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Comparative Spatial Distribution of Sucking Insect-Pest-Complex in Summer and Monsoon Cowpea [*Vigna unguiculata* (L.) Walp.]

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ABSTRACT

Background: Pulse crops are known as an important dietary source of proteins for a major part of the vegetarian population across the globe; especially in India. Legume crops help restoration of soil fertility through symbiotic nitrogen fixation. Spatial distribution is an important aspect as it interprets the interaction between individuals of the species and their habitat. The biological reason of aggregation is highly unpredictable and it depends on behavioural pattern of the insect; therefore, spatial distribution accounts for informative description of organisms.

Methods: In order to study the spatial distribution of sucking pests of cowpea, a field trial was laid out during *Zaid* and *Kharif* separately at the Instructional Farm of Rajasthan College of Agriculture, Udaipur in 2019 and 2020. Cowpea variety Pusa Komal was cultivated in 6 plots each of 3 m × 3 m with the row to row and plant to plant spacing of 50 cm and 10 cm, respectively. Different distribution pattern were used to determine spatial distribution pattern of species of insect fauna associated with cowpea during the summer and monsoon season.

Result: The spatial distribution for most the insect pest complex was contagious during both the respective seasons. All positive IDM (index of clumping) values confirmed the clumping of the pest during the season. The mean crowding index was more than unity, indicated clumped interaction.

Key words: Dispersion parameter, Iwao's patchiness index, Jassids, Sucking bugs, Taylor's power law, Thrips, Whiteflies.

INTRODUCTION

Pulse crops are known as an important dietary source of proteins for a major part of the vegetarian population across the globe; especially in India. Legume crops help restoration of soil fertility through symbiotic nitrogen fixation (Chhangani *et al*., 2022a). Cowpea [*Vigna unguiculata* (L.) Walp.] is one of the principal pulse crops of the tropics and is commonly known as crowdel pea, *chala*, *chola* or *choli*, *chavli*, *lobia*, southern pea and black eyed bean. Being, an annual herbaceous legume it is a widely adapted and cultivated crop in tropical Africa, Asia, North and South America mostly for its edible seeds as a grain; besides, as a vegetable and the whole plant as fodder having high levels of proteins ensuring tolerance against several stresses (Chhangani *et al*., 2022b). It is one of the oldest farmed crops cultivated on 12.5 million hectares, having a worldwide production of 3 million tons. In India *lobia* is grown on an area of approximately 3.9 million hectares with a production of 2.21 million tons having a national productivity of 683 kg per hectare.

Studies on the diversity of insect fauna help to understand their species richness and abundance. It gives an account to quantify the interaction between the insect pest and their associated natural enemies. This knowledge helps to understand the insect ecology, hence provides a guide for developing management tools which are area specific and result in efficient reduction in pest damage. Spatial distribution is an important aspect as it interprets the interaction between individuals of the species and their habitat. The biological reason of aggregation is highly unpredictable and it depends on behavioural pattern of the insect; therefore, spatial distribution accounts for informative

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description of organisms. (Lloyd, 1967; Iwao, 1968). Type of pest distribution can affect the sampling programme and method of analysis. Hence, studies on distribution patterns has significant role in designing effective tools and programmes for estimation of population dynamics, to understand bio-ecology, integrated pest management modules and damage level assessment.

MATERIALS AND METHODS

In order to study the spatial distribution of sucking pests of cowpea, a field trial was laid out during *Zaid* and *Kharif* separately at the Instructional Farm of Rajasthan College of Agriculture, MPUAT, Udaipur in 2019 and 2020. Cowpea variety Pusa Komal was cultivated in 6 plots each of 3 m × 3 m with the row to row and plant to plant spacing of 50cm and 10 cm, respectively. Weekly population data of insect peststhus obtained were analysed. Different distribution pattern were used to determine spatial distribution pattern of species of insect fauna associated with cowpea during the summer and monsoon season.

Variance to mean ratio (VMR)

It is the simplest method to analyze the distribution pattern of the organism given by (Patil and Stiteler, 1974). It is also known as Index of dispersion (ID).

$$ID = \frac{Variance}{Mean}$$

The value of VMR is one for 'Poisson' distribution, less than one for positive binomial and more than one for negative binomial distribution. VMR also gives an idea about the population dispersion which reveals the value being > 1 clumped; <1 regular and =1 random distribution.

After analyzing the data, for convenience the VMR values were approximated as follows: > 1 clumped (>1.25); <1: regular (0.85 to 1.25) and =1 random distribution (<0.85).

The clumping or dispersion parameter (*k*)

It was worked out by the following method as given by Southwood and Henderson (2000):

$$K = \frac{x}{s^2 x}$$

Where,
x= Mean density of population.
s^2= Variance.

If the value of k is more than 8 it means clumping is low or population have a tendency towards randomness; while, if value is less than 8 than population will show high amount of aggregation given by Mareena and Dutta (2011).

Index of clumping (I_{DM})

It is also known as David and Moore's Index using the formula given by David and Moore, 1954.

$$I_{DM} = \frac{Variance}{Mean} - 1$$

The positive value of the index indicates the negative binomial distribution *i.e.* aggregated dispersion; whereas, negative value of the index indicates the positive binomial distribution/regular distribution of the population. If value of index is zero, it will indicate the random distribution pattern.

Lloyd's mean crowding (X*)

$$X^* = X + \left\{ \frac{Variance}{Mean} - 1 \right\}$$

It indicates the mutual interference or competition among individuals. The value of this index revealed >1: contagious; <1: regular and =1: random distribution (Lloyd, 1967).

Taylor's power law

It relates square of variance (S^2) to the mean (x) as: (Taylor, 1961).

$$s^2 = a.x^b$$

Where:
'a'= Constant depending upon experimental conditions.
'b'= Coefficient of contagion.

