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Effect of weather parameters on population dynamics of sucking insect-pests infesting sole soybean and soybean intercropped with pigeonpea

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Abstract
Studies were conducted at Research Farm of Department of Agricultural Entomology, College of Agriculture, Latur (VNKMV, Parbhani) during *kharif*-2015 to investigate the effect of weather parameters on the occurrence of sucking insect-pests of sole soybean and soybean intercropped with pigeonpea. During the investigation, *Aphis glycines*, *Empoasca kerri* and Thrips were emerged as major sucking insect-pests on late season soybean and soybean intercropped with pigeonpea. *A. glycines* (14.7 aphids per quadrat), *E. kerri* (17.8 jassids per quadrat) and Thrips (17 thrips per quadrat) reached its peak population during 35th, 39th and 35th standard meteorological week, respectively on sole soybean. The population of *A. glycines* infesting sole soybean exhibited a positive correlation with number of rainy days while, negative correlation with rainfall, maximum temperature and afternoon relative humidity. *E. kerri* population infesting sole soybean indicated a negative correlation with rainfall, maximum temperature and afternoon relative humidity. The population of Thrips infesting sole soybean had a positive correlation with minimum temperature while, negative correlation with rainfall, maximum temperature and afternoon relative humidity. However, on soybean intercropped with pigeonpea peak population of *A. glycines* (20 aphids per quadrat), *E. kerri* (16.6 jassids per quadrat) and Thrips (19.6 thrips per quadrat) was recorded during 39th, 35th and 35th standard meteorological week, respectively. *A. glycines* population infesting soybean intercropped with pigeonpea showed a positive correlation with number of rainy days and minimum temperature while, negative correlation with rainfall, maximum temperature and afternoon relative humidity. The population of *E. kerri* infesting soybean intercropped with pigeonpea indicated a negative correlation with maximum temperature, beforenoon relative humidity and afternoon relative humidity population of *E. kerri*. The population of Thrips infesting soybean intercropped with pigeonpea had a positive correlation with minimum temperature.

Keywords: Population dynamics, soybean, *Aphis glycines*, *Empoasca kerri*, Thrips

Introduction
Soybean [*Glycine max* (L.) Merrill], the wonder crop or golden bean of 21st century belongs to family Leguminaceae is rich in proteins (43.2 per cent), fats (19.5 per cent) and carbohydrates (20.9 per cent). Besides this, it is rich source of amino acids, vitamins and minerals. Soybean is prominent seed legume of the globe which provides 25 per cent of vegetable oil production, about two thirds of the world's protein concentrate for livestock feeding and is a valuable component in formulated feeds for poultry and fish. Soybean oil is utilized as raw matter in manufacturing antibiotic, adhesive, lubricants, paints, varnishes, etc. Apart from supplying food to humans and animals, soybean also improves the soil fertility by fixing atmospheric nitrogen.

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) [31]. 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) [5]. Soybean occupied 42 per cent of India's total oilseeds and 25 per cent of edible oil production (Sharma *et al*. 2014) [20]. 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) [31]. 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) [27].

The several biotic and abiotic factors are responsible for low productivity of soybean, but the damage caused by insect-pests is major. In India soybean was attacked by 273 species of insects (Rawat and Kapoor, 1968) [17] of which, 20 insect-pest species have been recorded as major pests infesting soybean (Singh and Singh, 1990) [23]. 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, *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 system based on the companion cropping pattern may be helpful in ecological manoeuvring resulting in escape or less infestation by insects (Hegde and Lingappa, 1996) [6]; (Singh *et al.*, 2011) [26]; (Singh *et al*., 2012) [25]; (Chakravorty and Yadav, 2013) [3]. 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) [28]; (Tingey and Lamont 1988) [30]; (Sastawa and Odo 1999) [18]; (Odo and Futuless 2000) [12]. Plant fitness is altered by insect colonization and behaviour through visual and aromatic stimuli. These factors differ between a sole crop and an intercropping system (Steiner 1984) [28]; (Tingey and Lamont 1988) [30] and pest situations are more dynamic in intercropping systems than in sole crops (Bhatnagar and Davies 1981) [1]; (Jervis 1997) [8]. A detailed understanding of such type of manipulation may be helpful in forecasting of pest out break on one hand and development of integrated crop management practices on the other (Singh and Singh, 1978) [24]. The population dynamics and ecology of many soybean insect-pests was not well studied with respect to cultivars and cropping system of soybean. Very scanty information is available on variations in the pattern of infestation caused by insect-pests when soybean is intercropped with pigeonpea.

