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Jagadish KS
Department of Agricultural
Entomology, University of
Agricultural Sciences, GKVK,
Bengaluru, Karnataka, India

Basavaraj K
Department of Agricultural
Entomology, University of
Agricultural Sciences, GKVK,
Bengaluru, Karnataka, India

Geetha S
Department of Agricultural
Entomology, University of
Agricultural Sciences, GKVK,
Bengaluru, Karnataka, India

Spatial distribution of the mycophagous ladybird predator, *Illeis cincta* (Fabricius) (Coleoptera Coccinellidae) in relation to powdery mildew disease in sunflower (*Helianthus annuus* L.) canopy

Jagadish KS, Basavaraj K and Geetha S

Abstract

To determine the spatial distribution pattern of *I. cincta* in relation to powdery mildew; an investigation was conducted at the Main Research Station, UAS, Hebbal, Bangalore in July to October, 2012. The results clearly indicated that the maximum number of all the life stages of the beetle (40.10 ± 19.43) as well as highest disease severity (7.45 ± 1.49) were found at the lower part of the crop canopy, as compared to the middle (20.00 ± 12.22 & 4.60 ± 2.03) and top (6.40 ± 5.81 & 1.25 ± 1.33) level canopies, respectively. Therefore, the severity of powdery mildew as well as the incidence of the predatory beetle was greater in the basal portion of the crop, followed by the middle and top level canopy. The correlation coefficient analysis between the numbers of different life stages of *I. cincta* with powdery mildew severity revealed that the number of egg masses, grubs, pupae and the total number of all life stages of *I. cincta* were positively correlated with the powdery disease severity, whereas the number of adult beetles was negatively correlated with disease severity. However, the number of grubs (0.654^*) at middle canopy and at lower canopy (0.913^{**}) and the total number of all life stages of *I. cincta* (0.680^*) were significantly positively correlated with powdery mildew severity in middle canopy respectively.

Keywords: Sunflower, Powdery mildew, *Illeis cincta*, Mycophagous beetle

1. Introduction

Karnataka is the leading producer of sunflower crop in the country (accounting for more than 54 per cent of the area and 35 per cent of India's sunflower production)^[10]. Since 2006 severe incidence of the disease has been observed in all the sunflower growing areas of the country, whenever there are prolonged dry spells. It has the potential to cause 70 to 100 per cent crop loss^[9]. However, a strong positive relation has been established between the mycophagous ladybird beetle, *Illeis cincta* (Fabricius) (Coleoptera: Coccinellidae) and the powdery mildew infection in sunflower^[10].

Majority of the ladybird beetles which belong to tribe psyllborini under order Coleoptera and family Coccinellidae feed on powdery mildew belonging to Erysiphales of Ascomycotina^[1, 13, 15, 5, 17]. *Illeis cincta* (Fabricius) was earlier reported to feed on the mycelia and spores of powdery mildew fungus (*Oidium* sp.) infecting mulberry, balsams and cowpea, besides feeding on the aphids infesting cotton, melon and brinjal^[20]. Beeson^[4] reported that *I. cincta* was found feeding on the red spider mite. However, these reports of Subramaniam^[20] and Beeson^[4] were later contradicted by Kapur^[11] who opined that members of the tribe psyllborini to which *I. cincta* belongs, live totally on the lower fungi. Further, Puttarudraiah and Channabasavanna^[19] have included *I. cincta* under the "Beneficial Coccinellids of Mysore". All stages of the mycophagous coccinellid, *Illeis cincta* (Fab.) were observed in appreciable numbers on the leaves of red gram (6-8grubs/leaf) and castor feeding on powdery mildew fungus at Thondamuthur, Coimbatore district, Tamil Nadu, India^[6]. Other entomologists from India also reported that adults and grubs of the coccinellid, *Thea cincta* Fab. (*Illeis cincta*) were found to feed on the powdery mildew fungus, *Oidium lini* infecting linseed^[18], powdery mildew fungus *Sphaerotheca* sp. infecting niger at Madhya Pradesh^[8] and also on the powdery mildew fungus *Erysiphe cichoracearum* infecting sunflower at Maharashtra^[16] and Bengaluru, Karnataka^[10].

