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# Influence of weather parameters on population dynamics of rice leaf folder (RLF) in rice crop at Raipur district of Chhattisgarh

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**Abstract**
A research analysis was carried out to assess the influence of weather parameters on population dynamics of rice leaf folder and develop a forewarning model based on weather parameters and validate the models developed. Earlier in the 1980s, rice leaf folder (*C. medinalis*) had its status changed from minor pest to major pest due to its ability to cause damage above the economic threshold level (E.T.L.) in severe cases of the pest attack. Therefore, our present study was aimed to assess the congenial weather conditions for pest attack. For correlation analysis between weather parameters and field population of rice leaf folder, cumulative date of 20 years (2000-2019) was analyzed. The obtained C.C.S. values showed RLF in non-significant relationship with the maximum temperature (r = -0.005) and morning relative humidity (r = -0.202). Negative significant (at 1% significance level) relationship of RLF was observed with minimum temperature (r = -0.753), rainfall (r = -0.871) and evening relative humidity (r = -0.825). Positive significant (at 1% significance level) relationship was observed with the sunshine hours (r = 0.905).

**Keywords:** rice, leaf folder, weather parameters, population dynamic, correlation coefficients

## 1. Introduction
Rice is one of the oldest cereal grains and staple food for more than half of the world's population, particularly those living in southern Asia. Grown chiefly in *kharif* season and in diversified soil types, topographical and hydrological situations, it is subjected to biotic and abiotic factors. Since most of the abiotic factors are either beyond capabilities of human manipulation or are too economically non-feasible, we tend to research and study about the factors we can control. The hot and humid environment wherein rice is grown is highly conducive for proliferation of insect pests resulting in serious outbreak. Weather factors regulate insect pest populations under field circumstances. Under Indian conditions, though paddy is attracted by a wide range of insect pests as compared to any other crop, scanty information is available on the incidence and population build-up of rice pests under varying agro- climatic conditions. The most damaging pest in paddy are the lepidopteran stem borers (*Tryporyza incertulas* and *T. innotata*) and the rice leaf folder (*Cnaphalocrocis medinalis*) which cause annual losses in the order of millions of tonnes. Yield losses caused by leaf folders ranging from 63% to 80% were reported in rice, with high- yielding or hybrid rice varieties being more susceptible ones (Teng *et al*. 1993) [5]. According to Hill 1983, *Cnaphalocrocis medinalis* (Gn.) is one of the important pests of rice that is widely distributed throughout parts of Asia (e.g., India, Pakistan, Bangladesh, Sri Lanka, China, Korea, Japan, Philippines, Indonesia). It has been reported from all the rice-growing areas of India and only sometimes causes economic damage to the crop. *C. medinalis* is a migratory pest with 1 to 11 generations per year (An *et al*. 2014) [1]. In the field it has been found on rice, some grasses and in the laboratory, it also accepted finger millet, sorghum, wheat, maize, sugar-cane and pearl millet. The larva of leaf folder feeds by scraping on the soft tissue with chlorophyll content of the leaves. Initially it feeds on open leaves but later produces a sticky substance that causes folding of leaves. Feeding is essentially confined to green mesophyll tissue and can occur virtually across the entire surface of the leaf. *C. medinalis* takes about 24 to 35 days for the complete development from egg to adult passing through five larval instars (Padmavathi *et al*. 2013) [4]. Murugesan and Chelliah (1986) [3] recorded that in a glasshouse analysis, about 10 percent flag leaf damage (FLD) through the leaf folder decreased grain yields by 0.13 g per tiller and the number of completely filled grains by 4.5 percent, although yields were not

affected in simulation studies. Therefore, in the present study, we attempted to accumulate data, facts and figures to make the best possible estimate of the relation of weather parameters and the severity of insect pests.

## 2. Materials and Methods

The field experiment was carried out during kharif 2019 at research farm of Department of Entomology, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The latitude and longitude of Raipur situated at Eastern Central part of Chhattisgarh are 21°16'N and 81°36'E respectively. The altitude of the experimental site is 289.5m above mean sea level.

Raipur falls under "Chhattisgarh plains zone" in agroclimatic division of Chhattisgarh comprising of other distrits such as Bilaspur, Dhamtari, Durg, Mahasamund, Raigarh etc. accounting to about 51% area of the state. Raipur prevalently has dry sub humid to semi-arid agro-climatic conditions. The average annual rainfall in Raipur is about 1211 mm, 85% of which is received during the monsoon rains in the months between mid-June to September. The rest is distributed between winter and summer season (October to May). The main source of rainfall is south western monsoon which enters around 10th of June from southern part of Bastar and reaches other part of Chhattisgarh by 20th June. The monsoon winds start receding after 15th September from Surguja region and by 25th September whole monsoon winds depart off the Chhattisgarh plains with some light rains over the region. Over Raipur May and December are usually the hottest and coolest months, respectively. Weekly maximum temperature rises up to 46°C during peak of summer and minimum temperature may drop as low as 6 °C during the winter nights. The average weekly maximum and minimum temperature were recorded as 33.6 °C and 20.4 °C, respectively.