Keeping these facts in view, the present investigation was planned to study the effect of weather parameters on population dynamics of sucking 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 (1:1 ratio). 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 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 *Aphis glycines*, *Empoasca kerri*, Thrips and weather parameters were worked out by simple correlation.

Results and discussion

Population dynamics of sucking insect-pests infesting soybean and soybean intercropped with pigeonpea and weather parameter

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, beforenoon 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.

Aphis glycines (Matsumura) on sole soybean

The population of *A. glycines* was first observed on sole soybean in 34th standard meteorological week (12.8 aphids per quadrat) with its peak of 14.7 aphids per quadrat in 35th standard meteorological week. At maximum level of pest population the prevailing weather factors *viz.*, rainfall, number of rainy days, maximum temperature, minimum temperature, beforenoon relative humidity, afternoon relative humidity, and were 14.0 mm, 1 day, 30.8 ^{0}C, 22.3 ^{0}C, 72 and 52 per cent, respectively (Table 1).

Aphis glycines (Matsumura) on soybean intercropped with pigeonpea

The first incidence of *A. glycines* was observed on soybean intercropped with pigeonpea in 34th standard meteorological week (7.9 aphids per quadrat) with its peak of 20.0 aphids per quadrat in 39th standard meteorological week. 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 mm, 0 day, 30.7 ^{0}C, 21.5 ^{0}C, 67 and 55 per cent, respectively (Table 2).

The present findings are in conformity with the findings of Quimo and Caliling (1993) [14] who revealed that the peak population of soybean aphids was observed at late vegetative to pre flowering stages. Magar (2006) [10] revealed that population of *A. glycines* ranged from 4.6 to 22.2 aphids per quadrat on soybean. The peak population was recorded in 35th meteorological week. Catangui *et al*. (2008) [2] revealed that peak levels of soybean aphid was observed at the R5 (beginning seed) development stage. Schmidt *et al*. (2012) [19] demonstrated that *A. glycines* were collected during late July to mid-August, followed by the fall, with a peak capture period during the last 2nd week of September. Thus the present findings agree with these reports.

Empoasca kerri (Pruthi) on sole soybean

The population of *E. kerri* was initialed on sole soybean in 34th standard meteorological week (14.6 jassids per quadrat) with its peak of 17.8 jassids per quadrat in 39th standard meteorological week. 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 mm, 0 day, 30.7 ^{0}C, 21.5 ^{0}C, 67 and 55 per cent, respectively (Table 1).

***Empoasca kerri* (Pruthi) on soybean intercropped with pigeonpea**

The population of *E. kerri* was initiated on soybean intercropped with pigeonpea in 34th standard meteorological week (11.6 jassids per quadrat) with its peak of 16.6 jassids per quadrat in 35th 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 14.0 mm, 1 day, 30.8 ^{0}C, 22.3 ^{0}C, 72 and 52 per cent, respectively (Table 2).

These results are analogous to the findings of Sutaria *et al*. (2010) [29] who revealed that *E. kerri* was remain active throughout the crop season on soybean. Its incidence was initiated from the IInd week after sowing i.e. IInd week of August (1.2 jassid nymphs per 3 leaves per plant) and reached to its peak (5.7 jassids nymphs per 3 leaves per plant) in 7th WAS coinciding with IIIrd week of September. Yadav *et al*. (2015) [32] observed jassids from July to September on soybean. The peak population (2.7 per plant) was recorded when crop was 70 days old. During this period weekly average maximum, minimum temperature and relative humidity were 32 ^{0}C, 24.8 ^{0}C and 72 per cent respectively. Thus the present findings are in line with these findings.