Iwao's patchiness index

It relates mean crowding (X*) to mean density as: (Iwao, 1968).

$$X^* = \alpha + \beta X$$

Where
'α'= Index of basic contagion and
'β' is the density contagiousness coefficient.

RESULTS AND DISCUSSION

Spatial distribution of the insect pest was calculated to understand the dispersion and distribution pattern of the insect pest and their associated natural enemies using Taylor's power law and Iwao's mean crowding regression. It is basic requisite in relation to insect ecology and pest management strategies.

Crop seasons of 2019

Leafhopper, *Empoasca* spp.

Jassids population was second to invade after flea beetles during both the seasons. The variance to mean ratio was more than unity for both the seasons indicating aggregated dispersion of the pest. The *k* (dispersion parameter) value was found to be less than 8 for all observation during the summer and monsoon season except 20th SMW with peak population in the summer. The maximum population in the 20th SMW attributed to tendency of pest towards randomness. Rest all the observation showed high level of aggregation.All positive values of IDM (Index of clumping)ranged from 0.15 to 0.81 and 0.50 to 18.43 in the summer and monsoon respectively, suggested aggregated dispersion of the pest. The mean crowding index was more than unity during the summer with less than unity values in

concluding weeks of pest incidence suggesting the clumped population with random distribution towards end. During the monsoon, the pest had mean crowding index around unity for first and last week of incidence, indicating mutual interference to be random as compared to clumped (value >1) during remaining weeks of incidence [Table 1 and 2; Fig 1.1 and 1.2 and 2.1 and 2.2].

Whiteflies, *Bemisia* spp.

Whiteflies attack was observed during the monsoon season only. The mean population ranged from 0.22 to 2.13 having more than unity variance to mean ratio for all the weeks. The variance to mean ratio indicated the aggregation of the pest. The *k* (dispersion parameter) value was found to be less than eight showing distribution with high amount of aggregation during entire infestation period. The IDM (Index of clumping) values were ranged from 0.48 to 18.75, all the values positive suggested negative binomial distribution. The mean crowding index was calculated to be more than unity for the entire season; showed clumped interaction among individuals [Table 3; Fig 3.1 and 3.2].

Thrips, *Megalurothrips* spp.

The infestation of thrips was observed during the monsoon only. The value of variance to mean ratio was calculated to be more than unity, with range 1.32 to 4.04.Population showed clumped dispersion throughout the season. The *k* (dispersion parameter) value was calculated to more than 8 only in first week of incidence with the maximum population, concluding low amount of aggregation in clumped

Table 1: Spatial distribution of leafhoppers on summer cowpea during, 2019.

SMW	Mean density ($\bar{x}$)	Variance (s^2)	Variance to mean ratio ($s^2/\bar{x}$)	Dispersion pattern (K)	Index of clumping g (I_{DM})	Mean crowding index (X)	Lloyd's patchiness index ($X/\bar{x}$)	Pattern of distribution
18	0.37	0.67	1.81	0.46	0.81	1.18	3.19	Clumped
19	2.10	2.70	1.29	7.35	0.29	2.39	1.14	Clumped
20	3.16	3.31	1.05	66.57	0.05	3.21	1.02	Random
21	1.56	2.46	1.58	2.70	0.58	2.14	1.37	Clumped
22	0.70	0.83	1.19	3.77	0.19	0.89	1.27	Random
23	0.46	0.53	1.15	3.02	0.15	0.61	1.33	Random

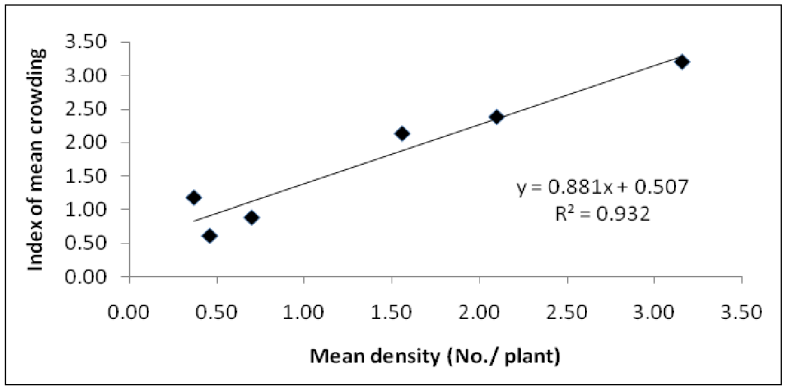

Fig 1.1: Iwao's patchiness index.

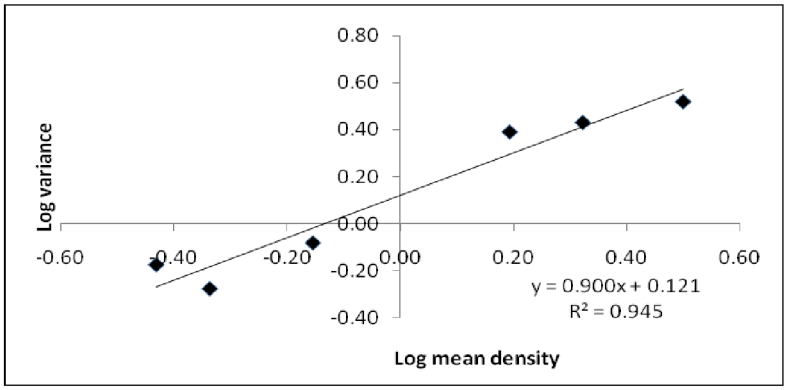

Fig 1.2: Taylor's power law.

dispersion. All positive IDM (index of clumping) values confirmed the clumping of the pest during the season. The mean crowding index was more than unity, indicated clumped interaction. [Table 4; Fig 4.1 and 4.2].

Sap sucking bugs, *Riptortus* spp. and *Clavigralla* spp.

