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Abundance of pod borer, *H. armigera* and pod damage on pigeonpea pea in relation to weather factors and cropping systems

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Abstract
Comparative studies on seasonal abundance of Pod borer, *H. armigera* and its associated pod damage in organic and conventional pigeon pea farming systems were carried out at the Navsari Agricultural University, Navsari during 2016 to 2018. The larval population first appeared at 11 WAS (40th SMW) and persisted upto 30 WAS (7th SMW). Peak (17.69 and 15.76 larvae/plant) population was observed during 51st SMW (22 WAS). On the other hand, lowest (0.90 and 0.73 larvae / plant) population was noticed at 11 WAS (40th SMW) in both the farming systems. Similarly the pod damage caused by pod borer initiated from 15 WAS (44th SMW) and continued till 30 WAS (8th SMW). The peak of 21.24 and 18.30 per cent pod damage was observed during 51st SMW (22 WAS), whereas the lowest (2.75 and 1.81 %) pod damage was noticed at 30 WAS (7th SMW). in both organic and conventional farming systems. Correlation studies exhibited significant a positive correlation with bright sunshine and significant negative correlation with minimum and average temperature, morning, evening and average relative humidity, wind velocity and rainfall. Relatively higher pod borer larval population and its associated pod damage were recorded in organic farming system as compared to conventional farming system which might be due to non-use of quick knock down insecticides in organic farming than conventional farming system.

Keywords: Pod borer, *H. armigera,* conventional farming system, organic farming system, pigeon pea

Introduction

Pigeonpea, *Cajanus cajan* (L.), is an important legume crop grown in the tropics and subtropics, mostly in Asia, Africa, Latin America and the Caribbean region occupying 6.5 per cent of the world's total pulse area and contributing 5.7 per cent to the total pulse production. In Asia, pigeonpea is grown on 4.1 million ha and India alone accounts for 86 per cent of Asia's total pigeonpea area and contributes 82 per cent to the total production and is the single largest producer of pigeonpea in the world. Though, India is the largest producer of pigeonpea, contributing more than 90 per cent of the world's production, the productivity has always been a concern. The low productivity of pigeonpea in the country may be attributed to many reasons, among which damage by insect pests is of paramount importance (Mishra *et al.*, 2012) [9]. More than 250 species of insect pests are known to infest pigeonpea crop at its various growth stages in India (Gopali *et al.*, 2010) [5] and as per a conservative estimate, losses due to these insect pests may vary from 27 per cent to even 100 per cent (Srilaxmi and Paul 2010). Amongst many insect pests attacking pigeonpea, gram pod borer, *Helicoverpa armigera* (Hubner) has been a major pest in most parts of the country; however, the pod fly, *Melanagromyza obtusa* (Malloch) is emerging as a serious pest of pigeonpea in Central and South India. Similarly, spotted pod borer, *Maruca vitrata* (Geyer) has now gained the status of major pest of short duration pigeonpea both in North and Central India (Ali and Gupta 2012) [1]
Among pod borer complex of pigeonpea, pod borer, *H. armigera* is very important which causes 40-50 per cent damage to the crop (Pareek and Bhargava 2003) [11]. This pestis charismatic in agriculture accounting for the consumption of over 55 per cent of total insecticides used in India (Puri 1995) [15]. The problem of pest is magnified due to its direct attack on fruiting structures, voracious feeding habits, high mobility, fecundity and multivoltine overlapping generations (Sarode 1999) [17]. Besides, the outbreak of *H. armigera* on crops has been attributed to the development of insecticide resistance to a broad spectrum of insecticides used in the agriculture and are known to have a detrimental effect on the populations of its natural enemies (Naseri *et al.*, 2009) [10].

Exposure of successive generations while moving from one crop to another, has made this pest highly resistant to the pesticides *i.e.* cyclodiene, pyrethroids, organophosphates, carbamates etc. (Kranthi 2002) [8]. *H. armigera* has become a threat to the intensive agriculture. To develop efficient pest management strategies, a thorough knowledge on the biology of this pest and its seasonal abundance in relation to weather factors provides an important basis especially with regard to management of this pest in organic farming systems.