Thrips on sole soybean

The first incidence of thrips on sole soybean was recorded in 34th standard meteorological week (13.4 thrips per quadrat). The population of thrips on soybean varied from 3.1 to 17.0 per quadrat. The highest level of population (17.0 thrips per quadrat) was observed in 35th standard meteorological week. 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 14.0 mm, 1 day, 30.8 ^{0}C, 22.3 ^{0}C, 72 and 52 per cent, respectively (Table 1).

Thrips on soybean intercropped with pigeonpea

The first incidence of thrips on soybean intercropped with pigeonpea was recorded in 34th standard meteorological week (11.0 thrips per quadrat). The population of thrips on soybean varied from 2.1 to 19.6 thrips per quadrat. The highest level of population (19.6 thrips per quadrat) was observed in 35th standard meteorological week. 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 14.0 mm, 1 day, 30.8 ^{0}C, 22.3 ^{0}C, 72 and 52 per cent, respectively (Table 2).

The results are discussed in the light of available literature. Radhika (2013) who revealed that in groundnut the incidence of thrips was high from the initial crop growth period 29.44 thrips per plant (25th Std. week) and attained to its peak of 39.64 thrips (33rd Std. week). Chavan *et al*. (2015) [4] reported the peak population of thrips on tomato and capsicum was recorded during October and again in May. Khan *et al*. (2015) [9] revealed that during *kharif* 2007-2008 incidence of thrips on brinjal was started in fifth week of September (4.10 per 3 leaves) and reached its peak in second week of October (5.00 per 3 leaves). During *kharif* 2008-2009 the incidence was commenced from third week of August (3.4 per 3 leaves) and reached its peak in first week of September (8.70 per 3 leaves). Patel and Patel (2015) [13] revealed that the population of thrips on onion initiated after 1st week after transplanting with its peak level (15.40 thrips per plant) during 2nd week of March.

Table 1: Population dynamics of *A. glycines*, *E. kerri* and thrips 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 per quadrat		
				Min	Max	Before noon	After noon	*A. glycines*	*E. kerri*	Thrips
Aug	34	24.5	2	29.4	21.3	69	62	12.8	14.6	13.4
Sept	35	14.0	1	30.8	22.3	72	52	14.7	16.2	17.0
	36	46.0	2	31.7	21.5	71	50	9.4	9.4	11.5
	37	104.0	4	28.1	21.1	88	67	3.7	3.2	5.1
	38	26.0	2	29.6	21.6	73	65	8.8	9.3	11.4
	39	0.0	0	30.7	21.5	67	55	13.2	17.8	16.2
Oct	40	15.0	3	31.2	19.5	64	55	11.2	13.0	10.1
	41	17.0	1	31.8	18.3	65	46	10.8	14.4	9.12
	42	0.0	0	32.8	18.0	60	48	7.8	13.6	8.3
	43	0.0	0	33.5	18.6	60	41	8.2	9.8	6.0
Nov	44	0.0	0	31.9	18.9	52	52	3.6	8.6	4.7
	45	0.0	0	32.0	18.2	42	56	3.2	8.2	3.1

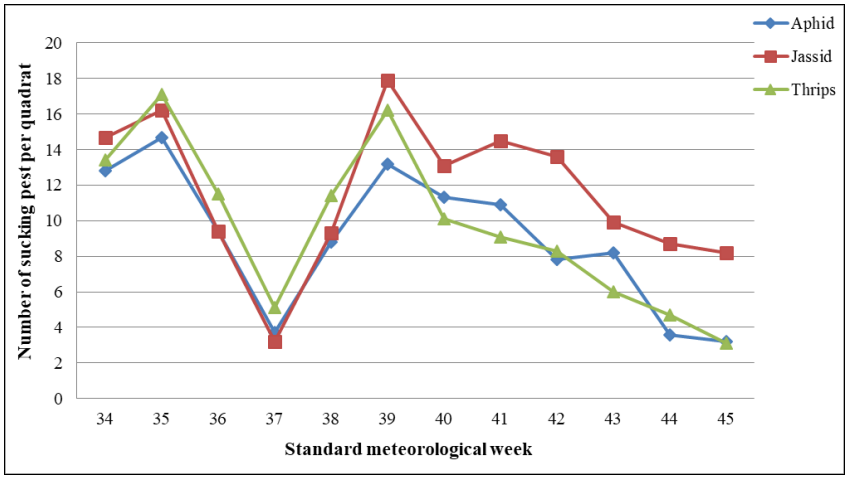

Fig 1: Population dynamics of *A. glycines*, *E. kerri* and thrips on sole soybean in relation to weather parameters