Correspondence

Jagadish KS
Department of Agricultural
Entomology, University of
Agricultural Sciences, GKVK,
Bengaluru, Karnataka, India

Kumar *et al.* [13] observed that the coccinellid, *Psylloborina bisoconotata* (Muls.) were seen on all parts of the plant, however, adults and grubs and were more congregated on the older (lower) and heavily infected leaves of mulberry (*Morus alba* L.) and *Dalbergia sissoo* Roxb. The cosmopolitan genus *Psyllobora* Chevrolat is represented in natural and managed systems in temperate and sub-tropical regions of the world and may be used as biological control agents of powdery mildew [7, 2]. The coccinellid beetle, *Halyzia hauseri* was found feeding on the powdery mildew fungi, *Phyllactinia corylea*, *Podosphaera leucotricha* and *Erysiphe cichoracearum*. In China, 95.2 per cent control of powdery mildew was obtained on apple leaves in 20 days. Control by another coccinellid, *Vibidia duodecimguttata* reached 84.0 per cent [20]. At Kerala, India, Krishnakumar and Maheswari [14] observed that mulberry plants, on which five pairs of *I. cincta* beetle were released, showed less powdery mildew infection and it was on par with those plants on which 4, 3 and 2 pairs of beetles were released. The percentage disease control was also highest when coccinellids were released than when the fungicide dinocap (2%) and neem oil (2%) were sprayed to infected plants. Though Krishnakumar and Maheswari [14] demonstrated that *I. cincta* and *I. bistigmosa* (Muls.) could effectively suppress powdery mildew infection in mulberry, another report by Patankar *et al.* [17] wherein the gut contents of two coccinellids viz., *I. cincta* and *P. bisoconotata* were analysed, it was observed that spores of *Phyllactinia dalbergiae*, *P. corylea*, *Cladosporium* spp., *Alternaria* spp. and *Curvularia* spp. were found in large numbers and intact in the gut, besides they were also found to be in the germinating condition in the gut and faecal pellets. Thus, Patankar *et al.* [17] advocated that the utilization of these beetles in bio-control of powdery mildew needs to be done cautiously.

However, looking into the devastating nature of powdery mildew infection on sunflower cultivation in our state during the last couple of years and the intense mycophagous activity of *I. cincta* on the powdery mildew fungus, the present objective of the investigation was conducted in order to know the spatial distribution pattern of this coccinellid in sunflower canopy.

2. Materials and Methods

The cytoplasmic male sterile entries of sunflower which were sown on 5th July, 2012 at the Main Agricultural Research Station, UAS, Hebbal, Bengaluru exhibited very severe incidence of both the powdery mildew fungus and its predatory beetle, *I. cincta* on 11th October, 2012 which coincided with the seed filling stage of the crop. In order to determine the within plant distribution pattern of *I. cincta* in relation to powdery mildew, the present investigation was conducted.

The different life stages of the beetle (*viz.*, egg masses, grubs, pupae and adults) were counted in two top, two middle and two bottom canopy leaves in 50 randomly selected plants. In addition to this, the powdery mildew disease severity was also recorded in the same leaves in which the predator counts were taken by observing the percentage of the leaf area covered by the disease, through visual observation by using the disease rating scale of 0-9, as suggested by Anon. [3].

3. Statistical analysis

The counts taken on the egg masses, grubs, pupae and adults of *I. cincta* were subjected to Pearson's correlation analysis (2-tailed) with the powdery mildew disease severity in the

top, middle and bottom leaves of the crop canopy and further conclusions were drawn. The Pearson's correlation analysis (2-tailed) were carried out by using SPSS-20 (Statistical Package for the Social Sciences (SPSS) software through bivariate statistical analysis.

4. Results and Discussion

The present study results clearly indicated that the maximum number of the individual life stages of *I. cincta* (*i.e.*, egg masses, grubs, pupae and adults) and the total number of all the life stages of the beetle (40.10 ± 19.43) as well as highest disease severity (7.45 ± 1.49) were found at the lower canopy of the crop, as compared to the middle (20.00 ± 12.22 & 4.60 ± 2.03 , respectively) and top (6.40 ± 5.81 & 1.25 ± 1.33 , respectively) level canopy of the crop. The present findings are in close conformity with that of Kumar *et al.* [13] who observed that the adults and grubs of the coccinellid, *Psylloborina bisoconotata* (Muls.) were congregated in more numbers on the older (lower) and heavily infected leaves of mulberry (*Morus alba* L.) and *Dalbergia sissoo* Roxb.