During the crop growth period the maximum temperature peaked 45.8 °C whereas lowest minimum temperature recorded was 22.5 °C. The total rainfall recorded was 1040mm during the entire crop period in the months June to September 2019 (Table 3.1). The morning relative humidity varied from 57% to 94% while in the afternoon it ranged between 25% to 80%.

The experiment on RLF infestation and its population dynamics during the Rice crop period was conducted at entomology research farm of IGKV, Raipur (CG) during kharif season of 2019. RLF was found most active in kharif season. The observations of RLF population density and infestation dynamics were recorded daily during the growing stages of Rice. The experimental field was free from insecticide sprays. The pest succession of major insect pest of rice was co- related with weather parameters to observe the effect of individual parameters on pest incidence. The leaf folder starts attacking the crop in its larval stage but damages the rice plant through-out the crop growth period. The young larvae feed on open leaves but later feed inside the rolled leaf formed by folding the leaf longitudinally with a sticky substance.

Leaves fold longitudinally and larvae remain inside. Larva scrapes the green tissues of the leaves, becomes white and dry. During severe infestation the whole field exhibits scorched appearance. The amount of damage in estimated by counting number of affected leaves per hill.

$$\%\ LF\ damage = \frac{No.\ of\ folded\ leaves}{Total\ no.\ of\ leaves} * 100$$

## 3. Result and Discussion

### 3.1 Weather parameters during the growing season.

Periodic observations were carried out for leaf folder population after first fortnight of transplanting on regular basis. Weekly data from the first week of incidence of leaf folder is presented in Table 1. It can be seen that the actual incidence of leaf folder adult occurred during 38th SMW i.e., 3rd week of September. During this week only 2 moths appeared causing damage to the leaves by feeding on them exhibiting behavioural folding of leaves. The maximum and minimum temperature ranged between 33 ºC and 25.5 ºC. Minimal rainfall of 2.4 mm was recorded during this week although SMW 36 recorded highest weekly rainfall total during the whole cropping season. RH-1 and RH-2 were 88% and 63% respectively while 8.2 hours of sunshine was also observed. From this week forth the moth population showed an exponential increase up to week 44 and 45 with moth population recorded 54 and 55 respectively. During this period maximum temperature averaged 30.8 ºC while minimum temperature averaged about 22.8 ºC and 262.1 mm total rainfall was recorded. The average RH-1 was about 91% while the average RH-2 was 63%. After achieving the peak population this week forth the moth population started declining steadily. SMW 48 and 49 both registered a population of 5 and by week 50 (i.e., 2nd week of December) none of the moths were observed. The following table shows the weather parameters and moth population during the week 38 to week 50 during which the highest population dynamic was recorded. The weather parameters are recorded as per Labhandi location where the IGKV meteorological observatory is situated. The research plot was untreated with any insecticides or weedicides.

**Table 1:** Field population data of rice leaf folder and weather parameters during *kharif* season of 2019 at Labhandi station of Raipur.

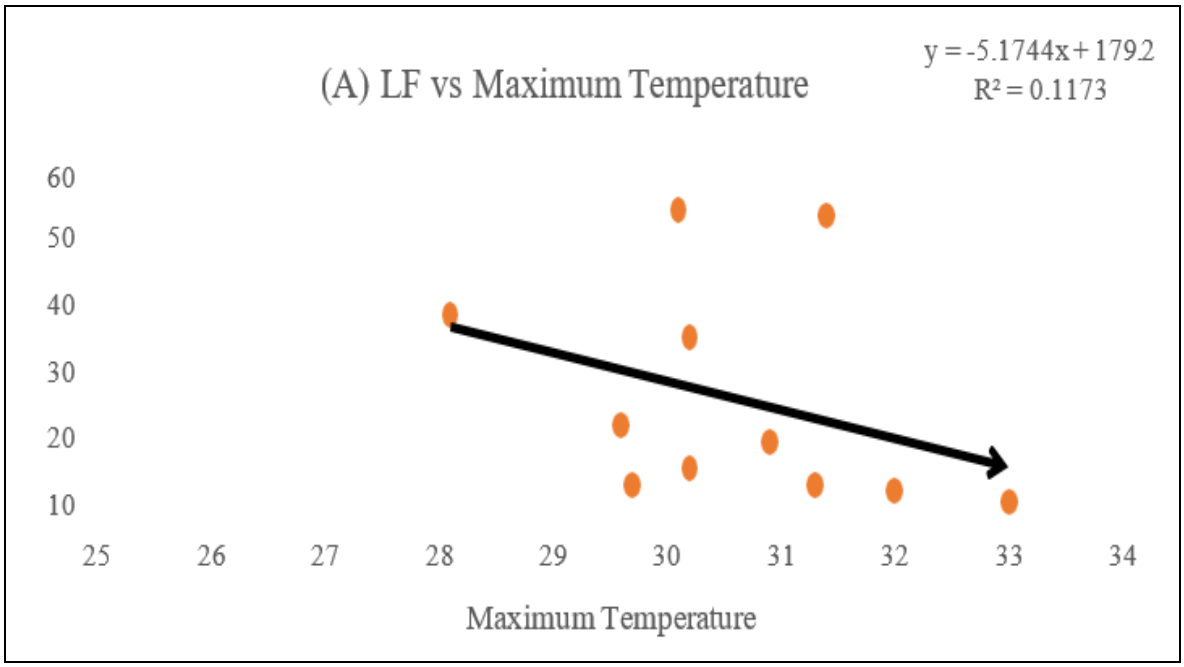
| SMW | LF Population | Maximum Temperature | Minimum Temperature | Rainfall | RH-I | RH-II | Sunshine Hours |
|---|---|---|---|---|---|---|---|
| 38 | 2 | 33 | 25.5 | 2.4 | 88 | 63 | 8.2 |
| 39 | 8 | 30.2 | 24.2 | 178.1 | 91 | 74 | 3.8 |
| 40 | 4 | 32 | 24.3 | 1.8 | 90 | 64 | 7.5 |
| 41 | 5 | 31.3 | 23.6 | 1.2 | 91 | 64 | 5.4 |
| 42 | 13 | 30.9 | 21.8 | 51 | 92 | 65 | 5.7 |
| 43 | 36 | 28.1 | 22.2 | 27.6 | 92 | 71 | 2.8 |
| 44 | 54 | 31.4 | 22.2 | 0 | 92 | 51 | 6.0 |
| 45 | 55 | 30.1 | 19.1 | 0 | 90 | 51 | 7.3 |
| 46 | 16 | 29.6 | 15.5 | 0 | 90 | 38 | 8.7 |
| 47 | 32 | 30.2 | 15.2 | 0 | 89 | 38 | 8.3 |
| 48 | 5 | 29.7 | 16.3 | 0 | 90 | 43 | 6.3 |