Table 2: Population dynamics of *A. glycines*, *E. kerri* and thrips 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 per quadrat		
				Min	Max	Before noon	After noon	*A. glycines*	*E. kerri*	Thrips
Aug	34	24.5	2	29.4	21.3	69	62	7.9	11.6	11.0
Sept	35	14.0	1	30.8	22.3	72	52	15.0	16.6	19.6
	36	46.0	2	31.7	21.5	71	50	3.4	8.2	13.4
	37	104.0	4	28.1	21.1	88	67	3.0	3.4	7.2
	38	26.0	2	29.6	21.6	73	65	4.7	7.6	10.2
	39	0.0	0	30.7	21.5	67	55	20.0	14.0	12.6
Oct	40	15.0	3	31.2	19.5	64	55	10.9	11.2	7.2
	41	17.0	1	31.8	18.3	65	46	4.2	14.2	6.4
	42	0.0	0	32.8	18.0	60	48	3.0	10.8	7.4
	43	0.0	0	33.5	18.6	60	41	2.6	9.2	4.2
Nov	44	0.0	0	31.9	18.9	52	52	3.2	5.6	2.1
	45	0.0	0	32.0	18.2	42	56	2.4	3.4	2.6

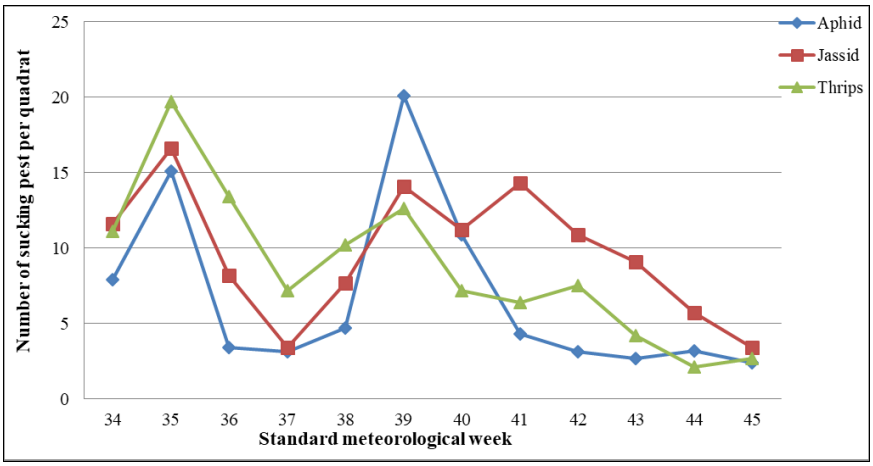

Fig 2: Population dynamics of *A. glycines*, *E. kerri* and thrips on soybean intercropped with pigeonpea in relation to weather parameters

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

***Aphis glycines* (Matsumura) on sole soybean**

The results in respect of simple correlations between the population of *A. glycines* infesting sole soybean and weather parameters during *kharif* season 2015 are tabulated in Table 3. The partitioning of correlation coefficient revealed that rainfall (-1.3583*), maximum temperature (-1.1609*) and afternoon relative humidity (-1.1966*) showed direct negative effect on population of *A. glycines* infesting sole soybean. Whereas, number of rainy days (0.6191*) exhibited direct positive effect on *A. glycines* population.

***Aphis glycines* (Matsumura) on soybean intercropped with pigeonpea**

The results in respect of simple correlations between the population of *A. glycines* infesting soybean intercropped with pigeonpea and weather parameters during *kharif* season 2015 are tabulated in Table 4. The partitioning of correlation coefficient revealed that rainfall (-1.1945*), maximum temperature (-1.4398*) and afternoon relative humidity (-

1.1828*) showed direct negative effect on population of *A. glycines* infesting soybean intercropped with pigeonpea. Whereas, number of rainy days (0.7319*) and minimum temperature (0.5450*) exhibited direct positive effect on *A. glycines* population.

