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Population dynamics of pod fly, *Melanagromyza obtusa* (Malloch) and its natural enemies on pigeonpea

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ABSTRACT: On pigeon pea pod fly infestation often noticed in the *Kharif* crop during 2022-23 and 2023-24, along with its other defoliating insects, although it persists up until the crop has been harvested. First appearance of *M. obtusa* larvae and pupa was observed in the 41st and 39th meteorological standard week (MSW). The peak larval population of 52.00 and 41.00 larvae per 100 pods was noticed in the 44th MSW at both years, while the peak pupal population of 49.00 and 40.00 pupae per 100 pods was seen during the 50th and 45th MSW. The study showed presence of two hymenopteran parasitoids viz., *Euderus lividus* (Ashmead) and *Ormyrus orientalis* (Walker) on the pigeon pea major pest, *Melanagromyza obtusa* (Malloch). The parasitism level of *E. lividus* declined from 31.82 to 10.53 and 29.72 to 7.14 per cent from 46th up to 52nd MSW and 45th up to 50th MSW, respectively. Higher pupal parasitism of *O. orientalis* was recorded in 47th (25.64%) and 44th (24.32%) MSW; While low parasitism was noted in 1st (3.22%) and 51st (3.84%) MSW at both years. Above all, correlation between weather parameters, with pod fly larvae and pupae showed that the larval population exhibited a significant positive relation with maximum temperature (r=0.646*) and (r=0.746**) at both years. The natural enemies, *E. lividus* and *O. orientalis* of *M. obtuse,* would improve the biological control of the pest population.

KEY WORDS: Hymenopteran parasitoids, *Euderus lividus, Ormyrus orientalis*, weather parameters, correlation

INTRODUCTION

Pigeon pea, *Cajanus cajan* (Millsp.) is the most significant and nutritious pulse (Sarkar *et al*., 2020). Pigeon pea is India's second-most significant pulse crop after gram and contributes to nearly ninety percent of the world's pigeon pea production. In India pigeon pea is cultivated in area of 5.05 million ha with an annual production of 4.34 million tonnes result on average yield is 859 kg per ha (Anonymous, 2022). The average yield per ha was 1014 kg in Punjab state (Anonymous, 2023). Pigeon pea associated bacteria benefit the soil through the symbiotic nitrogen fixation. This inclusion of pigeon pea in crop rotation aims to ensure the long-term preservation of soil health and fertility. Pigeon pea is a rich source of protein (21.71%), minerals (3.5%), and carbohydrate (57.6%) for vegetarian population Khamoriya *et al*. (2017).

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The pod fly, *Melanagromyza obtusa* (Malloch) (Diptera, Agromyzidae) is most obnoxious pest, leading to grain losses ranging from 20 to 80 percent due to its destructive impact (Sreekanth *et al*., 2020). Its infestation leads to significant loss of the pods and seeds of pigeon pea, resulting in reduced germination rate and rendering them unsuitable for human consumption or any other purpose (Hadiya *et al*., 2020). Pod fly oviposition occurs in tender pods and inner surface of the pods. The larvae feed on the seeds and pupate inside the pods Nair *et al*. (2017). Pod fly laid fewer eggs in December and January when temperatures are low. Pod fly population increases with temperature raise Chiranjeevi and Patange (2018). The female pod fly lays up to 80 eggs into maturing green pods. Such pods don't exhibit any visible signs of damage until the larvae emergence and same cause shot-holes in the pod walls upon maturity. Typically, one maggot requires only a single seed for its development Yadav *et al*. (2016). After hatching, the larva burrows into the pods and feeds upon tender seeds, rendering them unfit for both human consumption and further propagation. The pod fly, being an internal feeder, inhabits both larval and pupal stages within the pod wall, leaving behind a fragile papery membrane. Inside the pod, the larvae consume the developing seeds, followed by pupal development Patange *et al*. (2017). This perforation serves as an exit point for the adult flies as they emerge from the pod as described by Kumar *et al*. (2015). Egg phase typically ranges from 3 to 5 days followed by larval development duration of 6 to 11 days and further the pupal stage extends from 9 to 23 days. Yadav *et al*. (2020) also discovered that the adult insects have a lifespan of about 6 days without nourishment, but this extends to 12 days when they provided with food. Such newly emerged young ones are small and black colored. Dry pigeon pea pods exhibit one or more perforations on upper surface, indicating infestation. Seeds within infested pods appear desiccated, wrinkled, and partially consumed Sharma and Keval (2021). Various workers have established that more than 20 Hymenopteran parasitoids on this pest (Yadav and Yadav, 2011). The incidence of parasitism of *M. obtusa* was studied by several workers Yadav *et al*. (2012). Studies were undertaken to observe population dynamics of pod fly and its natural hymenopteran parasitoids, *Euderus lividus* (Ashmead, 1886) (larval ecto-parasitoid) belonging to Eulophidae and *Ormyrus orientalis* Walker, 1871 (larval-pupal endo-parasitoid) (Ormyridae) in Punjab state.

