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Ocurrence of leaf folder, *Cnaphalocrosis medinalis* (lepidoptera: pyralidae)-A major pest of rice in eastern Vidarbha (Maharashtra)

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Abstract
A pest complex of about 23 insect pests belonging to 7 orders and 14 families was recorded and identified during both *kharif* and *rabi* seasons. Among the lepidopteran pest species, a leaf folder, *Cnaphalocrosis medinalis* was infesting rice crop very commonly causing major damage and thus representing major pest status. The peak density of *C. medinalis* in the *kharif* season was much higher than that of the *rabi* season. The damage was severe in the later stage of the crop growth, particularly in shady areas.
The correlation analysis study showed that *C. medinalis* and its damage had significantly positive correlation with maximum and minimum temperatures and wind velocity during *rabi* season, whereas *it* showed highly significant negative correlation with minimum temperature and relative humidity during *kharif* season. The linear regression equations derived from the present study may helpful in predicting the occurrence of this pest in rice ecosystem of this region.

Keywords: Correlation, *Cnaphalocrosis medinalis*, linear regression, peak density, rice pests, Vidarbha

Introduction
The insect pests are one of the major yields limiting biotic factors for rice crop throughout the world. About 300 species of insects in India have been reported to attack rice crop, of which 20 have been reported as the major pests (Pathak, 1977, Arora and Dhaliwal, 1996) [2, 16] causing 21 to 51 percent yield losses (Singh and Dhaliwal, 1994) [20]. Some attempts have been made to study the incidence of rice pests and their natural enemies in other states of India such as Andhra Pradesh, Punjab, Gujarat, Karnataka, Bihar and Uttaranchal (Brar *et al*., 1994; Pandya *et al*., 1995; Naganagoud *et al*., 1999; Rai *et al*., 2000; (Pushpakumari & Tiwari, 2005) [5, 12, 13, 17, 18], but there was no information on the occurrence of minor pest, *Cnaphalocrosis medinalis* in relation to climatic conditions of eastern Vidarbha (Maharashtra), especially Bhandara and Gondia districts, rice bowls of state. The present paper describes the occurrence of a major pest, *C. medinalis* and its population fluctuations in relation to climatic conditions of this region.

Materials and Methods
Rice crop in eastern Vidarbha is grown in monsoon and summer seasons one after the other and called as *kharif* and *rabi*, respectively. The survey of leaf folder, *Cnaphalocrosis medinalis* was carried out in the farmer's fields of Bhandara and Gondia districts during both *kharif* (monsoon crop) and *rabi* (summer crop) rice seasons from 2019 to 2020.
Regular monitoring of the occurrence and abundance of leaf folder, *C. medinalis* in rice fields was made visually as well as by hand collection or by hand in 1 x 1 quadrate sample from five randomly selected spots in the field.
The population *C. medinalis* was estimated at weekly interval in 1x1m quadrate from five randomly selected spots in each field site under study. Its population and damage were assessed by counting the adults and folded leaves per m^2. Simultaneously information on weather parameters was also collected from near by meteorological department. The statistical analysis of the data and weather parameters were carried out by Pearson correlation and bilinear regression by using software SPSS 7.0 version.

Results and Discussions
During both *rabi* and *kharif* seasons, a pest complex of about 23 insect pests belonging to 7 orders and 14 families was recorded and identified. It consisted of 11 lepidopteran, 5 homopteran, 2 each of heteropteran and coleopteran and 1 each of dipteran, thysanopteran and orthopteran species. Among the defoliators, leaf folder, *Cnaphalocrosis medinalis* (Fig. 13,14,15, and 16) was observed as the major pests during both *rabi* and *kharif* seasons causing considerable damage to rice crop as a leaf folder. The larva folds the leaf and scrapes the green tissues from within and cause scorching and leaf drying. One larva can destroy several leaves by its feeding. Under heavy infestation, each rice plant has several rolled leaves, which severely restricts the photosynthetic activity. In Gujarat the major pests during summer and wet-season crop were *S. incertulus* and *C. medinalis* while *Pelopidas mathias* and *Dicladispa armigera* were minor pests (Pandya *et al.*, 1995) [13].