The results obtained are in conformity with the findings of Magar (2006) [10] who indicated that rainfall showed highest positive influence while, number of rainy days noticed negative influence on *A. glycines* on soybean. There was also direct negative effect of maximum temperature (-0.4823) on population of aphids. Schmidt *et al*. (2012) [19] showed that alates of *A. glycines* captures were positively correlated with latitude. Sharma *et al.* (1997) [21] reported that *Aphis* sp. population on soybean had significant positive correlation with temperature.

Table 3: Simple regression coefficients, path analysis showing direct and indirect effects of weather parameters on population of *A. glycines* infesting sole soybean during *kharif* season 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)	-1.3583*	-1.1460	0.9840	-0.6028	-1.0777	-0.7928
Number of rainy days	0.5223	0.6191*	-0.4612	0.2900	0.4640	0.3971
Maximum temperature (^{0}C)	0.8410	0.8648	-1.1609*	0.8095	0.8421	1.0652
Minimum temperature (^{0}C)	0.1750	0.1847	-0.2750	0.3944	0.2793	0.2160
Before noon relative humidity (%)	0.2921	0.2759	-0.2670	0.2607	0.3681	0.1730
Afternoon relative humidity (%)	-0.6984	-0.7675	1.0980	-0.6554	-0.5625	-1.1966*
Correlation coefficient (r)	-02264	0.0310	-0.0822	0.4963	0.3133	-0.1381
Simple regression coefficient (bi)	95.7100	88.5600	15.5300	-15.0100	20.2800	12.7400

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

Table 4: Simple regression coefficients and path analysis showing direct and indirect effects of weather parameters on population of *A. glycines* infesting soybean intercropped with pigeonpea during *kharif* season 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)	-1.1945*	-1.0077	0.8653	-0.5301	-0.9477	-0.6971
Number of rainy days	0.6175	0.7319*	-0.5452	0.3428	0.5485	0.4695
Maximum temperature (^{0}C)	1.0430	1.0725	-1.4398*	1.0039	1.0444	1.3210
Minimum temperature (^{0}C)	0.2419	0.2552	-0.3800	0.5450*	0.3859	0.2985
Before noon relative humidity (%)	-0.1751	-0.1653	0.1600	-0.1563	-0.2206	-0.1037
Afternoon relative humidity (%)	-0.6903	-0.7586	1.0853	-0.6478	-0.5560	-1.1828*
Correlation coefficient (r)	-0.1575	0.1280	-0.2544	0.5575	0.2546	0.1053
Simple regression coefficient (bi)	63.5400	54.2200	27.4200	-22.6200	-63.9900	28.6100

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

***Empoasca kerri* (Pruthi) on sole soybean**

The results in respect of simple correlations between the population of *E. kerri* infesting sole soybean and weather parameters during *kharif* 2015 are tabulated in Table 5. The data indicated that there was significant negative correlation between the population of *E. kerri* infesting sole soybean and rainfall (-1.4438*), maximum temperature (-1.4684*) and afternoon relative humidity (-1.1567*).

***Empoasca kerri* (Pruthi) on soybean intercropped with pigeonpea**

The results in respect of simple correlations between the population of *E. kerri* infesting soybean intercropped with pigeonpea and weather parameters during *kharif* 2015 are tabulated in Table 6. The data indicated that there was significant negative correlation between the population of *E. kerri* infesting soybean intercropped with pigeonpea and maximum temperature (-1.2981*), beforenoon relative humidity (-0.6759*) and afternoon relative humidity (-0.9277*).

These findings are in close agreement with the results of Sutaria *et al*. (2010) [29] who indicated that maximum temperature, rainfall and rainy days were negatively correlated with jassid population on soybean. Jadhao *et al*. (2015) [7] revealed non-significant correlation between nymphal population of *A. biguttula biguttula* and weather factors on sunflower crop. Mahto (1990) [11] found that mean weekly temperature and relative humidity had non-significant relationships between populations of jassid on sunflower. However, in cotton, correlation between sunshine hours and population size of jassid was found to be significant (Simwat and Gill, 1992) [22]. Minimum temperature, average temperature and vapour pressure were negatively associated with population build-up of *A. biguttula biguttula* in brinjal. Sunshine hours had a positive association with increasing numbers of the pest (Ratanpara *et al*., 1994) [16]. The results observed in present studies are more or less similar with those of above scientists.

