C)	Minimum temperature (^{0}C)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	0.7697*	0.6493	-0.5576	0.3416	0.6107	0.4492
Number of rainy days	-0.3136	-0.3717	0.2769	-0.1741	-0.2785	-0.2384
Maximum temperature (^{0}C)	-0.1707	-0.1755	0.2356	-0.1643	-0.1709	-0.2161
Minimum temperature (^{0}C)	0.0423	0.0446	-0.0664	0.0953	0.0675	0.0522
Before noon relative humidity (%)	-0.7372	-0.6964	0.6740	-0.6580	-0.9292*	-0.4367
Afternoon relative humidity (%)	0.0007	0.0007	-0.0010	0.0006	0.0005	0.0011
Correlation coefficient (r)	0.4088	-0.5488	0.5615	-0.5589	-0.6999	-0.3888
Simple regression coefficient (bi)	45.4100	57.7800	-60.2500	41.1100	24.8800	17.9900

***** = 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 *C. ptychora* infesting soybean intercropped with pigeonpea during *kharif* 2015

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (^{0}C)	Minimum temperature (^{0}C)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	0.8397*	0.7084	-0.6083	0.3727	0.6662	0.4901
Number of rainy days	-0.3212	-0.3807	0.2836	-0.1783	-0.2853	-0.2442
Maximum temperature (^{0}C)	-0.0894	-0.0920	0.1234	-0.0861	-0.0895	-0.1133
Minimum temperature (^{0}C)	0.0552	0.0582	-0.0867	0.1243	0.0881	0.0681
Before noon relative humidity (%)	-0.8946	-0.8450	0.8179	-0.7985	-1.1275*	-0.5300
Afternoon relative humidity (%)	-0.0007	-0.0007	0.0010	-0.0006	-0.0005	-0.0011
Correlation coefficient (r)	-0.4110	-0.5517	0.5310	-0.56695	0.7486	-0.3304
Simple regression coefficient (bi)	60.5500	77.0400	-75.3400	55.2400	35.0400	20.9000

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

***Obereopsis brevis* (Swedenborg) on sole soybean**

The results in respect of simple correlations between grub population of *O. brevis* infesting sole soybean and weather parameters during *kharif* season 2015 are tabulated in Table 7. The partitioning of correlation coefficient revealed that maximum temperature (2.3738*), minimum temperature (0.6052*), before noon relative humidity (0.8740*) and afternoon relative humidity (1.8261*) showed significantly positive effect on grub population of *O. brevis* infesting sole soybean.

***Obereopsis brevis* (Swedenborg) on soybean intercropped with pigeonpea**

The results in respect of simple correlations between grub population of *O. brevis* infesting soybean intercropped with pigeonpea and weather parameters during *kharif* season 2015 are tabulated in Table 8. The partitioning of correlation coefficient revealed that maximum temperature (2.2483*), before noon relative humidity (0.8678*) and afternoon relative humidity (1.7783*) showed significantly positive effect on grub population of *O. brevis* infesting soybean intercropped with pigeonpea.

These findings are supported with the work of Netam *et al*. (2013) [14] who revealed that girdle beetle incidence was significantly and positively correlated with morning relative humidity. Ahirwar *et al*. (2015b) [2] revealed the positive and significant correlation between girdle beetle and parameters *viz*., maximum temperature and sunshine hours. However, the negative and significant correlation was noted between girdle beetle and mean evening R.H. (per cent). Thus the present findings agree with these reports.

Table 7: Simple regression coefficients, path analysis showing direct and indirect effects of weather parameters on population of *O. brevis* infesting sole soybean during *kharif* 2015

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (^{0}C)	Minimum temperature (^{0}C)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	-0.1382	-0.1166	0.1001	-0.0613	-0.1096	-0.0806
Number of rainy days	0.2475	0.2934	-0.2186	0.1374	0.2199	0.1882
Maximum temperature (^{0}C)	-1.7196	-1.7683	2.3738*	-1.6552	-1.7220	-2.1781
Minimum temperature (^{0}C)	0.2686	0.2835	-0.4220	0.6052*	0.4286	0.3315
Before noon relative humidity (%)	0.6934	0.6550	-0.6340	0.6189	0.8740*	0.4108
Afternoon relative humidity (%)	1.0658	1.1713	-1.6755	1.0001	0.8583	1.8261*
Correlation coefficient (r)	0.4176	0.5182	0.5182	0.6452	0.5492	0.4979
Simple regression coefficient (bi)	27.2100	15.9300	62.1700	-42.9600	-14.0700	-16.2600

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

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

Weather Parameters	Rainfall (mm)	Number of rainy days	Maximum temperature (^{0}C)	Minimum temperature (^{0}C)	Before noon relative humidity (%)	Afternoon relative humidity (%)
Rainfall (mm)	-0.1297	-0.1095	0.0940	-0.0576	-0.1029	-0.0757
Number of rainy days	0.3818	0.4526	-0.3371	0.2120	0.3392	0.2903
Maximum temperature (^{0}C)	-1.6287	-1.6748	2.2483*	-1.5677	-1.6309	-2.0629
Minimum temperature (^{0}C)	0.1925	0.2031	-0.3024	0.4337	0.3072	0.2375
Before noon relative humidity (%)	0.6885	0.6503	-0.6295	0.6145	0.8678*	0.4079
Afternoon relative humidity (%)	1.0379	1.1406	-1.6316	0.9739	0.8358	1.7783*
Correlation coefficient (r)	0.5422	0.6623	-0.5583	0.6089	0.6160	0.5753*
Simple regression coefficient (bi)	16.8000	72.8400	489200	-27.0400	-10.8400	-12.9700

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

Conclusion

Thus it can be concluded that *Helicoverpa armigera*, *Cydia ptychora* and *Obereopsis brevis* were emerged as major insect-pests on late season sole soybean and soybean intercropped with pigeonpea. The population of *H. armigera* and *O. brevis* was found to be reduced however, population of *C. ptychora* was found to be increased when soybean intercropped with pigeonpea in comparison with sole soybean. 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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