Fig 1: Leaf folder- 13. Adult mot, 14. Caterpillar larva, 15, Pupa, and 16. Damage caused by larva

The overall population growth rate and peak density of *C. medinalis* in the *kharif* season were much higher than that of the *rabi* season. The damage was severe in the later stage of the crop growth, particularly in shady areas. Misuse of insecticides and excessive use of nitrogenous fertilizers have been cited as the cause for high *C. medinalis* populations (Dhaliwal *et al*., 1979) [7].

The infestation of *C. medinalis* was evidenced throughout the year in both *rabi* and *kharif* season but the degree of infestation was varied (Table 1,2 & 3,4). During *rabi* 2019 occurrence of adults started from 3rd week of March reaching highest peak (1.8 adults/m^2) at 91 DAT (May 1st week). The leaf damage was evidenced from April 3rd week (77 DAT) and reached to its highest in May 1st week (91 DAT). However, in *kharif* 2019 the occurrence of adults and leaf damage was simultaneously observed in the last week of August (14 DAT) and continued till the harvest of the crop. The adult population was dominating in October (11.2 adults/m^2) and the leaf damage was highest in the month of November (20.2 damaged leaves/m^2).

In *rabi* 2020 the adult population and leaf damage were negligible till April 3rd week (77 DAT) and a very low population of adults (0.4 adults/m^2) was appeared from last week of April to middle of May. During this period the leaf damage at the rate of 1.2 to 1.6 leaves/m^2 was noticed. This type of population trend was also existed in *kharif* 2020 where negligible number of adults and leaf damage was evidenced till October 1st week (42 DAT). Thereafter, the adult population and leaf damage appeared in very low proportion as compared to *kharif* 2019 till the harvest of crop. This trend of population in 2019-2020 indicated that *C. medinalis* was a major and sporadic pest of rice ecosystem of this region. Moreover, its infestation was always high in *kharif* season mainly in October as compared to *rabi* seasons. The collection of maximum number of moths in the month of September-October in the trap catches was reported in Gujarat (Upadhyay *et al*. 1981; Khorat & Pathak, 1996) [9], Japan (Miyahara, 1990) [11, 22], Madhya Pradesh (Bhatnagar *et al*., 1999) [4] and in Pakistan (Alvi *et al*. 2003) [1]. However, Puspakumari and Tiwari (2005) in their one-year study of *C. medinalis* population trend and leaf damage reported the highest leaf damage in 3rd week of August, which decline in subsequent weeks. Thereafter they could not record the adult population in the field from September to 3rd week of October but the adults appeared in October last week and continued till November 1st week, causing most of the damage in flag leaves.

Outbreaks of *C. medinalis* were earlier reported from India (Yadava *et al*., 1972 & Chatterjee 1979) [6, 24], Southern Japan (Hirao 1981) [8] and Vietnam (Bautisa *et al*., 1984). Dhaliwal *et al*. (1979) [7] cited the misuse of insecticides and excessive use of nitrogenous fertilizers as the cause for high leaf folder population. According to Regupathy and Subramanian (1972) [19] a combined application of high doses of NPK alters the metabolism of rice plants in favour of *C. medinalis* development and multiplication. The incidence of LF was positively correlated to the level of nitrogen fertilizers (Regupathy & Subramanian, 1972; Michael Raj & Morachan, 1973; Subhaia & Morachan, 1974; and Upadhay *et al*. 1981) [10, 19, 21]. In this region the use of nitrogenous fertilizers might be one of the reasons for the incidence of *C. medinalis* as it was the routine practice of addition of chemical fertilizers by the farmers.

The high humidity and optimum temperature are the conducive ecological factors for the rapid multiplication of *C. medinalis* (Pathak, 1975) [15]. According to Wada and Kobayashi and Shimazu (1980) [23] the threshold temperatures for development of egg, larva and pupa are 12.5, 12.2, and 14.2 ºC, respectively. Bhatnagar *et al*. (1999) [4] reported that it exhibited a significant negative correlation with minimum temperature, evening RH and rain fall and a positive significant correlation with maximums temperature and sun shine hours. In the present study it exhibited a significant negative correlation with minimum temperature, morning, and evening RH during *kharif* seasons, whereas it showed a significant positive correlation with maximum and minimum temperatures during *rabi* seasons (Table 5 & 6).