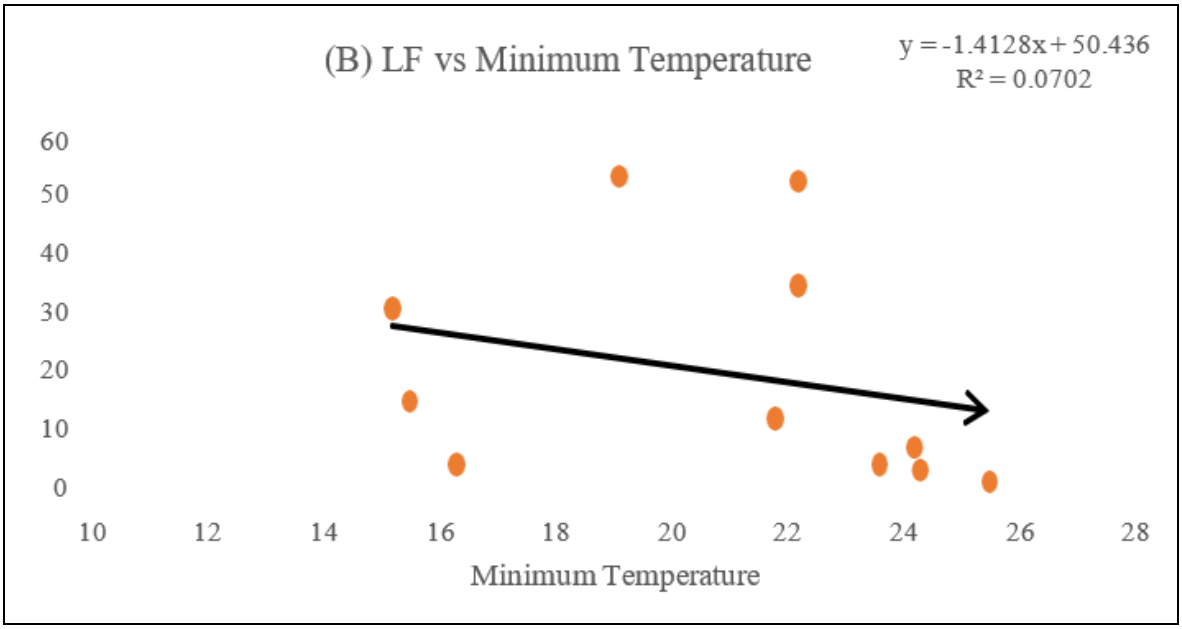
**3.2 Correlation between weather parameters and rice leaf folder.**