The mean number of the different life stages of *I. cincta* across the 3 different canopy levels showed that the grubs were in maximum numbers (13.63 ± 8.08), followed by adult beetles (4.36 ± 2.25), pupae (2.85 ± 2.77) and egg masses (1.50 ± 1.00) in that decreasing order (Table 1). The results were conformity with findings of Karuna *et al.* [12] who reported that the population of *I. cincta* was dependent on the severity of the disease and the population of grubs of *I. cincta* was more than the adults. The highest total population of beetles (32 per plant) was recorded with 66.10% powdery mildew and the lowest (1.24 per plant) was recorded when the disease severity was low (1.41 percent). All stages (Plate 2) egg batches (0.83), larvae (26.75), pupae (2.92) and adults (1.59) were in higher numbers when the disease severity was 66.10%. Both adults and larvaewere found feeding on the powdery mildew conidia.. Likewise, Bhuvaneshwari, *et al.* [6] who reported all stages of the mycophagous coccinellid, *Illeis cincta* (Fab.) were observed in appreciable numbers on the leaves of red gram (6-8grubs/leaf) and castor feeding on powdery mildew fungus at Thondamuthur, Coimbatore district, Tamil Nadu, India. Other entomologists from India also reported that adults and grubs of the coccinellid, *Thea cincta* Fab. (*Illeis cincta*) were found to feed on the powdery mildew fungus, *Oidium lini* infecting linseed [18], powdery mildew fungus *Sphaerotheca* sp. infecting niger at Madhya Pradesh [8] and also on the powdery mildew fungus *Erysiphe cichoracearum* infecting sunflower at Maharashtra [16] and Bengaluru, Karnataka [10].

4.1 Correlation between spatial distribution of different life stages of *Illeis cincta* and powdery mildew disease in different canopy levels of sunflower crop.

4.1.1 Lower Canopy

The correlation between the number of different life stages of *I. cincta* with powdery mildew disease severity revealed that the number of grubs, pupae, adult beetles and the total number of all life stages *I. cincta* were positively correlated with the disease severity, whereas the number of egg masses were negatively correlated with disease severity, however, none of these correlation co-efficient were found to be statistically significant (Table 2). The results were agreements with findings of Jagadish *et al.* [10] found a positive correlation between the severity of powdery mildew and *Illeis cincta* in sunflower.

4.1.2 Middle Canopy

The correlation analysis between the numbers of different life stages of *I. cincta* with powdery mildew severity revealed that the number of egg masses, grubs, pupae and the total number of all life stages of *I. cincta* were positively correlated with the powdery disease severity, whereas the number of adult beetles was negatively correlated with disease severity. However, the number of grubs (0.654*) and the total number of all life stages of *I. cincta* (0.680*) were significantly positively correlated with powdery mildew severity, whereas the other life history parameters of *I. cincta* were not significantly correlated with the disease (Table 3). The results were agreements with findings of Jagadish *et al.* [10] and Kumar *et al.* (2010) reported the feeding potential of the ladybird beetle, *Psylloborini bisoconotata* the instars were ranked as third, fourth, adults, second and first with third instar being the most voracious and with terrific feeding rates. They found that the adults were seen on all parts of the plants while the grubs were more aggregated on the leaves affected with powdery mildew. They were found on the lower surface of the leaves during the period of bright sun. Population of

adults ranged from 5-12 per plant. The later instars and adults were also more prevalent on older and heavy infested leaves.

4.1.3 Top Canopy

The correlation between the number of egg masses, pupae and adults of *I. cincta* with powdery mildew severity was negative but non significant. However, the number of grubs (0.913**) was highly significantly (P=0.01) and positively correlated with powdery mildew severity. The total number of all life stages of *I. cincta* was positively correlated with powdery mildew severity; however, this correlation was statistically not significant (Table 4).

In relation to correlation coefficient between the number of egg masses, pupae and adults of *I. cincta* with powdery mildew severity, there was no work carried out by earlier workers. However, the similar results were agreement with the findings of Kumar *et al.* [13] who observed that the adults and grubs of the coccinellid, *Psylloborina bisoconotata* (Muls.) were congregated in more numbers on the older (lower) and heavily infected leaves of mulberry (*Morus alba* L.) and *Dalbergia sissoo* Roxb.