Table 5: Simple regression coefficients, path analysis showing direct and indirect effects of weather parameters on population of *E. kerri* 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)	-1.4438*	-1.2181	1.0459	-0.6408	-1.1456	-0.8427
Number of rainy days	0.1845	0.2187	-0.1692	0.1024	0.1639	0.1403
Maximum temperature (^{0}C)	1.0637	1.0939	-1.4684*	1.0239	1.0652	1.3473
Minimum temperature (^{0}C)	0.0270	0.0285	-0.0424	0.0608	0.0430	0.0333
Before noon relative humidity (%)	0.2481	0.2343	-0.2268	0.2214	0.3127	0.1470
Afternoon relative humidity (%)	-0.6751	-0.7419	1.0613	-0.6335	-0.5437	-1.1567*
Correlation coefficient (r)	-.05957	-0.3847	0.2067	0.1342	-0.1045	-0.3315
Simple regression coefficient (bi)	13.2500	13.0300	-59.9500	46.5900	14.0200	21.2000

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

Table 6: Simple regression coefficients, path analysis showing direct and indirect effects of weather parameters on population of *E. kerri* 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)	-0.0311	-0.0262	0.0225	-0.0138	-0.0247	-0.0181
Number of rainy days	-0.1762	-0.2088	0.1555	0.0978	-0.1565	-0.1339
Maximum temperature (0C)	0.9404	0.9670	-1.2981*	0.9051	0.9417	1.1911
Minimum temperature (0C)	0.0106	0.0112	-0.0167	0.0239	0.0170	0.0131
Before noon relative humidity (%)	-0.5363	-0.5065	0.4903	-0.4787	-0.6759*	-0.3177
Afternoon relative humidity (%)	-0.5414	-0.5950	0.8511	-0.50081	-0.4360	-0.9277*
Correlation coefficient (r)	-0.3339	-0.3583	0.2047	-0.1692	-0.3344	-0.1932
Simple regression coefficient (bi)	17.6000	19.1000	-48.3200	45.4700	42.5300	34.3900

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

Thrips on sole soybean

The results in respect of simple correlations between the population of thrips infesting sole soybean and weather parameters during *kharif* season 2015 are tabulated in Table 7. The partitioning of correlation coefficient revealed that rainfall, maximum temperature and afternoon relative humidity exhibited direct negative effect (-1.0295*, -0.6177*, and -0.5925*, respectively) on thrips population of sole soybean. However, minimum temperature showed direct positive effect (0.6668*) on the population of thrips.

Thrips on soybean intercropped with pigeonpea

The results in respect of simple correlations between population of thrips infesting soybean intercropped with pigeonpea and weather parameters during *kharif* season 2015 are tabulated in Table 8. The partitioning of correlation coefficient revealed that minimum temperature showed direct positive effect (0.9252*) on population of thrips infesting soybean intercropped with pigeonpea.

These findings are in coincidence with the results of Patel and Patel (2015) [13] who indicated that the population of thrips had significant positive correlation with maximum temperature and mean temperature. However, morning relative humidity, evening relative humidity and mean relative humidity had significantly negatively correlated with the population of thrips. Chavan *et al*. (2015) [4] reported that on tomato and capsicum crops, moderate temperatures with mean relative humidity played a pivotal role in boosting the thrips population whereas, the lower temperatures in winter months adversely affected their population build-up.