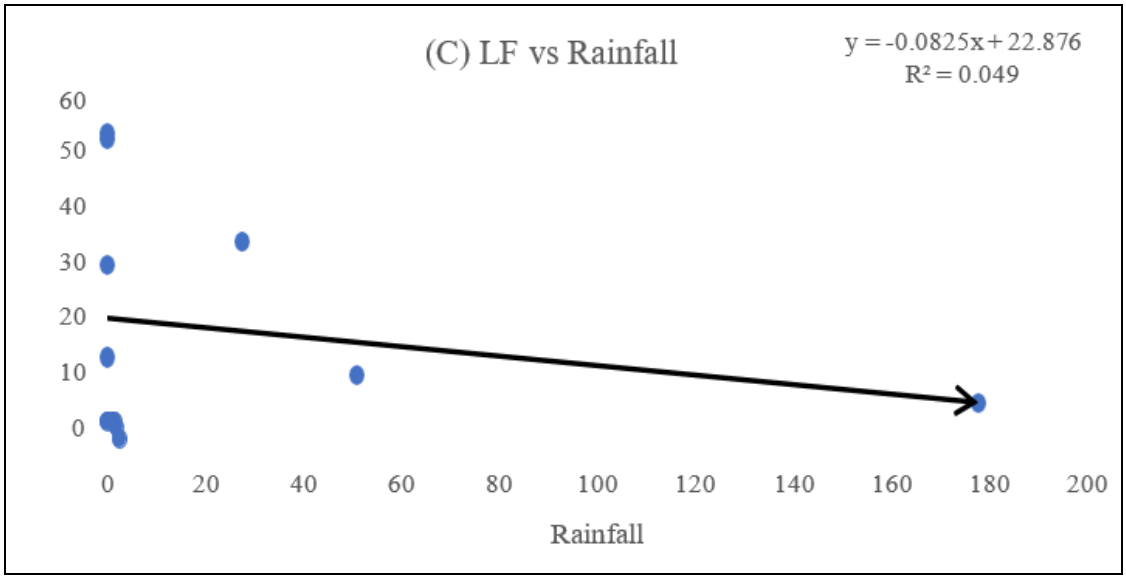
The highest moth population of leaf folder was recorded between 43rd and 45th SMW (i.e., from October last week to November 2nd week). The correlation coefficients were worked out between the weekly mean of weather parameters and population total using data analysis operations in SPSS (Statistical Package for the Social Sciences). The moth population showed a strong but non-significant negative correlation (r = -0.34) with the max temperature as well as minimum temperature (r = -0.26), rainfall (r = -0.22), RH-II (r = -0.11) and sunshine duration (r = -0.11). The only positive yet non-significant correlation was obtained against morning relative humidity (r = -0.23). The sig 2-tailed values revealed that the non-significant relationships between weather parameters and population dynamics for the year 2019 as shown in Table 2. Trendline have been shown in graphical representation of correlation between insect population and individual weather parameter in figure 1(A-E)

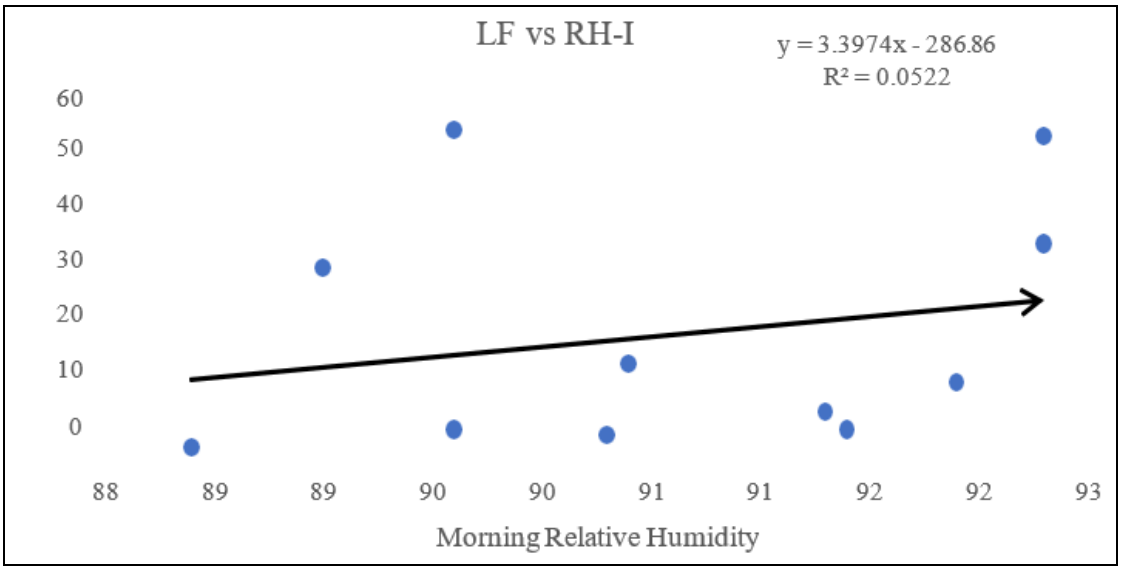
**Table 2:** Correlation coefficients obtained between weather parameters and rice leaf folder for the *kharif* season of 2019.