There was no infestation of pod sucking bug observed during summer season. The variance to mean ratio ranged from 1.37 to 2.30 indicating aggregated dispersion of the pest. The *k* (dispersion parameter) value ranged from 0.43 to 5.17, less than 8 having positive IDM value. All the indices showed that the pest was distributed in negative binomial distribution and showed clumped pattern of dispersion. The mean crowding index was calculated to be more than unity except concluding week, suggesting clumped interference among individuals of the pest population [Table 5; Fig 5.1 and 5.2].

Crop seasons of 2020

Leafhopper, *Empoasca* spp.

Jassids population initiated in 11th SMW and observed to be second to invade after flea beetle during both the seasons. The variance to mean ration was more than unityfor both the seasons indicating aggregated dispersion of the pest. The *k* (dispersion parameter) value was calculated to be less than 8 for all observation during the summer and monsoon season. All positive values of IDM (Index of clumping) during both the seasons ranged from 0.39 to 5.21 and 1.04 to 4.70 in the summer and monsoon respectively,

Table 2: Spatial distribution of leafhoppers on monsoon cowpea during, 2019.

SMW	Mean density ($\bar{x}$)	Variance (s^2)	Variance to mean ratio ($s^2/\bar{x}$)	Dispersion pattern (K)	Index of clumping g (I_{DM})	Mean crowding index (X)	Lloyd's patchiness index ($X/\bar{x}$)	Pattern of distribution
30	0.40	0.66	1.65	0.62	0.65	1.05	2.63	Clumped
31	2.46	3.70	1.50	4.88	0.50	2.96	1.20	Clumped
32	0.23	4.47	19.43	0.01	18.43	18.66	81.15	Clumped
33	0.53	3.92	7.40	0.08	6.40	6.93	13.07	Clumped
34	1.46	5.15	3.53	0.58	2.53	3.99	2.73	Clumped
35	0.56	1.21	2.16	0.48	1.16	1.72	3.07	Clumped

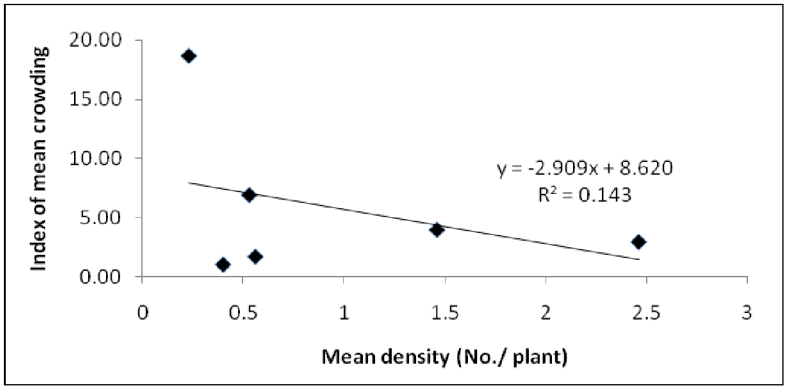

Fig 2.1: Iwao's patchiness index.

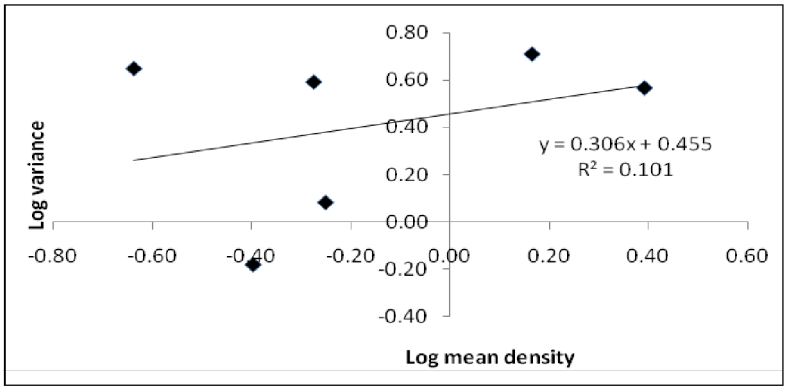

Fig 2.2: Taylor's power law.

suggested aggregated dispersion of the pest. The mean crowding index was more than unity except in last week of the summer season; suggested the clumped population during the summer and monsoon season [Table 6 and 7; Fig 6.1 and 6.2 and 7.1 and 7.2].

Whiteflies, *Bemisia* spp.

Whiteflies attack was observed during the monsoon season only. The mean population ranged from 0.20 to 2.90 having more than unity variance to mean ratio for all the weeks. The variance to mean ratio indicated aggregation of the pest. The *k* (dispersion parameter) value was found to be less than eight showing distribution with high amount of aggregation during entire infestation period. The IDM (Index of clumping) values ranged from 0.48 to 1.61, all the values more than unity suggested negative binomial distribution. The mean crowding index was calculated to be more than unity except for initial and final week; showed clumped interaction among individuals.[Table 8; Fig 8.1 and 8.2].

Thrips, *Megalurothrips* spp.

The infestation of thrips was observed during the monsoon only. The value of variance to mean ratio was calculated to be more than unity, ranging from 2.04 to 3.41. Population showed clumped dispersion throughout the season. The *k* (dispersion parameter) value was calculated to less than 8 for the complete season, concluded high amount of aggregation in clumped dispersion. The IDM (index of clumping) values confirmed the clumping of the pest during the season. The mean crowding index was more than unity,

Table 3: Spatial distribution of whiteflies on monsoon cowpea during, 2019.