MATERIALS AND METHODS

The experiment was conducted at Experimental Research Farm of Lovely Professional University, Punjab, India during 2022-2023 and 2023-24 in a Randomized Block Design with seven treatments and three replications, to observe population dynamics of pod fly and its natural hymenopteran parasitoids. In Punjab state UPAS-120 variety of pigeon pea crop was cultivated in the mid of June with recommended agricultural practices by PAU, Ludhiana (Bisen *et al*., 2023). The variety is early sown high yield variety is not check in Punjab against pod fly. The pigeon pea variety UPAS-120 was grown in normal field condition by spacing 20 X 90 cm as per recommendation of PAU. No synthetic chemicals were applied to protect crop from natural incidence of pod fly and its parasitoids. The population of pod fly and parasitoids were weekly recorded from pod formation to maturity of crop. The immature stages (larval and pupal) along with its pod damage were counted on randomly collected 100 pods were plucked by selecting 5 plants at weekly interval in each replication (Tiwari *et al*., 2006; Yadav and Yadav, 2013). The healthy and damaged pods in pigeon pea crops were regularly monitored by dissecting each pod in the laboratory and placing them in glass vials (capacity of 30 ml) covered with muslin cloth. Larvae and pupae collected were kept at room temperature until the emergence of *M. obtusa* and various parasitoids. Number of pod fly larvae and pupae within each pod was recorded.

Correlations between the population of pod flies (larvae and pupae), parasitoids *E. lividus* and *O. orientalis* with various abiotic factors such as maximum temperature, minimum temperature, relative humidity and rainfall were worked out (Shankar *et al*., 2021). The pod fly infestation was

Table 1. Natural parasitoids associated with *Melanagromyza obtusa* (Malloch) during *Kharif*, 2022-23

SMW	Pod damage/ 100 pods	Larvae	Pupae	Emergence(%)		Temperature (°C)		Rh (%)		Rainfall (mm)
				E. lividus	*O. orientalis*	Max.	Min.	Max.	Min.	
41	29	16	10	0.00	0.00	32.00	23.00	59.00	43.00	0.00
42	42	27	28	0.00	0.00	31.00	20.00	56.00	46.00	0.00
43	56	34	30	11.76	0.00	29.00	18.00	53.00	43.00	0.00
44	78	52	32	17.31	9.37	34.00	19.00	56.00	42.00	0.00
45	69	47	28	25.53	17.86	24.00	18.00	59.00	49.00	0.20
46	79	44	41	31.82	21.95	28.00	13.00	52.00	47.00	0.00
47	72	48	39	22.91	25.64	28.00	19.00	81.00	76.00	0.00
48	65	36	42	25.00	21.43	25.00	11.00	89.00	77.00	0.00
49	70	41	45	12.19	13.33	26.00	9.00	89.00	61.00	0.00
50	68	32	49	18.75	8.16	25.00	10.00	97.00	65.00	0.00
51	57	22	46	13.64	4.35	24.00	9.00	90.00	79.00	0.00
52	43	19	27	10.53	3.70	21.00	9.00	98.00	88.00	2.00
1	31	11	31	0.00	3.22	12.00	6.00	98.00	86.00	0.00
2	17	5	8	0.00	0.00	12.00	10.00	94.00	86.00	0.00

*No incidence of pod fly on pigeonpea crop at 3rd Standard Meteorological Week of 2022-23

calculated during maturity stage. Correlation analysis by OPSTAT software. As a result, the information on parasitoids emerging from the host fly stages (larvae and pupae of *M. obtusa*) was appropriately processed to determine the percentage of parasitism and interpret the results. The following formula is used to find the percentage of parasitism Patange *et al*. (2017).

RESULTS AND DISCUSSION

During the kharif crop 2022-23 and 2023-24 the incidence of pest started with the development of pod and continued to the maturity throughout the reproductive stage of crop. The larval population was started at 16.00 and 14.00 larvae per 100 pods during the 41st and 39th SMW of both years which increased at peak level 52.00 and 41.00 larvae per 100 pods by the 44th SMW at that time maximum temperature of 34.00 and 31.32 °C, while minimum temperature of 19.00 and 13.30 °C, maximum relative humidity of 56.00 and 94.01 percent and minimum relative humidity of 42.00 and 45.82

Table 2. Correlation between the population of pod fly with weather parameters 2022-23.