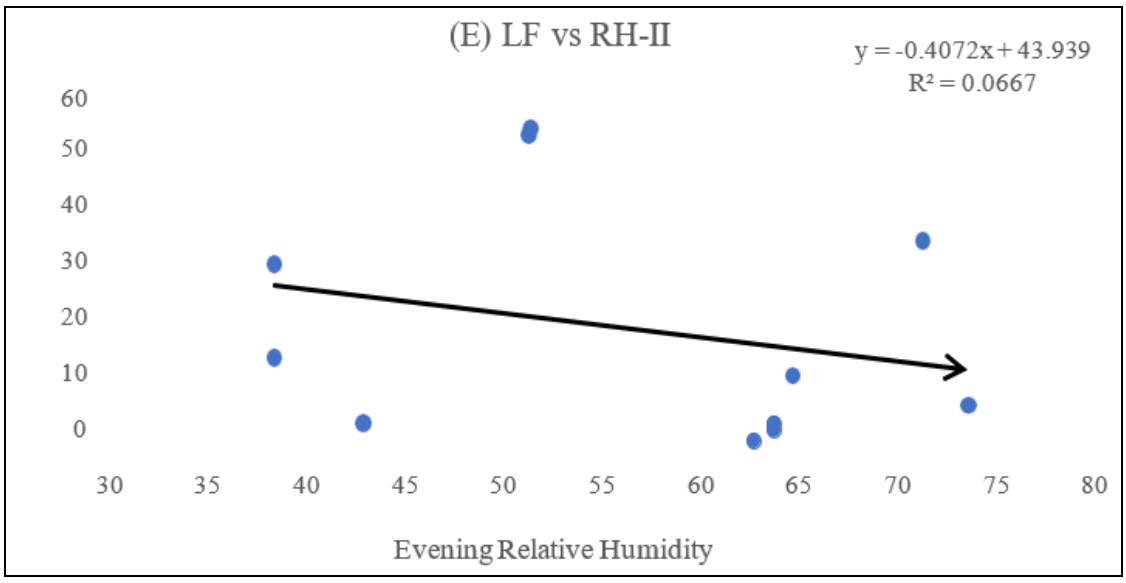
| Weather Parameters | Correlation Coefficients (r) | Sig 2-tailed values |
|---|---|---|
| Maximum temperature (ºC) | -0.34 | 0.763 |
| Minimum Temperature (ºC) | -0.26 | 0.301 |
| Rainfall (mm) | -0.22 | 0.247 |
| Morning Relative Humidity (%) | 0.23 | 0.256 |
| Evening Relative Humidity (%) | -0.11 | 0.142 |
| Sunshine Duration(hours) | -0.11 | 0.084 |




(C) LF vs Rainfall
y = -0.0825x + 22.876
R² = 0.049
60
50
40
30
20
10
0
0 20 40 60 80 100 120 140 160 180 200
Rainfall


LF vs RH-I
y = 3.3974x - 286.86
R² = 0.0522
60
50
40
30
20
10
0
88 89 89 90 90 91 91 92 92 93
Morning Relative Humidity


(E) LF vs RH-II
y = -0.4072x + 43.939
R² = 0.0667
60
50
40
30
20
10
0
30 35 40 45 50 55 60 65 70 75 80
Evening Relative Humidity

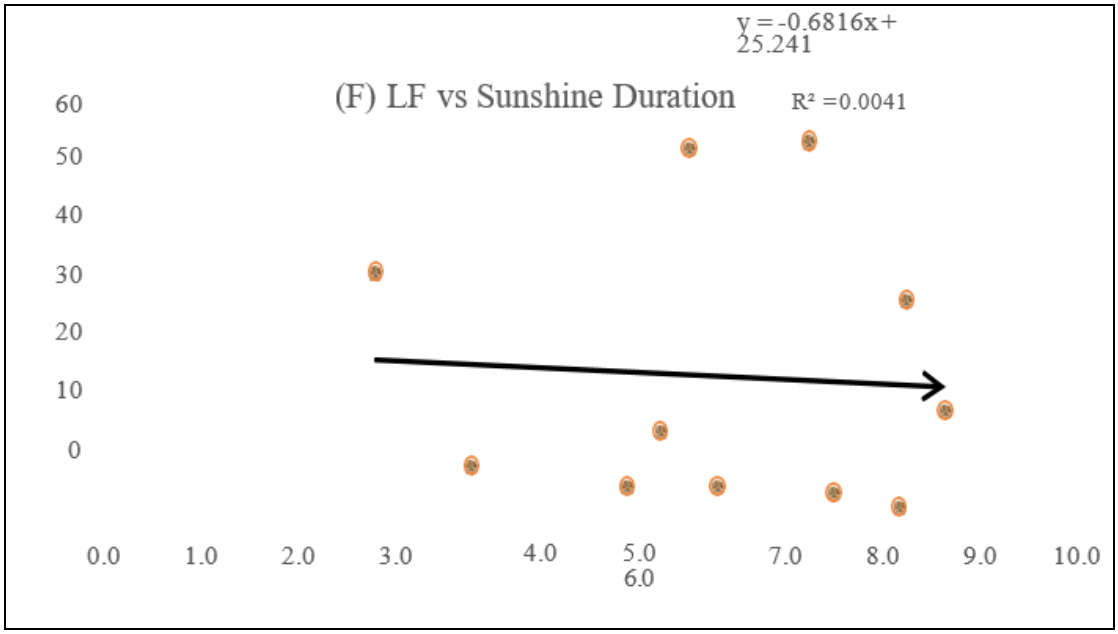



**Fig. 1(A-E):** Scattered diagram with regression line showing the relationship between weather parameters and population dynamics.