SMW	Mean density ($\bar{x}$)	Variance (s^2)	Variance to mean ratio ($s^2/\bar{x}$)	Dispersion pattern (K)	Index of clumping g (I_{DM})	Mean crowding index (X)	Lloyd's patchiness index ($X/\bar{x}$)	Pattern of distribution
30	0.46	0.80	1.74	0.62	0.74	1.20	2.61	Clumped
31	2.13	3.22	1.51	4.16	0.51	2.64	1.24	Clumped
32	0.22	3.75	17.05	0.01	16.05	16.27	73.93	Clumped
33	0.40	7.90	19.75	0.02	18.75	19.15	47.88	Clumped
34	1.16	3.45	2.97	0.59	1.97	3.13	2.70	Clumped
35	0.66	0.98	1.48	1.36	0.48	1.14	1.73	Clumped

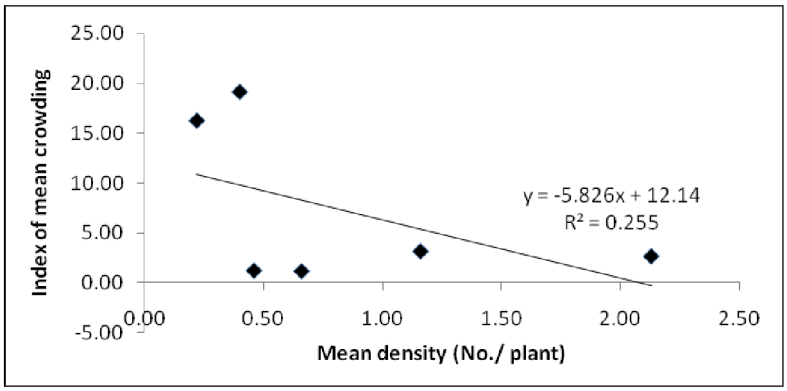

Fig 3.1: Iwao's patchiness index.

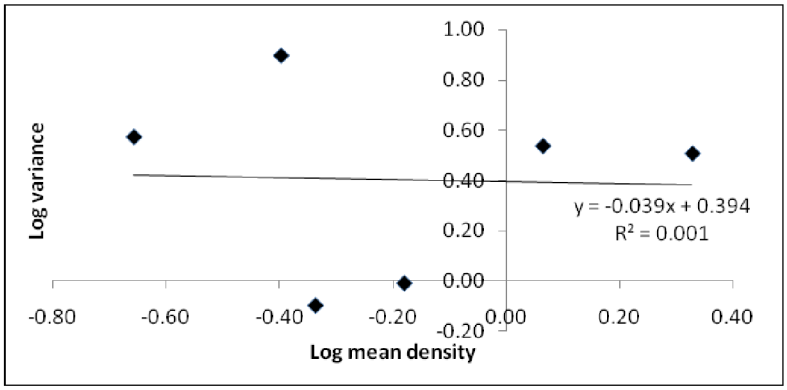

Fig 3.2: Taylor's power law.

indicated clumped interaction of the pest [Table 9; Fig 9.1 and 9.2].

Sap sucking bugs, *Riptortus* spp. and *Clavigralla* spp.

The infestation of sap sucking bugs initiated during 13th and 30th SMW of the summer and monsoon season, respectively. The variance to mean ratio ranged from 1.54 to 3.06 and 2.35 to 5.83 during the summer and monsoon season, respectively. The values indicated aggregated dispersion of the pest. The *k* (dispersion parameter) values were calculated to be less than 8 having positive IDM values. All the indices showed that the pest was distributed in negative binomial distribution and showed clumped pattern of dispersion. The mean crowding index was calculated to be more than unity during entire season, suggesting clumped interference among individuals of the pest population. [Table-10 and 11; Fig 10.1 and 10.2 and 11.1 and 11.2].

The spatial distribution pattern for observed to be aggregated with either low or high level of aggregation among the individuals of the species. Various indices were used to calculate the distribution pattern of the insect pest, which indeed confirmed the negative binomial distribution suggesting clumping of the pest in most of cases.

Pandey (2004) also found negative binomial distribution for the cowpea aphid confirming our results. Likewise, various scientists also reported aggregated distribution of

Table 4: Spatial distribution of thrips on monsoon cowpea during, 2019.

SMW	Mean density ($\bar{x}$)	Variance (s^2)	Variance to mean ratio ($s^2/\bar{x}$)	Dispersion pattern (K)	Index of clumping g (I_{DM})	Mean crowding index (X)	Lloyd's patchiness index ($X/\bar{x}$)	Pattern of distribution
31	3.56	4.69	1.32	11.22	0.32	3.88	1.09	Clumped
32	1.56	5.65	3.62	0.60	2.62	4.18	2.68	Clumped
33	2.14	6.40	2.99	1.08	1.99	4.13	1.93	Clumped
34	2.56	6.80	2.66	1.55	1.66	4.22	1.65	Clumped
35	1.16	4.69	4.04	0.38	3.04	4.20	3.62	Clumped
36	0.6	1.97	3.28	0.26	2.28	2.88	4.81	Clumped

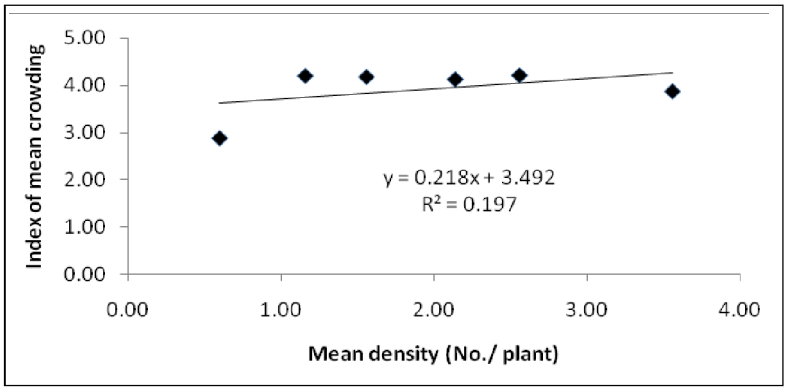

Fig 4.1: Iwao's patchiness index.