factor	Temperature °C		RH (%)		Rainfall (mm)
	Max.	Min.	Max.	Min.	
Damage Pods	0.550*	0.116	-0.276	-0.360	-0.161
Larvae	0.646*	0.380	-0.472	-0.515	-0.203
Pupae	0.198	-0.370	0.217	0.075	-0.140
E. lividus	0.313	0.018	-0.186	-0.160	-0.049
O. orientalis	0.194	0.021	-0.051	0.003	-0.146

* = significant at 5% level

percent. Eventually, the larval population decreased to 5.00 and 9.00 larvae in the 2nd and 52nd SMW. The pupal population of *M. obtusa* (10.00 and 7.00 pupae/ 100 pods) was observed from the 41st and 40th SMW; Which showed increasing trend, progressively, peaked at 49.00 and 40.00 pupae per 100 pods on the 50th and 45th SMW at maximum temperature of 25.00 and 29.00 °C, minimum temperature of 10.00 and 13.57 °C, maximum relative humidity of 97.00 and 93.23 percent, minimum relative humidity of 65.00 and 47.22 percent and rainfall of 0.60 mm (in 2023-24). When the temperature was very low then population decreased to 8.00 and 14.00 pupae in the 2nd and 1st SMW. Pod damage symptoms appeared on the 41st and 39th SMW in 29 and 25 percent. Increased gradually pod damage peaked on the 46th (79%) and 44th (73%) SMW with maximum temperature of 28.00 and 34.30 °C, minimum temperature of 23.00 and 19.96 °C, maximum relative humidity of 59 and 92.65 and minimum of 43.00 and 65.50 percent then population declined to 17 and 19 percent on the 2nd and 1st SMW of both years (Table 1, 3).

The findings from the current study regarding the population dynamics of the pod fly, *M. obtusa* and its impact on pigeon pea align closely with the reports of Pillai and Agnihotri (2013), indicating the highest activity of the pod fly occurred around the 46th SMW, whereas the lowest population of *M. obtusa* (31 per 100 pods) during the 49th standard week. Similarly, Patange *et al*. (2017) reported that the pod fly was first time noticed in the 48th SMW, while pods (26.00%) infestation with larvae and pupae were observed during that period. According to Chiranjeevi and Patange (2018) found that the larvae of the pod fly were initially detected during the 44th SMW with an infestation rate of 11.00 larvae, reaching a peak of 125.00 larvae during the 3rd SMW; and the larval parasitism level of pod fly from 43rd and 41st SMW on the 11.76 and 4.17 percent, which increased at 46th and 45th SMW with 31.82 and 29.72.

The pupal parasitization of *M. obtusa* was identified during 44th SMW (9.37%) and 42nd SMW (11.53%), which increased gradually until reach a peak stage i.e. 25.64 and 24.32 percent with 47th and 44th SMW during both years with maximum temperature of 28.00 and 31.32 °C, minimum temperature of 19.00 and 13.30 °C, maximum relative humidity of 81.00 and 94.01, minimum relative humidity of 76.00 and 45.82 percent. Along with decrease in temperature, the percentage of pupal population also decreased in 1st SMW with 3.22 percent. similarly next year 2023-24, the percentage of pupal population also decreased in 51st SMW with 3.84 percent with decreased in temperature. The pupal parasitization level was observed nil during the 2nd and 52nd SMW of 2022-23 and 2023-24 (Table 1, 3). According to Chakravarty *et al*. (2016), noted the presence of *O. orientalis* on pod flies. The highest natural

Table 3. Natural parasitoids associated with *Melanagromyza obtusa* (Malloch) during *Kharif*, 2023-24

SMW	Pod damage/ 100 pods	Larvae	Pupae	% of Emergence		Temperature (°C)		Rh (%)		Rainfall (mm)
				E. lividus	*O. orientalis*	Max.	Min.	Max.	Min.	
39	25	14	0	0.00	0.00	34.30	19.96	92.65	65.50	0.00
40	32	26	7	0.00	0.00	34.03	17.42	92.38	51.33	0.20
41	41	27	13	4.17	0.00	32.51	16.32	92.81	45.53	0.00
42	43	29	26	13.79	11.53	28.31	13.12	92.79	51.68	0.80
43	52	35	30	22.85	23.33	31.16	12.36	92.95	35.87	0.00
44	73	41	37	24.39	24.32	31.32	13.30	94.01	45.82	0.00
45	65	37	40	29.72	22.50	29.05	13.57	93.23	47.22	0.60
46	61	30	32	23.33	18.75	27.06	10.20	93.84	49.26	0.00
47	53	22	37	9.09	10.81	26.70	7.38	92.48	40.96	0.20
48	40	21	28	0.00	17.85	22.70	10.10	91.20	59.70	0.20
49	44	17	34	11.76	8.82	23.33	9.44	94.00	47.00	0.00
50	33	14	25	7.14	4.00	20.55	7.77	94.00	52.00	0.00
51	34	8	26	0.00	3.84	21.11	6.66	97.00	57.00	0.00
52	21	9	21	0.00	0.00	16.66	10.55	95.00	74.00	0.00
1	19	0	14	0.00	0.00	10.00	7.22	94.00	87.00	0.00
2	0	0	0	0.00	0.00	11.11	5.55	94.00	80.00	0.00