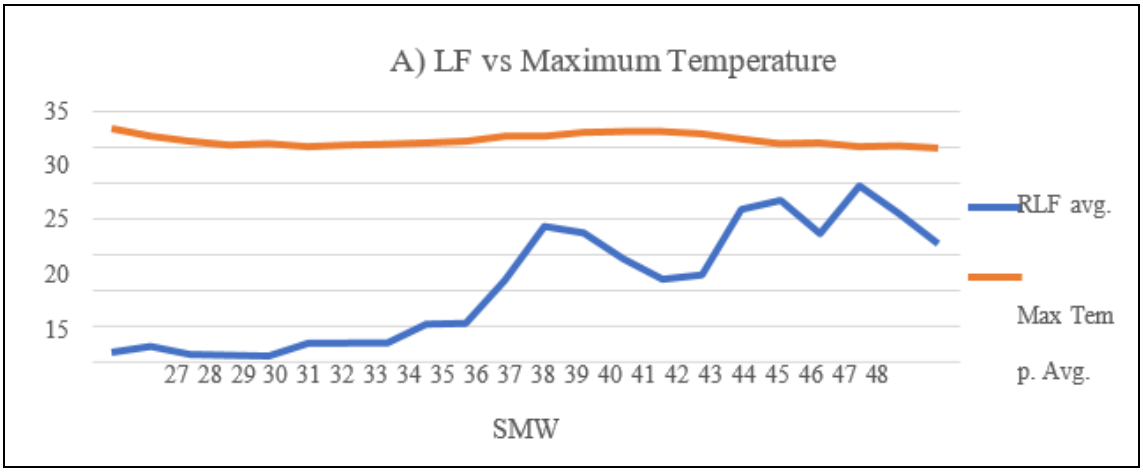
Although statistical analysis for cumulated years from 2000 to 2019 reveals a clearer picture regarding the relationship between weather elements and their influence on population dynamics of rice leaf folder. The correlation coefficients obtained through analysis of 20 years are presented in Table 3.

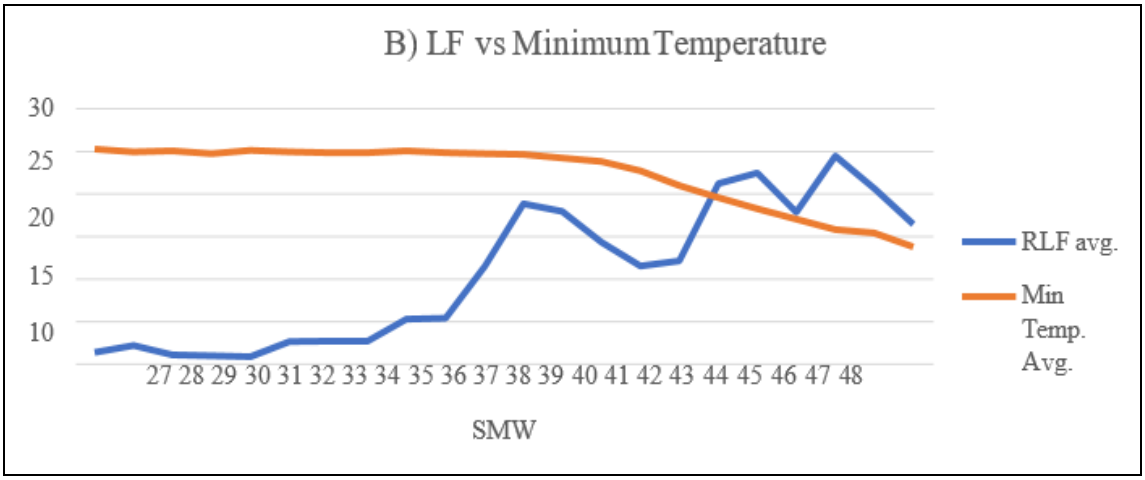
**Table 3:** Correlation analysis between average of weather elements and leaf folder population between years 2000 to 2019.