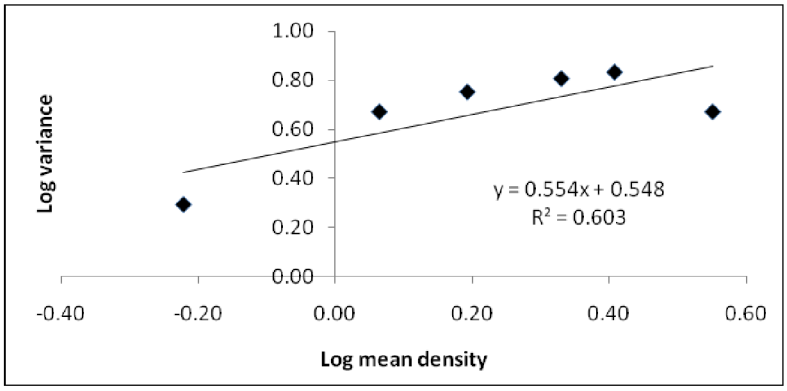

Fig 4.2: Taylor's power law.

Table 5: Spatial distribution of sap sucking bugs on monsoon cowpea during, 2019.

SMW	Mean density ($\bar{x}$)	Variance (s^2)	Variance to mean ratio ($s^2/\bar{x}$)	Dispersion pattern (K)	Index of clumping g (I_{DM})	Mean crowding index (X)	Lloyd's patchiness index ($X/\bar{x}$)	Pattern of distribution
32	0.36	0.66	1.83	0.43	0.83	1.19	3.31	Clumped
33	1.80	3.80	2.11	1.62	1.11	2.91	1.62	Clumped
34	2.46	3.63	1.48	5.17	0.48	2.94	1.19	Clumped
35	2.0	4.6	2.30	1.54	1.30	3.30	1.65	Clumped
36	0.76	1.42	1.87	0.88	0.87	1.63	2.14	Clumped
37	0.43	0.59	1.37	1.16	0.37	0.80	1.87	Clumped

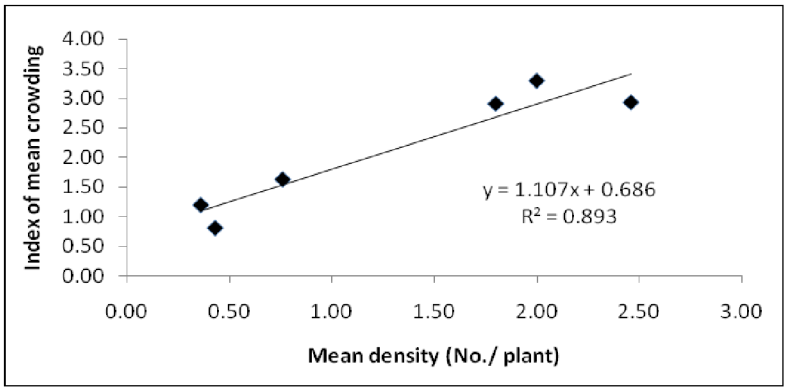

Fig 5.1: Iwao's patchiness index.

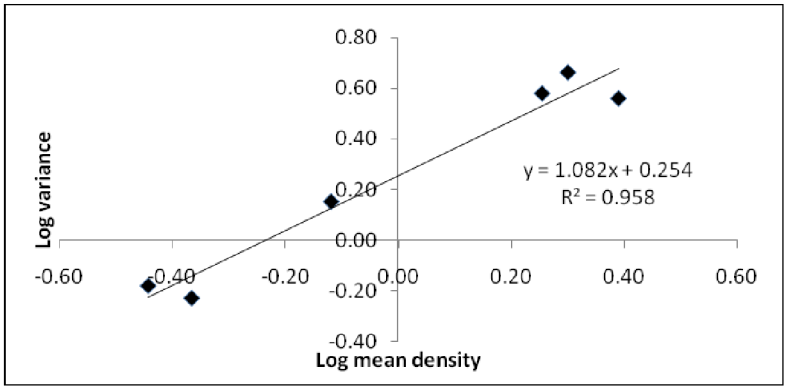

Fig 5.2: Taylor's power law.

Table 6: Spatial distribution of leafhoppers on summer cowpea during, 2020.

SMW	Mean density ($\bar{x}$)	Variance (s^2)	Variance to mean ratio ($s^2/\bar{x}$)	Dispersion pattern (K)	Index of clumping g (I_{DM})	Mean crowding index (X)	Lloyd's patchiness index ($X/\bar{x}$)	Pattern of distribution
11	0.53	1.43	2.70	0.31	1.70	2.23	4.20	Clumped
12	1.13	5.98	5.29	0.26	4.29	5.42	4.80	Clumped
13	2.43	15.08	6.21	0.47	5.21	7.64	3.14	Clumped
14	1.13	6.39	5.65	0.24	4.65	5.78	5.12	Clumped
15	0.66	1.61	2.44	0.46	1.44	2.10	3.18	Clumped
16	0.23	0.32	1.39	0.59	0.39	0.62	2.70	Clumped

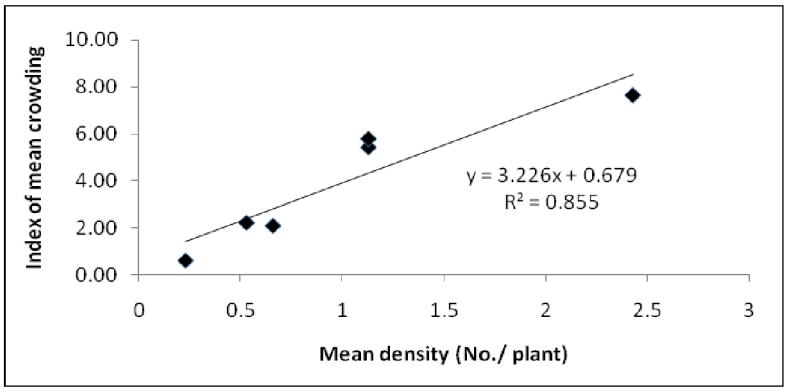

Fig 6.1: Iwao's patchiness index.