Table 1: Spatial distribution of *I. cincta* in relation to powdery mildew infection

No. of life stages of <i>I. cincta</i> / disease severity	Different levels of the crop canopy			
	Lower	Middle	Top	Mean
Egg masses	2.90 ± 2.90	1.00 ± 1.70	0.60 ± 1.11	1.50 ± 1.00
Grubs	23.60 ± 15.98	13.50 ± 11.24	3.80 ± 5.14	13.63 ± 8.08
Pupae	6.65 ± 4.43	1.80 ± 2.13	0.10 ± 0.30	2.85 ± 2.77
Adults	7.40 ± 5.75	3.70 ± 3.30	2.00 ± 2.42	4.36 ± 2.25
Total of all life stages of beetle	40.10 ± 19.43	20.00 ± 12.22	6.40 ± 5.81	22.16 ± 13.84
Powdery mildew severity	7.45 ± 1.49	4.60 ± 2.03	1.25 ± 1.33	4.43 ± 2.53

Table 2: Correlation between spatial distribution of different life stages of *Illeis cincta* and powdery mildew disease in lower level canopy of sunflower.

No. of life stages of <i>I. cincta</i> / disease	Powdery mildew severity	Life stages of <i>Illeis cincta</i>				
		Egg mass	Grubs	Pupa	Adults	Total of all the stages
Powdery mildew Disease	1.000	-	-	-	-	-
Egg mass	-0.002	1.000	-	-	-	-
Grubs	0.482	0.018	1.000	-	-	-
Pupa	0.528	-0.234	-0.171	1.000	-	-
Adults	0.213	0.524	0.344	0.146	1.000	-
Total of all stages	0.581	0.241	0.926**	0.033	0.631	1.000

n = 50; * - Correlation is significant at the 0.05 level (2-tailed)

** - Correlation is significant at the 0.01 level (2-tailed)

Table 3: Correlation between spatial distribution of different life stages of *Illeis cincta* and powdery mildew disease in middle level canopy of sunflower.

No. of life stages of <i>I. cincta</i> / disease	Powdery mildew severity	Life stages of <i>Illeis cincta</i>				
		Egg mass	Grubs	Pupa	Adults	Total of all the stages
Powdery mildew	1.000	-	-	-	-	-
Egg mass	0.268	1.000	-	-	-	-
Grubs	0.654*	0.307	1.000	-	-	-
Pupa	0.161	-0.326	-0.469	1.000	-	-
Adults	-0.006	0.325	0.061	-0.137	1.000	-
Total of all the stages	0.680*	0.451	0.928**	-0.400	0.386	1.000

n = 50; * - Correlation is significant at the 0.05 level (2-tailed)

** - Correlation is significant at the 0.01 level (2-tailed)

Table 4: Correlation between spatial distribution of different life stages of *Illeis cincta* and powdery mildew disease in top level canopy of sunflower.

No. of life stages of <i>I. cincta</i> / disease	Powdery mildew severity	Life stages of <i>Illeis cincta</i>				
		Egg mass	Grubs	Pupa	Adults	Total of all the stages
Powdery mildew Disease	1.000	-	-	-	-	-
Egg mass	-0.222	1.000	-	-	-	-
Grubs	0.913**	-0.121	1.000	-	-	-
Pupa	-0.210	-0.452	-0.165	1.000	-	-
Adults	-0.044	0.365	0.202	-0.421	1.000	-
Total of all the stages	0.602	0.238	0.807**	-0.350	0.724*	1.000

n = 50; * - Correlation is significant at the 0.05 level (2-tailed)

** - Correlation is significant at the 0.01 level (2-tailed)

5. Conclusion

From the present investigation on spatial distribution pattern of *I. cincta*, the population was distributed all over the plants, but more grubs were observed on lower canopy. The *I. cincta* population was positive correlation with powdery mildew disease severity irrespective of the sunflower canopy levels. Apart from all stages of *I. cincta* the population of grubs was more in all canopy levels as compare to adults. Hence, it is very much required to know the predatory potentiality of the beetle on Sunflower powdery mildew diseases fungus, which is essential for devising eco-friendly and sustainable management options for this disease in sunflower.

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