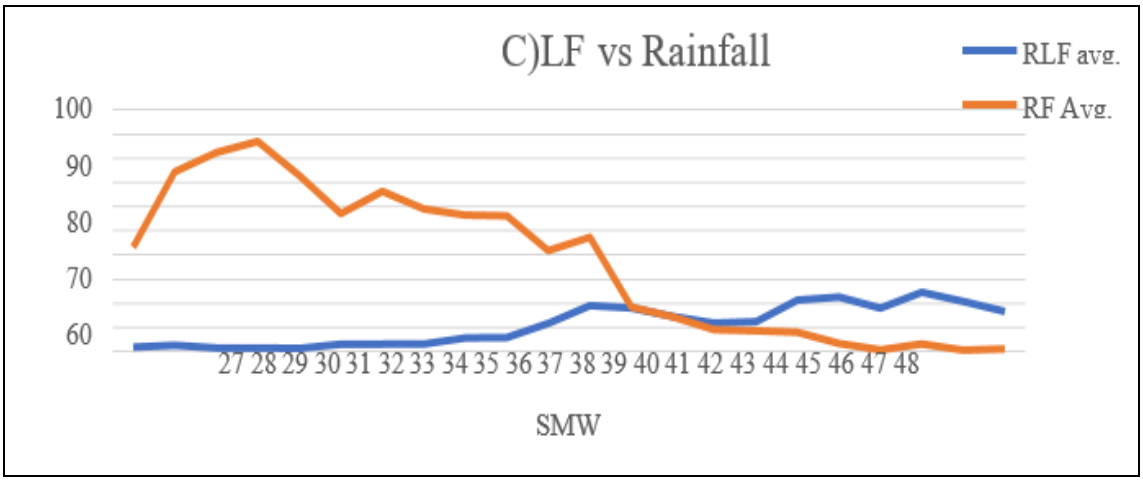
| Week | Leaf Folder | Maximum Temperature (°C) | Minimum Temperature (°C) | Rainfall (mm) | Relative Humidity (%) | | Sunshine Hours |
|---|---|---|---|---|---|---|---|
| | | | | | Morning | Evening | |
| 27 | 1.4 | 32.4 | 25.12 | 42.7 | 86.5 | 67.6 | 3.5 |
| 28 | 2.2 | 31.4 | 24.8 | 73.7 | 89.9 | 73.4 | 2.7 |
| 29 | 1.1 | 30.7 | 24.9 | 81.7 | 91.3 | 75.9 | 2.6 |
| 30 | 1 | 30.2 | 24.6 | 86.3 | 91.2 | 75 | 2.5 |
| 31 | 0.9 | 30.4 | 25 | 72.2 | 90.5 | 75.7 | 2.9 |
| 32 | 2.7 | 30 | 24.8 | 56.5 | 91.7 | 77.9 | 2.7 |
| 33 | 2.7 | 30.2 | 24.7 | 65.7 | 92.3 | 77.3 | 2.7 |
| 34 | 2.7 | 30.3 | 24.7 | 58.4 | 91.9 | 75.7 | 3.5 |
| 35 | 5.3 | 30.5 | 24.9 | 55.9 | 92.6 | 76.6 | 3.3 |
| 36 | 5.4 | 30.7 | 24.7 | 55.6 | 92.5 | 75.4 | 3.7 |
| 37 | 11.4 | 31.4 | 24.6 | 41.3 | 92.9 | 71.9 | 4.8 |
| 38 | 18.8 | 31.4 | 24.5 | 46.8 | 92.4 | 69.5 | 5.5 |
| 39 | 17.9 | 31.9 | 24.1 | 18 | 91.4 | 63.6 | 6.5 |
| 40 | 14.3 | 32 | 23.7 | 13.9 | 91.7 | 61.6 | 6.9 |
| 41 | 11.5 | 32 | 22.6 | 8.7 | 91 | 55.4 | 6.9 |
| 42 | 12.1 | 31.7 | 20.9 | 8.2 | 90.9 | 49 | 8.2 |
| 43 | 21.15 | 31 | 19.5 | 7.6 | 90.7 | 45.8 | 7.7 |
| 44 | 22.4 | 30.4 | 18.2 | 3 | 90.3 | 44.4 | 7.4 |
| 45 | 17.8 | 30.5 | 17 | 0.3 | 90 | 38.8 | 7.9 |
| 46 | 24.4 | 30 | 15.8 | 2.8 | 89 | 37.6 | 7.8 |
| 47 | 20.6 | 30.1 | 15.4 | 0.2 | 88.5 | 33.4 | 8.2 |
| 48 | 16.4 | 29.8 | 13.8 | 0.7 | 88.2 | 33.1 | 8.2 |
| | R values= | -0.005 | -0.753** | -0.871** | -0.202 | -0.825** | 0.905** |

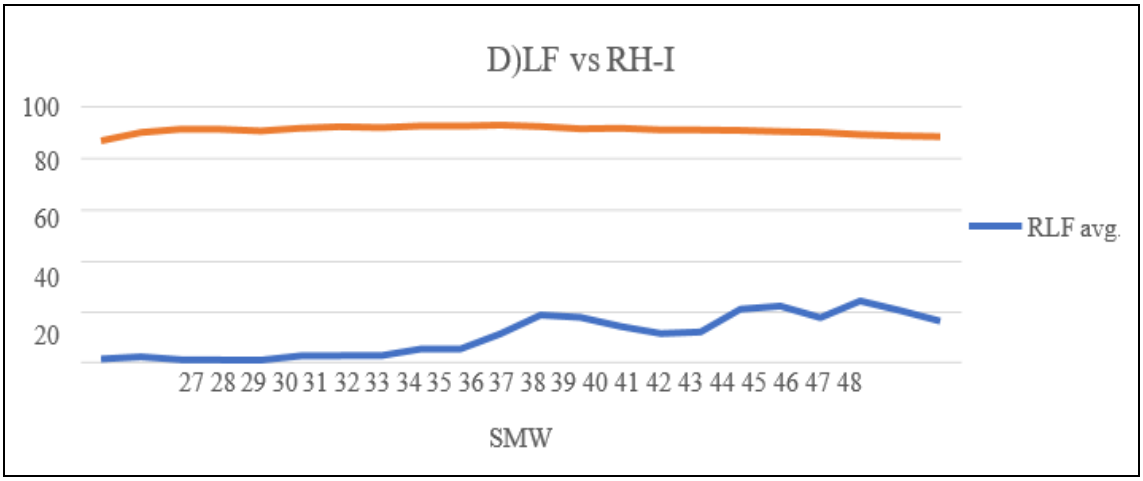
**Significant at 1% level of confidence.