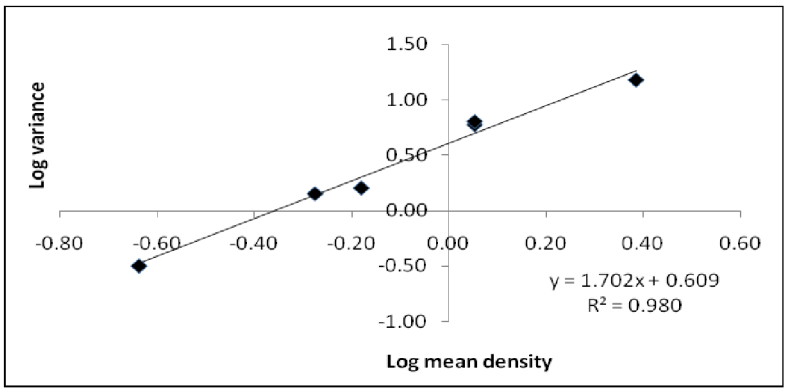

Fig 6.2: Taylor's power law.

Table 7: Spatial distribution of leafhoppers on monsoon cowpea during, 2020.

SMW	Mean density ($\bar{x}$)	Variance (s^2)	Variance to mean ratio ($s^2/\bar{x}$)	Dispersion pattern (K)	Index of clumping g (I_{DM})	Mean crowding index (X)	Lloyd's patchiness index ($X/\bar{x}$)	Pattern of distribution
29	0.77	2.8	3.64	0.29	2.64	3.41	4.42	Clumped
30	1.36	7.75	5.70	0.29	4.70	6.06	4.45	Clumped
31	2.20	10.85	4.93	0.56	3.93	6.13	2.79	Clumped
32	1.06	3.78	3.57	0.41	2.57	3.63	3.42	Clumped
33	0.70	2.35	3.36	0.30	2.36	3.06	4.37	Clumped
34	0.46	0.94	2.04	0.44	1.04	1.50	3.27	Clumped

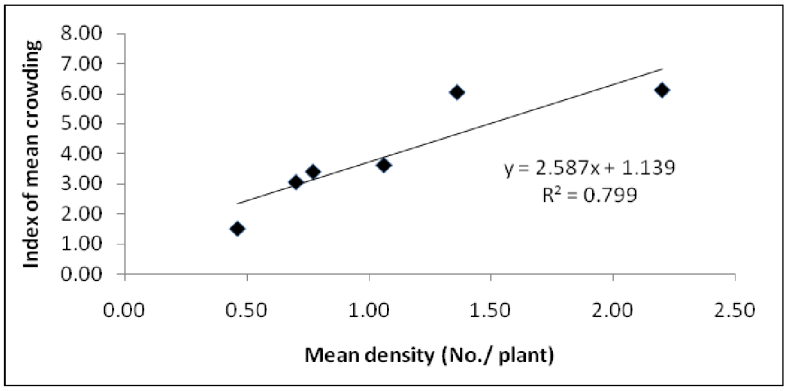

Fig 7.1: Iwao's patchiness index.

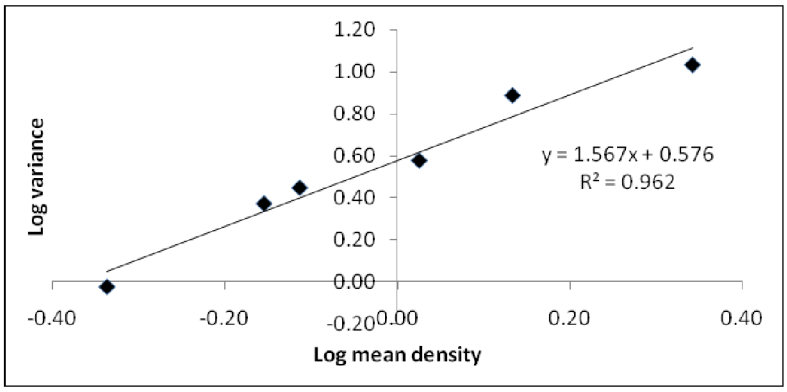

Fig 7.2: Taylor's power law.

Table 8: Spatial distribution of whiteflies on monsoon cowpea during, 2020.

SMW	Mean density ($\bar{x}$)	Variance (s^2)	Variance to mean ratio ($s^2/\bar{x}$)	Dispersion pattern (K)	Index of clumping g (I_{DM})	Mean crowding index (X)	Lloyd's patchiness index ($X/\bar{x}$)	Pattern of distribution
30	0.20	0.37	1.85	0.24	0.85	1.05	5.25	Clumped
31	1.43	2.39	1.67	2.13	0.67	2.10	1.47	Clumped
32	1.76	4.59	2.61	1.09	1.61	3.37	1.91	Clumped
33	2.90	6.64	2.29	2.25	1.29	4.19	1.44	Clumped
34	0.90	1.81	2.01	0.89	1.01	1.91	2.12	Clumped
35	0.40	0.59	1.48	0.84	0.48	0.88	2.19	Clumped

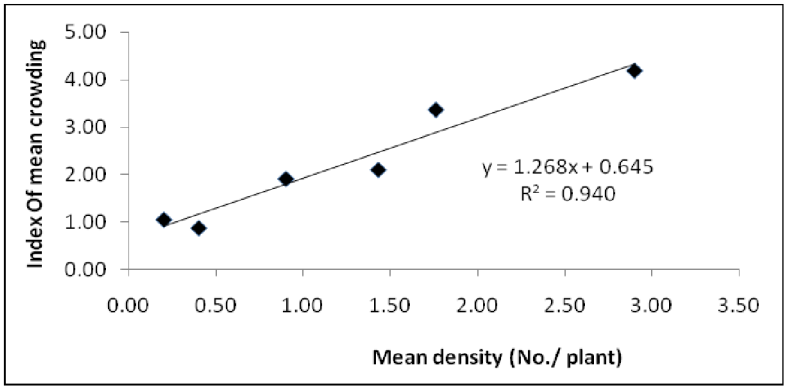

Fig 8.1: Iwao's patchiness index.