Table 7: Simple regression coefficients, path analysis showing direct and indirect effects of weather parameters on population of thrips infesting sole soybean during *kharif* season 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)	-1.0295*	-0.8685	0.7458	-0.4569	-0.8168	-0.6009
Number of rainy days	0.1823	0.2160	-0.1609	0.1012	0.1619	0.1386
Maximum temperature (^{0}C)	0.4474	0.4601	-0.6177*	0.4307	0.4481	0.5667
Minimum temperature (^{0}C)	0.2959	0.3123	-0.4649	0.6668*	0.4722	0.3652
Before noon relative humidity (%)	0.3462	0.3270	-0.3166	0.3090	0.4364	0.2051
Afternoon relative humidity (%)	-0.3458	-0.3800	0.5436	-0.3245	-0.2785	-0.5925*
Correlation coefficient (r)	-0.1034	0.0669	-0.2707	0.7263	0.4233	0.0823
Simple regression coefficient (bi)	99.8800	93.9100	34.6500	-30.9000	-11.6800	70.7000

***** = 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 population of thrips infesting soybean intercropped with pigeonpea and during *kharif* season 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)	-0.3428	-0.2892	0.2483	-0.1522	-0.2720	-0.2001
Number of rainy days	0.0549	0.0651	-0.0485	0.0305	0.0488	0.0418
Maximum temperature (^{0}C)	0.0399	0.0411	-0.0551	0.0384	0.0400	0.0506
Minimum temperature (^{0}C)	0.4106	0.4333	-0.6451	0.9252*	0.6552	0.5067
Beforenoon relative humidity (%)	0.2084	0.1969	-0.1905	0.1860	0.2627	0.1235
Afternoon relative humidity (%)	-0.2184	-0.2400	0.3433	-0.2049	-0.1759	-0.3742
Correlation coefficien (r)	0.1527	0.2072	-0.3477	0.8231	0.5588	0.1483
Simple regression coefficient (bi)	81.6500	77.3300	44.4900	-42.6100	-72.7600	34.6400

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

Conclusion

Thus it can be concluded that *A. glycines*, *E. kerri* and Thrips were emerged as major sucking insect-pests on late season sole soybean and soybean intercropped with pigeonpea. The population of *E. kerri* was found to be significantly reduced when soybean intercropped with pigeonpea in comparison with sole soybean. Nervertheless, abundance of aphids and thrips was more in soybean intercropped with pigeonpea in comparison with sole soybean.