Table 1: Population fluctuation of Leaf Folder (LF), *C. medinalis* during *Rabi*, 2019

Month & Week	DAT	Mean Population of LF/hill		Weather Parameters			
				Temperature (°C)		Relative Humidity (%)	
		Adults	Damaged leaves	Max.	Min.	Morning	Evening
Feb. II	7	0.0	0.0	27.5	21.5	74	66
Feb. III	14	0.0	0.0	31.0	22.0	70	64
Feb. IV	21	0.0	0.0	31.0	22.5	59	49
Mar I	28	0.0	0.0	35.0	28.5	69	48
Mar II	35	0.0	0.0	32.0	19.0	41	41
Mar III	42	0.0	0.0	35.0	28.0	53	45
Mar IV	49	0.2	0.0	34.5	26.0	72	45
Mar V	56	0.2	0.0	36.5	26.5	53	39
April I	63	0.4	0.0	39.0	32.0	44	36
April II	70	0.4	0.0	39.0	31.0	52	39
April III	77	0.4	0.4	42.0	35.0	42	29
April IV	84	0.6	0.8	43.0	34.5	37	24
May I	91	1.8	1.2	41.5	33.0	44	35

DAT- Days after transplanting, **LF**-Leaf folder

Table 2: Population fluctuation of Leaf Folder (LF), *C. medinalis* during *Rabi*, 2020

Month & Week	DAT	Mean Population of LF/hill		Weather Parameters			
				Temperature (°C)		Relative Humidity (%)	
		Adults	Damaged leaves	Max.	Min.	Morning	Evening
Feb. II	7	0.0	0.0	30.0	14.3	78	33

Feb. III	14	0.0	0.0	30.0	16.5	66	28
Feb. IV	21	0.0	0.0	35.0	19.0	64	23
Mar I	28	0.0	0.0	34.5	18.0	50	20
Mar II	35	0.0	0.0	33.5	19.5	53	29
Mar III	42	0.0	0.0	39.5	25.5	57	21
Mar IV	49	0.0	0.0	41.5	21.0	51	16
Mar V	56	0.0	0.0	38.0	24.0	52	37
April I	63	0.0	0.0	40.5	31.0	48	25
April II	70	0.0	0.0	44.0	34.0	23	12
April III	77	0.0	0.0	43.5	33.5	43	18
April IV	84	0.4	1.2	42.0	33.0	48	25
May I	91	0.4	1.6	39.5	32.0	49	28
May II	98	0.4	1.4	41.5	30.5	60	36
May III	105	0.0	0.0	44.0	34.0	33	16

DAT- Days after transplanting, **LF-**Leaf folder

Table 3: Population fluctuation of Leaf Folder (LF), *C. medinalis* during *Kharif*, 2019

Month & Week	DAT	Mean Population of LF/hill		Weather Parameters			
				Temperature (°C)		Relative Humidity (%)	
		Adults	Damaged leaves	Max.	Min.	Morning	Evening
Aug. IV	7	0.0	0.0	28.0	24.0	92	87
Aug. V	14	0.8	1.4	29.0	26.0	92	92
Sept. I	21	1.2	3.0	27.0	24.0	92	81
Sept. II	28	0.8	3.4	29.0	25.0	92	92
Sept. III	35	0.6	0.6	33.0	27.5	84	76
Sept. IV	42	0.4	1.0	31.0	25.0	96	78
Oct. I	49	1.6	3.2	31.0	23.0	84	71
Oct. II	56	2.6	3.8	33.5	25.5	58	76
Oct. III	63	11.2	8.4	33.0	22.0	84	63
Oct. IV	70	7.6	13.0	29.0	20.0	78	60
Nov. I	77	4.0	19.6	33.0	24.0	84	71
Nov. II	84	3.0	20.2	32.0	21.5	75	56
Nov. III	91	1.6	18.4	30.5	19.0	81	49

DAT- Days after transplanting, **LF-**Leaf folder

Table 4: Population fluctuation of Leaf Folder (LF), *C. medinalis* during *Kharif*, 2020