Materials and Methods

The studies on Seasonal abundance of pod borer *H. armigera* in organic and conventional farming systems was carried out at certified organic farming unit and Pulses research unit, Navsari Agricultural university, Navsari during 2016-18. The pigeon pea variety Vaishali was grown according to the recommended package of practice in both organic and conventional farming systems.

The pod borer, larval population was counted weekly interval by visual search method (on whole plant basis) on 25 plants (Five plants/ spot) and recorded. Apart from larval population its associated pod damage was also recorded by taking randomly collected fifty pods from the field and examined for damage due to pod borer. Number of pods damaged due to pod borer larva was ascertained by large circular bored hole on pod indicated damage due to pod borer larvae in both the farming systems.

Results and Discussion

Pod borer, *H. armigera* larval population in organic and conventional farming systems

Seasonal abundance of pod borer recorded in pigeon pea grown under organic and conventional farming systems revealed first appearance at 11 WAS (40th SMW) and it continued upto 30 WAS (7th SMW). Initially the larval population was low thereafter, it increased gradually and attained peak (17.69 and 15.76 larvae/plant) during 51st SMW (22 WAS) in both the farming systems. On the other hand, the lowest (0.90 and 0.73 larvae / plant) population was noticed at 11 WAS (40th SMW) in both the farming systems (Table 1, Fig. 1).

Relatively higher pod borer larval population was recorded in an organic farming system (6.28 larvae/ plant) as compared to conventional farming system (5.00 larvae/ plant). This might be due to non-use of quick knock down insecticides in organic farming than conventional farming system. In conventional farming system, application of insecticides might have reduced the pod borer population instantaneously. Khokhar and Singh (1983) [7], Srilaxmi and Paul (2010) [18], Reddy *et al.*, (1998) [16] and Balikai and Yelshetty (2008) [2] reported that *H. armigera* appeared during flowering to maturity of the crop. The present finding also recorded appearance of *H. armigera* larval population during flowering and maturity of the crop. This similarity confirms the current investigation.

Similarly, Pawar *et al.*, (2014) [14] reported first appearance of the pod borer larva when the crop age was about 116 days, 45th SW and the pest was present on the crop during the reproductive stage and remained available upto the first week of January, 1st SW *i.e.* maturity stage of the crop.

Correlation between pod borer larval population in organic and conventional farming systems and weather parameters revealed significant positive correlation with bright sunshine (‘r’ = 0.347 and 0.298) and significant negative correlation with minimum (‘r’= -0.714 and -0.669) and average (‘r’ = -0.717 and -0.684) temperature, morning (‘r’ = -0.575 and -0.553), evening (‘r’ = -0.606 and -0.553) and average (‘r’ = -0.640 and -0.594) relative humidity, wind velocity (‘r’ = -0.337 and -0.298) and rainfall (‘r’ = -0.349 and -0.318) (Table 2 and 3). Dhar *et al.*, (2003) [4] and Jha (2003) [6] also noticed similar observation and trend of pest a population. Observations made by Patel and Koshiya (1999) [12] at Junagadh, Gujarat found negative association of maximum and minimum temperature as well as vapour pressure with *H. armigera* infesting pigeon pea supports the present findings. While, Reddy and Singh (2001) reported that morning relative humidity, maximum and minimum temperature had non-significant positive association, while evening relative humidity, wind speed and sunshine hours had non-significant negative correlation with larval population of *H. armigera* in pigeon pea. This variation might be due to changes in weather parameters in the regions. Deshmukh *et al.*, (2005) [3] reported that none of the weather parameters showed any effect on the population build-up of *H. armigera* larva. This might be due to variation in the weather parameters prevailing in a particular region and type of farming system. Pawar *et al*., (2014) at Parbhani, Maharashtra studied the correlation and regression coefficient of larval population of *H. armigera* on pigeon pea with maximum and minimum temperature and maximum and minimum relative humidity, which was found non-significant and supports the present research outcomes.

Pod damage (%) by pod borer, *H. armigera*in organic and conventional farming systems

The pod damage caused by pod borer observed in organic and conventional farming systems revealed initiation of pest damage from 15 WAS (44th SMW) which continued till 30 WAS (8th SMW) in both organic and conventional farming systems. The peak of 21.24 and 18.30 per cent pod damage was observed during 51st SMW (22 WAS), whereas the lowest (2.75 and 1.81 %) pod damage was noticed at 30 WAS (7th SMW) (Table 1, Fig. 1). The present findings are more or less similar with the studies of Patra *et al.*, (2016) [13] who reported pod damage caused by different insect pests to the tune of 8.75 and 6.25 per cent by *H. armigera*, and 44.94 and 17.75 per cent by *M. obtusa*. They further revealed that pod boring insects (*H. armigera* and *M. obtusa*) caused major crop losses to pigeon pea.