* No incidence of pod fly on pigeonpea crop at 2nd Standard Meteorological Week of 2023-24
(The Meteorology Department of Lovely Professional University, Punjab Meteorological data)

parasitization percentage (17.39%) of *M. obtusa* by these parasitoids occurred during the 51st MSW at maturity stage of crop. These results are in accordance with Chiranjeevi and Patange (2018) documented the initial observation of larval and pupal parasitization during the 46th (SMW) by *E. lividus* (41.18%) and *O. orientalis* (18.75%) with observed during the 48th MSW. Yadav *et al*. (2020) reported that parasitization in the pod fly ranged between from 14.28 to 25.71 per cent. There was an increase in parasitization during the first fortnight of March, reaching its peak at 25.71 per cent.

The correlation between abiotic factors and pod fly, ratios of larval, pupal population, indicate (Table 2, 4) that the damaged pods showed a maximum positive correlation (r=0.550*) with the maximum temperature in 2022-2023. Conversely, the relative humidity had a significant negative correlation (r=0.744**) with maximum temperature in 2023-2024. The findings were similar for the larval population of pod fly in 2022-2023 (r=0.646*), indicating a significant positive correlation with the maximum temperature. However, in 2023-2024 there was an even significant positive correlation

Table 4. Correlation between the population of pod fly with weather parameters 2023-24.

factor	Temperature °C		RH (%)		Rainfall (mm)
	Max.	Min.	Max.	Min.	
Damage pods	0.482	0.027	-0.149	-0.744**	0.246
Larvae	0.746**	0.420	-0.403	-0.776**	0.376
Pupae	-0.091	-0.541*	0.127	-0.513	0.245
E. lividus	0.360	0.035	-0.055	-0.612*	0.303
O. orientalis	0.287	-0.084	-0.219	-0.564*	0.276

* = significant at 5% level

(r=0.746**) between both years. Similar type of results was also reported by Chakravarty *et al*. (2016) it revealed that there was a positive significant correlation with maximum temperature (r=0.746*). While according to, Yadav *et al*. (2011) observed that the larval population began to increase when the maximum temperature fell below 32°C, reaching its highest point before subsequently decreasing. In the 2022-23 year, the pupal population of pod flies had non-significant positive correlation (r=0.198) with the maximum temperature, but in the following year, 2023-24 there was negative significant correlation (r=-541*) with minimum temperature. Patange and Chiranjeevi (2017) reported that the data analysis revealed a moderate negative correlation (r=-0.4387) between the pupal population of *M. obtusa* and the maximum temperature. Whenever temperature rises, there is a decrease in the pupal population of pod fly. During 2022–2023, larval parasitization (*E. lividus*) of pod fly was showed non-significant positive correlation (r=0.313) with maximum temperature. However, in 2023-24 there was a showed negative correlation (r=-0.612*) with the minimum relative humidity. The pupal parasitization (*O. orientalis*) of pod flies exhibited a non-significant correlation (r=0.194) with the maximum temperature of 2022-2023. While, the pupal population of pod fly in 2023–24 demonstrated a negative significant connection (r=-0.564*) between the minimum relative humidity. The study is according to previous researcher Yadav *et al.* (2012), which identified four species of hymenopteran parasitoids namely *E. lividus*, *O. orientalis*, *Eurytoma* sp and *Pseudotorymus* sp. Makinson *et al*. (2005) conducted the initial rearing of two parasitoids, namely *Callitula* sp. (Hymenoptera, Pteromalidae) and *Ormyrus* sp. (Hymenoptera, Ormyridae) from *M. obtusa* found on *Cajanus latisepalus* pods in Australia. The current results align that those reported by Dar *et al*. (2005) indicating that *O. orientalis*, a parasitoid species was identified as the primary parasitoid of the pod fly. The current results partially coincide with the research conducted by Chakravarty *et al*. (2016), where it was shown that *E. lividus* and *O. orientalis* was detected in association with pod fly. The highest natural parasitization rate (31.82 and 25.64%) of *M. obtusa* by these parasitoids occurred during the 46th and 47th SMW period. It is concluded that the emergence of two parasitoids of *M. obtusa* (Malloch) viz., *E. lividus* (31.82%) and *O. orientalis* (25.64%) are effective to reduce pod fly population.

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