Month & Week	DAT	Mean Population of LF/hill		Weather Parameters			
				Temperature (°C)		Relative Humidity (%)	
		Adults	Damaged leaves	Max.	Min.	Morning	Evening
Aug. IV	7	0.0	0.0	33.0	26.0	80	51
Aug. V	14	0.0	0.0	33.0	25.5	84	81
Sept. I	21	0.0	0.0	34.0	26.0	77	62
Sept. II	28	0.0	0.0	33.0	26.0	84	75
Sept. III	35	0.0	0.0	33.0	27.0	81	75
Sept. IV	42	0.0	0.0	32.5	26.0	84	66
Oct. I	49	0.2	1.0	35.5	26.0	70	61
Oct. II	56	0.2	2.0	31.5	23.0	67	60
Oct. III	63	1.6	1.4	32.0	21.0	62	49
Oct. IV	70	0.4	1.4	32.0	21.5	67	52
Nov. I	77	1.4	1.4	31.5	21.0	65	57
Nov. II	84	0.4	1.2	33.0	24.0	79	59
Nov. III	91	0.2	1.0	31.5	19.0	72	42

DAT- Days after transplanting, **LF-**Leaf folder

Table 5: Correlation between weather parameters and population of *C. medinalis* (G.) during *Rabi*, 2019 and 2020

LF	Weather para-meters	*Rabi* 2019		*Rabi* 2020	
		Correlation coefficient (r)	Regression equations	Correlation coefficient (r)	Regression equations
LF adult (L_1)	A_1	0.669*	L_1= -2.167+0.069 A_1	0.274	L_1= -0.286+-0.010 A_1
	A_2	0.612*	L_1= -1.273+0.047 A_2	0.451	L_1= -0.183+0.010 A_2
	A_3	-0.478	L_1= 1.298+(-0.018) A_3	0.026	L_1= 0.063+0.000 A_3
	A_4	-0.509	L_1= 1.196+(-0.021) A_4	0.360	L_1=-0.115+0.008) A_4
	A_5	0.532	L_1= 0.366+0.229 A_5	0.290	L_1= -0.036+0.014 A_5
Damaged leaves	A_1	0.664*	L_2= -1.740+0.054 A_1	0.259	L_2= 0.940+0.032 A_1
	A_2	0.604*	L_2= - 1.037+0.044 A_2	0.444	L_2= -0.634+0.036 A_2
	A_3	-0.527	L_2= 1.041+(-0.016) A_3	0.028	L_2= 0.216+0.001 A_3

(L_2)	A_4	-0.543	L_2= 0.927+(-0.017) A_4	0.366	L_2= -0.421+0.029 A_4
	A_5	0.584*	L_2= -0.394+0.071) A_5	0.313	L_2= -0.161+0.054 A_5

Table 6: Correlation between weather parameters and population of *C. medinalis* (G.) during *kharif*, 2019 and 2020

LF	Weather para-meters	*Kharif* 2019		*Kharif* 2020	
		Correlation coefficient (r)	Regression equations	Correlation coefficient (r)	Regression equations
LF adult (L_1)	A_1	0.334	L_1= -12.822+0.506 A_1	-0.414	L_1= 6.786+(-0.197) A_1
	A_2	-0.488	L_1= 18.165+(-0.655) A_2	-0.642*	L_1= 0.519+(-0.133) A_2
	A_3	-0.302	L_1= 10.955+(-0.098) A_3	-0.765**	L_1= 4.161+(-0.051) A_3
	A_4	-0.511	L_1= 11.782+(-0.124) A_4	-0.442	L_1= 1.622+(-0.021) A_4
	A_5	-0.245	L_1= 4.553+(-0.229) A_5	-0.250	L_1= 0.505+(-0.056) A_5
Damaged leaves (L_2)	A_1	0.301	L_2= -25.734+1.079 A_1	-0.437	L_2= 10.065+(-0.285) A_1
	A_2	-0.711**	L_2= 60.578+(-2.256) A_2	-0.733**	L_2= 5.700+(-0.207) A_2
	A_3	-0.367	L_2= 31.103+(-0.282) A_3	-0.860**	L_2= 6.614+(-0.079) A_3
	A_4	-0.784**	L_2= 40.254+(-0.449) A_4	-0.564*	L_2= 2.965+(-0.037) A_4
	A_5	-0.559*	L_2= 17.254+(-1.232) A_5	-0.456	L_2= 1.141+(-0.139) A_5

LF - Leaf folder, **A_1**- Max. Temp; **A_2**- Min. Temp; **A_3**-Relative Humidity (Mor.), **A_4**- Relative Humidity (Eve.), **A_5**- Wind vel
***** -Correlation is significant at 0.05 (5%) levels; ****** -Correlation is significant at 0.01 (1%) levels.

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