Correlation between per cent pod damage by pod borer recorded in organic and conventional farming systems and weather parameters revealed significant positive correlation with bright sunshine (‘r’ = 0.40 and 0.318) and significant negative association with minimum (‘r’ = -0.696 and -0.692) and average (‘r’ = -0.693 and -0.701) temperature, morning (‘r’ = -0.609 and -0.599), evening (‘r’ = -0.605 and -0.588) and average (‘r’ = -0.651 and -0.636) relative humidity, wind velocity (‘r’ = -0.302 and -0.289) and rainfall (‘r’ = -0.329 and -0.321) (Table 2 & 3).

Table 1: Population of pod borer, *H. armigera* and pod damage (%) in pigeon pea grown under organic and conventional farming systems

SMW	WAS	*H. armigera* larva/plant						*H. armigera* pod damage (%)					
		2016-17		2017-18		Pooled (2016-18)		2016-17		2017-18		Pooled (2016-18)	
		ORG	CNV	ORG	CNV	ORG	CNV	ORG	CNV	ORG	CNV	ORG	CNV
33	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
40	11	0.84	0.68	0.96	0.78	0.90	0.73	0.00	0.00	0.00	0.00	0.00	0.00
41	12	1.56	1.12	1.92	1.36	1.74	1.24	0.00	0.00	0.00	0.00	0.00	0.00
42	13	2.12	1.60	2.42	1.76	2.27	1.68	0.00	0.00	0.00	0.00	0.00	0.00
43	14	3.32	1.68	3.96	2.02	3.64	1.85	0.00	0.00	0.00	0.00	0.00	0.00
44	15	4.60	3.28	5.00	3.66	4.80	3.47	7.12	5.56	7.32	5.96	7.22	5.76
45	16	6.72	4.40	7.89	5.88	7.31	5.14	11.60	7.76	12.04	8.16	11.82	7.96
46	17	9.20	6.86	9.65	7.65	9.43	7.26	11.76	10.24	12.76	11.24	12.26	10.74
47	18	12.16	10.48	13.45	11.24	12.81	10.86	13.28	11.60	14.84	12.36	14.06	11.98
48	19	13.52	11.04	14.52	12.34	14.02	11.69	14.62	12.24	15.14	13.02	14.88	12.63
49	20	15.72	13.20	15.96	13.96	15.84	13.58	16.78	15.62	17.12	15.96	16.95	15.79
50	21	16.86	14.98	16.86	14.96	16.86	14.97	18.92	16.02	19.20	16.64	19.06	16.33
51	22	17.26	15.48	18.12	16.04	17.69	15.76	20.52	17.68	21.96	18.92	21.24	18.30
52	23	14.92	13.84	16.66	14.22	15.79	14.03	15.64	14.32	16.88	14.96	16.26	14.64
1	24	10.86	9.16	12.86	10.16	11.86	9.66	9.76	8.20	10.24	9.16	10.00	8.68
2	25	10.48	8.28	11.88	9.88	11.18	9.08	8.52	7.48	9.52	8.88	9.02	8.18
3	26	10.12	6.24	10.64	5.44	10.38	5.84	7.88	6.60	8.04	6.96	7.96	6.78
4	27	8.52	6.12	7.86	5.88	8.19	6.00	7.32	5.88	7.96	6.66	7.64	6.27
5	28	6.36	4.12	5.22	3.88	5.79	4.00	5.68	5.28	6.68	5.96	6.18	5.62
6	29	3.24	1.92	3.16	2.68	3.20	2.30	4.92	5.20	5.92	4.92	5.42	5.06
7	30	2.14	0.00	2.00	1.96	2.07	0.98	2.28	1.36	3.22	2.26	2.75	1.81
8	31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Season mean		6.09	4.80	6.46	5.21	6.28	5.00	6.31	5.39	6.74	5.79	6.53	5.59