References

1. Bhatnagar VS, Davies JC. Pest management in intercrop subsistence farming. In: Willey, R.W. (Ed.), International Workshop on Intercropping. ICRISAT, Hyderabad, India, 1981, 246-257.
2. Catangui MA, Beckendorfb EA, Walter ER. Soybean aphid population dynamics, soybean yield loss, and development of stage specific economic injury levels. Agronomy Journal. 2008; 101(5):1080-1092.
3. Chakravorty S, Yadav DK. Effect of intercrops on jassid (*Empoasca kerri* Pruthi) infesting green gram, *Vigna radiata* (L.) Wilczek. Ann. Pl. Prot. Sci. 2013; 21(2):229-232.
4. Chavan VM, Bhosle AB, Chandrashekar K. Population dynamics of thrips species infecting vegetable crops in Maharashtra. Indian J Pl. Prot. 2015; 43(3):370-374.
5. FAOSTAT. http://www.fao.org/faostat/en/#data/QC. 01 August, 2018.
6. Hegde R, Lingappa S. Effect of intercropping on incidence and damage by Helicoverpa armigera in pigeon pea. Karnataka J Agril. Sci. 1996; 9(4):616-621.
7. Jadhao SM, Shetgar SS, Bhamare VK. Population dynamics of sucking insect-pests infesting sunflower and its relationship with weather parameters. Ann. Pl. Soil Res. 2015; 17:486-488.
8. Jervis MA. Metapopulation dynamics and control of mobile agricultural pests: fresh insights. Int. J. Pest Manage. 1997; 43:251-252.
9. Khan FS, Borikar PS, Sangle PM. Population dynamics of major insect-pests of brinjal. Bioinfolet. 2015; 12(2a):408-412.
10. Magar SA. Population dynamics and field life-tables of major pests of soybean. M.Sc. (Agri.) Thesis submitted to Marathwada Agricultural University, Parbhani (MS) India, 2006.
11. Mahto Y. A note on population dynamics of *Amrasca bigutulla bigutulla* (Mid.) on sunflower. Indian J Entomol. 1990; 52(3)506-508.
12. Odo PE, Futuless KN. Millet-soybean intercropping as affected by different sowing dates of soybean in a semi-arid environment. Cereal Res. Commun. 2000; 28(1-2):153-160.
13. Patel HC, Patel JJ. Population dynamics of thrips (thrips tabaci Lindeman) on onion in relation to different weather parameters. Trends in Biosciences. 2015; 8(2):531-534.
14. Quimo CM, Caliling VJ. Survey of flying viruliferous aphid species and population buildup of Aphis glycines Matsumara in soybean fields. Philipp. Ent. 1993; 9:52-100.
15. Radhika P. Influence of weather on the seasonal incidence of insect-pests on groundnut in the scarce rainfall zone of Andhra Pradesh. Adv. Res. J Crop Improv. 2013; 4(2):123-126.
16. Rantnapara HC, Shekh AM, Patel JR, Patel NM. Effect of weather parameters on brinjal jassid, Amrasca biguttula biguttula Ishida. Gujarat Agril. Univ. Res. J. 1994; 19(2):39-43.
17. Rawat RR, Kapoor RH. Arthropod pest of soybean in M.P conference on soybean production and marketing. September 20-23. Proceeding JNKKV, Jabalpur, 1968, 62-65.
18. Sastawa BM, Odo PE. Damage by coreid bugs (Hemiptera: Coreidae) on successionally planted cowpea in crop mixtures in the semi-arid zone of Nigeria. J Arid Agric. 1999; 9:35-39.
19. Schmidt NP, O'Neal ME, Anderson PF, Lagos D, Voegtlin D, Bailey W *et al*. Spatial Distribution of Aphis Glycines (Hemiptera: Aphididae) A Summary of the Suction Trap Network. J Economic Entomol. 2012; 105(1):259-271.
20. Sharma AN, Gupta GK, Verma RK, Sharma OP, Bhagat S, Amaresan N *et al*. Handbook of integrated pest management package for soybean, NCIPM, New Delhi, 2014, 1-2.
21. Sharma D, Bagmare A, Gupta A. Effect of weather parameters on population build-up of key pests of soybean. J Insect Sci. 1997; 10(2):120-124.
22. Simwat GS, Gill BS. Population build up of cotton jassid and white fly on Gossypium arboreum and its correlation with weather parameters. J Entomol. Res. 1992; 29(1):70-76.
23. Singh OP, Singh KJ. Insect pest of soybean and their management. Indian farming. 1990; 39(10):9-14.
24. Singh RN, Singh KM. Influence of intercropping on succession and population building of insect-pests in early variety of red gram, *Cajanus cajan* (L.) Millsp. Indian J Entomol. 1978; 40:361-375.
25. Singh RS, Nath P, Kumar A. Influence of intercropping on larval population and pod damage by pod fly and its

parasitization by eulophid parasitois (Euderus lividus ashm.) in pigeon pea. Bhartiya Krishi Anusandhan Patrika. 2012; 27(1):23-29.
26. Singh RS, Nath P, Kumar Akhilesh. Influence of intercropping and bio-insecticides on the population of eco-friendly insects inhabiting pigeon pea. Bhartiya Krishi Anusandhan Patrika. 2011; 26(3-4):71-74.
27. SOPA. http:// http://www.sopa.org/statistics/, 2018.
28. Steiner KG. Intercropping in small holder agriculture, with particular reference to West Africa. GTZ publication, Eschborn, 1984, 304.
29. Sutaria VK, Motka MN, Jethva DM, Ramoliya DR. Seasonal abundance of jassid, *Empoasca kerr*; infesting soybean and weather parameters. Ann. Pl. Prot. Sci. 2010; 18(1):223-282.
30. Tingey WM, Lamont Jr WJ. Insect abundance in field beans altered by intercropping. Bull. Entomol. Res. 1988; 78:527-535.
31. USDA. World Agricultural Production. United States Department of Agriculture, Foreign Agricultural Service, Circular Series WAP 8-18 August, 2018, 27.
32. Yadav P, Banerjee S, Gupta MP, Yadav VK. Effect of weather factors on seasonal incidence of insect-pests of soybean. Technofame-A Journal of Multidisciplinary Advance Research. 2015; 4(1):46-51.