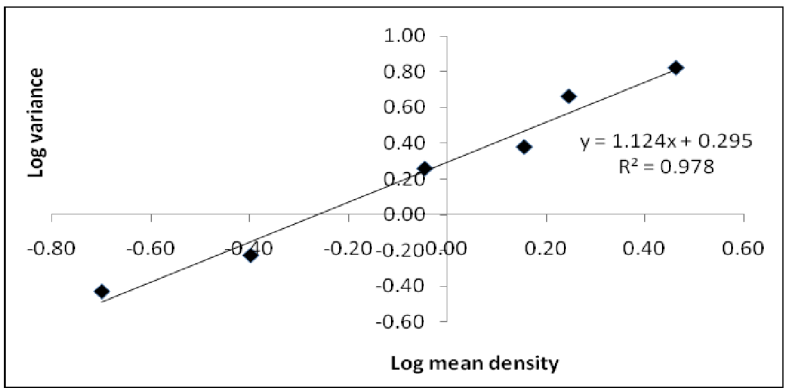

Fig 8.2: Taylor's power law.

Table 9: Spatial distribution of thrips on monsoon cowpea during, 2020.

SMW	Mean density ($\bar{x}$)	Variance (s^2)	Variance to mean ratio ($s^2/\bar{x}$)	Dispersion pattern (K)	Index of clumping g (I_{DM})	Mean crowding index (X)	Lloyd's patchiness index ($X/\bar{x}$)	Pattern of distribution
31	0.60	1.28	2.13	0.53	1.13	1.73	2.89	Clumped
32	0.96	2.58	2.69	0.57	1.69	2.65	2.76	Clumped
33	1.40	4.17	2.98	0.71	1.98	3.38	2.41	Clumped
34	1.70	5.80	3.41	0.70	2.41	4.11	2.42	Clumped
35	0.66	1.47	2.23	0.54	1.23	1.89	2.86	Clumped
36	0.46	0.94	2.04	0.44	1.04	1.50	3.27	Clumped

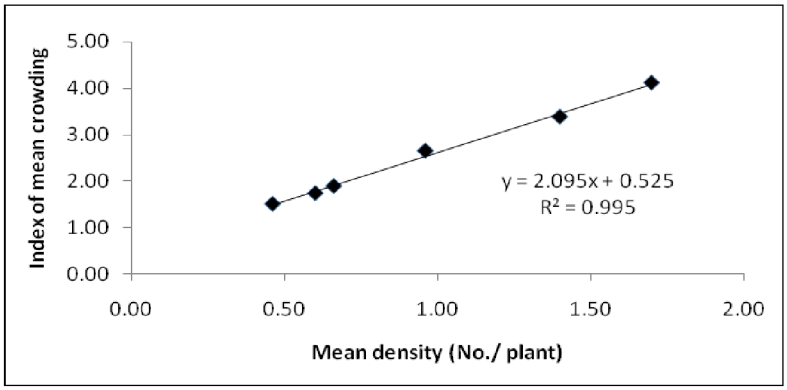

Fig 9.1: Iwao's patchiness index.

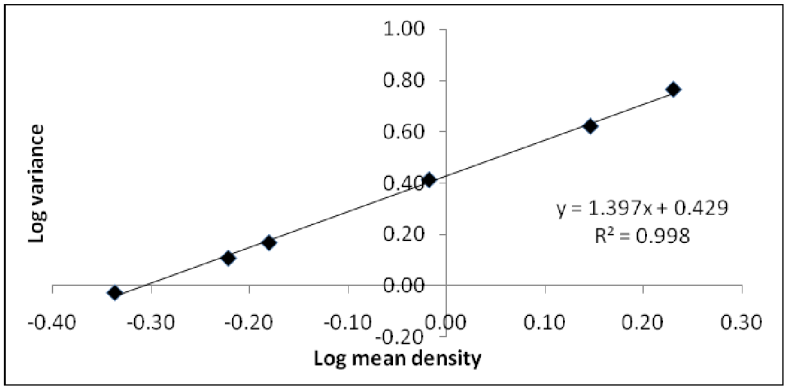

Fig 9.2: Taylor's power law.

Table 10: Spatial distribution of sap sucking bugs on summer cowpea during, 2020.

SMW	Mean density ($\bar{x}$)	Variance (s^2)	Variance to mean ratio ($s^2/\bar{x}$)	Dispersion pattern (K)	Index of clumping g (I_{DM})	Mean crowding index (X)	Lloyd's patchiness index ($X/\bar{x}$)	Pattern of distribution
13	0.36	0.58	1.61	0.59	0.61	0.97	2.70	Clumped
14	1.60	2.80	1.75	2.13	0.75	2.35	1.47	Clumped
15	1.96	3.41	1.74	2.65	0.74	2.70	1.38	Clumped
16	1.90	3.60	1.89	2.12	0.89	2.79	1.47	Clumped
17	0.66	2.02	3.06	0.32	2.06	2.72	4.12	Clumped
18	0.26	0.40	1.54	0.48	0.54	0.80	3.07	Clumped