Note: SMW- Standard meteorological week; WAS- Weeks after sowing, ORG- Organic farming system, CNV- Conventional farming system

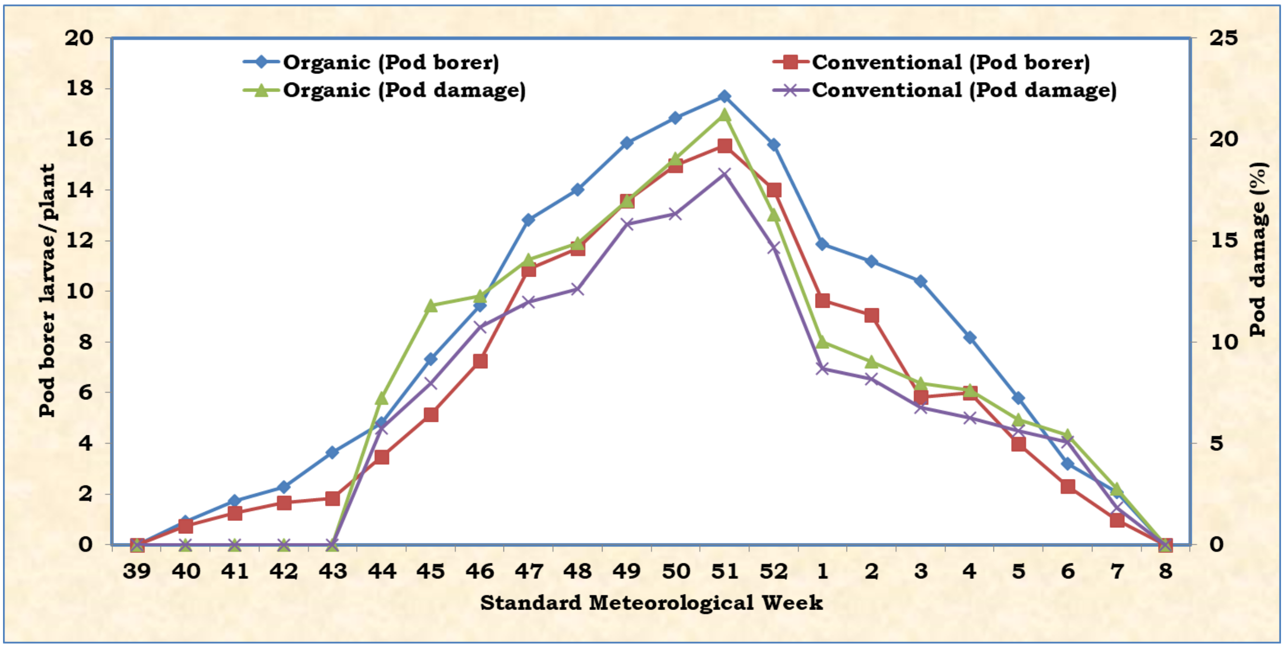

Fig 1: Abundance of pod borer, *H. armigera* and pod damage (%) in organic and conventional farming systems

Table 2: Correlation and regression coefficients between pod borer *H. armigera* population, pod damage (%) and weather parameters in organic farming system

Weather Parameters	*H. armigera* larval Population (Y_1)						*H. armigera* pod damage (%) (Y_2)					
	Correlation coefficient (r)			Regression coefficient			Correlation coefficient (r)			Regression coefficient		
	2016-17	2017-18	Pooled (2016-18)	2016-17	2017-18	Pooled (2016-18)	2016-17	2017-18	Pooled (2016-18)	2016-17	2017-18	Pooled (2016-18)
Maximum Temp. (X_1)	0.260	-0.417*	-0.139	-	-	-	0.296	-0.409*	-0.118	-	-	-
Minimum Temp. (X_2)	-0.794**	-0.646**	-0.714**	-0.992	-	-	-0.761**	-0.642**	-0.696**	-1.078	-	-1.00

Average Temp. (X_3)	-0.755**	-0.709**	-0.717**	-	-1.476	-1.322	-0.705**	-0.703**	-0.693**	-	-1.330	-
Morning RH (X_4)	-0.652**	-0.525**	-0.575**	-	-	-0.122	-0.686**	-0.558**	-0.609**	-	-0.231	-0.249
Evening RH (X_5)	-0.720**	-0.502**	-0.606**	-	-	-	-0.703**	-0.516**	-0.605**	-	-	-
Average RH (X_6)	-0.739**	-0.557**	-0.640**	-	-	-	-0.738**	-0.579**	-0.651**	-	-	-
Wind velocity (X_7)	-0.434*	-0.227	-0.337*	-	-	-	-0.398*	-0.186	-0.302*	-	-	-
Rainfall (X_8)	-0.393*	-0.308	-0.349*	-	-	-	-0.369	-0.291	-0.329*	-	-	-
Bright sunshine (X_9)	0.608**	0.081	0.347*	-	-	-	0.599**	0.072	0.340*	-	-	-0.979
‘A’ value				23.69	43.51	53.72				25.44	59.97	52.34
‘R^2’ value				0.630	0.503	0.578				0.579	0.579	0.605
Variation Explained (%)				63.00	50.30	57.80				57.90	57.90	60.50
‘R’ value				0.794	0.709	0.761				0.761	0.761	0.778

Note: *Correlation significant at 5%; **Correlation significant at 1%
*Regression significant at 5%; **Regression significant at 1%
Regression coefficients are mentioned on the basis of significant variables in stepwise analysis

Table 3: Correlation and regression coefficients between pod borer *H. armigera* population, pod damage (%) and weather parameters in conventional farming system

Weather Parameters	***H. armigera* larval Population (Y_1)**						***H. armigera* pod damage (%) (Y_2)**					
	Correlation coefficient (r)			**Regression coefficient**			**Correlation coefficient (r)**			**Regression coefficient**		
	2016-17	**2017-18**	**Pooled (2016-18)**	**2016-17**	**2017-18**	**Pooled (2016-18)**	**2016-17**	**2017-18**	**Pooled (2016-18)**	**2016-17**	**2017-18**	**Pooled (2016-18)**
Maximum Temp. (X_1)	0.219	-0.435*	-0.161	-	-	-	0.271	-0.442*	-0.148	-	-	-
Minimum Temp. (X_2)	-0.739**	-0.609**	-0.669**	-0.811	-	-	-0.759**	-0.636**	-0.692**	-0.934	-1.446	-
Average Temp. (X_3)	-0.712**	-0.686**	-0.684**	-	-1.224	-1.090	-0.714**	-0.711**	-0.701**	-	-	-1.212
Morning RH (X_4)	-0.616**	-0.515**	-0.553**	-	-	-0.145	-0.685**	-0.539**	-0.599**	-	-	-0.193
Evening RH (X_5)	-0.660**	-0.454*	-0.553**	-	-	-	-0.692**	-0.494**	-0.588**	-	-	-
Average RH (X_6)	-0.683**	-0.518**	-0.594**	-	-	-	-0.730**	-0.556*	-0.636**	-	-	-
Wind velocity (X_7)	-0.393*	-0.180	-0.298*	-	-	-	-0.384*	-0.175	-0.289*	-	-	-
Rainfall (X_8)	-0.353	-0.283	-0.318*	-	-	-	-0.363	-0.280	-0.321*	-	-	-
Bright sunshine (X_9)	0.558**	0.025	0.298*	-	-	-	0.589**	0.038	0.318*	-	-	-
‘A’ value				19.19	35.92	44.358				21.971	42.077	52.078
‘R^2’ value				0.546	0.471	0.529				0.576	0.505	0.575
Variation Explained (%)				54.60	47.10	52.90				57.60	50.05	57.50
‘R’ value				0.739	0.686	0.727				0.759	0.711	0.758

Note: *Correlation significant at 5%; **Correlation significant at 1%
*Regression significant at 5%; **Regression significant at 1%
Regression coefficients are mentioned on the basis of significant variables in stepwise analysis

Conclusion

It can be concluded that the pod borer larval population and its associated pod damage commences at the same time and reaching its peak population and damage in the same standard meteorological week in both the farming system. Sufficient control measures can be taken to manage this pest before reaching its peak population in both organic and conventional farming systems. Relatively higher pod borer larval population and its inflicted pod damage was recorded at organic farming system and this might be due to non-use of quick knock down insecticides in organic farming than conventional farming system. In conventional farming system, application of insecticides might have reduced the pod borer population instantaneously.

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