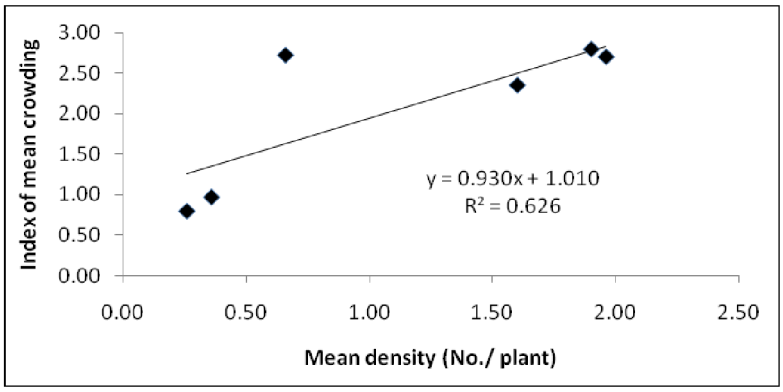

Fig 10.1: Iwao's patchiness index.

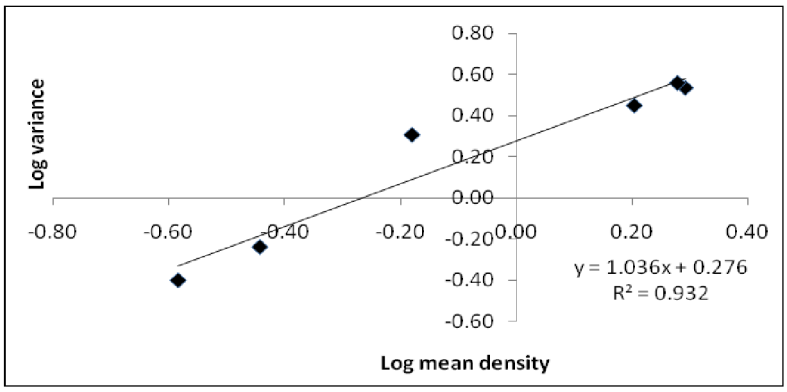

Fig 10.2: Taylor's power law.

Table 11: Spatial distribution of sap sucking bugs on monsoon cowpea during, 2020.

SMW	Mean density ($\bar{\chi}$)	Variance (s^2)	Variance to mean ratio ($s^2/\bar{\chi}$)	Dispersion pattern (K)	Index of clumping g (I_{DM})	Mean crowding index (X)	Lloyd's patchiness index ($X/\bar{\chi}$)	Pattern of distribution
30	0.50	1.91	3.82	0.18	2.82	3.32	6.64	Clumped
31	0.93	3.85	4.14	0.30	3.14	4.07	4.38	Clumped
32	1.50	8.74	5.83	0.31	4.83	6.33	4.22	Clumped
33	1.83	10.35	5.66	0.39	4.66	6.49	3.54	Clumped
34	0.60	3.0	5.00	0.15	4.00	4.60	7.67	Clumped
35	0.26	0.61	2.35	0.19	1.35	1.61	6.18	Clumped

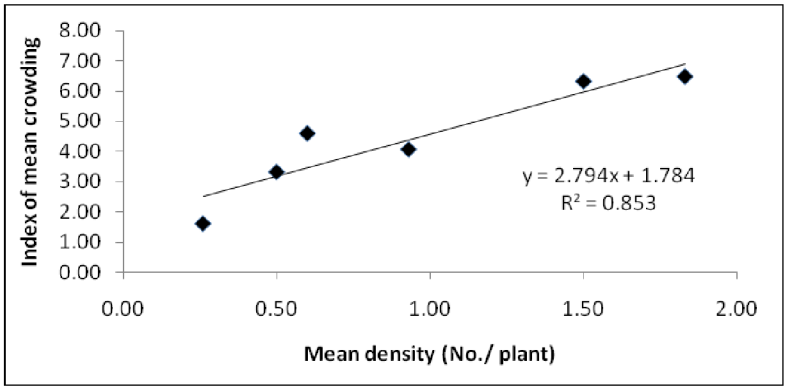

Fig 11.1: Iwao's patchiness index.

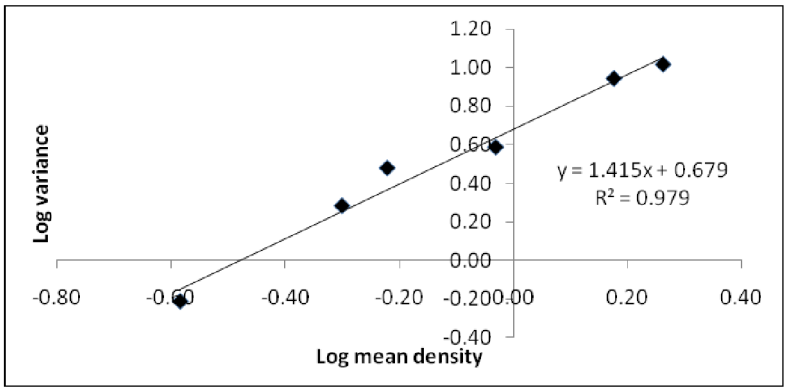

Fig 11.2: Taylor's power law.

the aphids in different crops: Naomi (1987) in *Solidago altissima*, Park and Obrycki (2004) in corn, Young (2005) in banana and Afsari *et al.* (2009) in cotton.

The contagious distribution pattern of *C. ptychora* in pigeonpea with >8 values of dispersion parameter (*k*) observed by Subharani and Singh (2011), which is comparable with aggregated distribution pattern of spotted and lycaenid borer. Our results are in conformity, with the findings of Sujithra and Chander (2015) whose experimental data suggested an aggregated distribution pattern of *M. vitrata* in pigeonpea.

As there is scarcity of literature available on the comparative studies on insect fauna associated with cowpea during the summer and monsoon season much discussion could not become possible.

Conflict of interest: None.

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