This statistic revealed strong negative correlation between leaf folder population and minimum temperature (r = -0.75), rainfall (r= -0.87), evening relative humidity (r= -0.82) while a significant positive correlation with sunshine hours (r = 0.9). From this statistic we can conclude that warm, humid climate with 6-8 hours of sunshine hours is favourable for the moth population to develop and cause significant infestation. Our results also align with the findings of Padmavathi *et al*. (2013) [4] who worked out temperature thresholds for development of egg to adult of *C. medinalis*. Temperature optimal for development of larva to adult is 31.5 ºC to 32 ºC. Line chart comparison for weekly average of weather parameter and sum total of leaf folder population collected is graphically presented in figure 2(A-E).


A) LF vs Maximum Temperature
35
30
25
20
15
27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
SMW
RLF avg.
Max Temp. Avg.


B) LF vs Minimum Temperature
30
25
20
15
10
27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
SMW
RLF avg.
Min Temp. Avg.


C)LF vs Rainfall
100
90
80
70
60
27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
SMW
RLF avg.
RF Avg.


D)LF vs RH-I
100
80
60
40
20
27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
SMW
RLF avg.

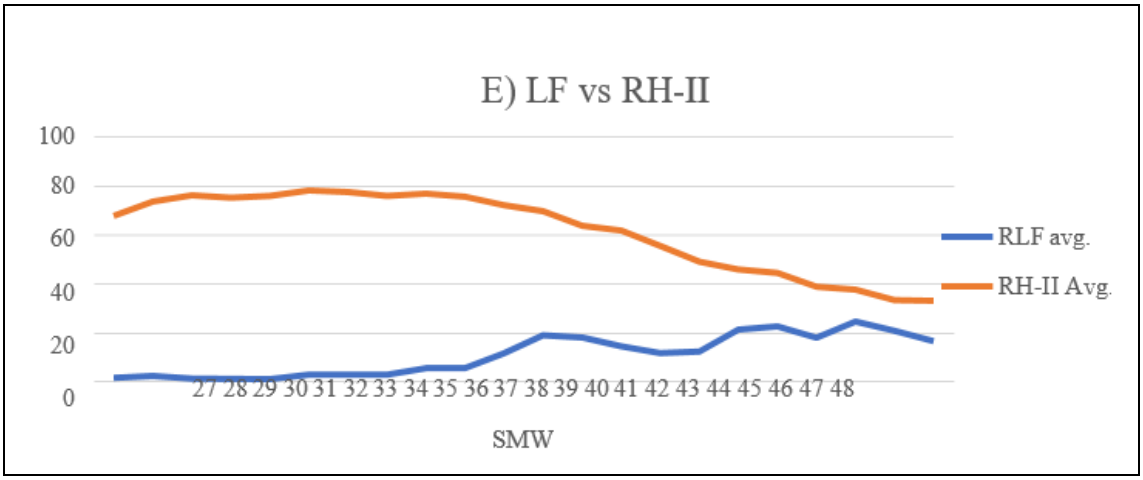



**Fig 2(A-E):** A line chart comparison for RLF population and average of weather parameters between weeks 27 to 48 for 20 years (2000-2019).

## 4. Conclusions

In our effort to study the influence of each of the six weather parameters on RLF infestation we accumulated 20-year (2000-19) weather as well as population data and worked out correlation coefficient. Result of this analysis pointed out the weather parameters that had significant influence on the population dynamics. Maximum temperature had negligible correlation (r = -0.005) with *C. medinalis*. Minimum temperature (r = -0.75**), rainfall (r = -0.87**) and evening relative humidity (r = -0.82**) had significant negative correlation while morning relative humidity was negative but non-significant (r = -0.202). In contrast to other weather variables sunshine duration showed very significant and positive correlation (r = 0.9**).

Further with the help of graphical and trendline assessment we worked out favourable weather conditions which favour the population growth. The usual build- up of population initiates between second to third week of August, however, C. *medinalis* incidence as of 2019 was first observed in second and third week of September which is characterized by declining rainfall and evening relative humidity. Sunshine hours during these weeks increased to about 6-7 hours. Peak population reached during last week of October to first week of November which is characterized by dry cold weather with 7-8 hours of sunshine for Labhandi Station. After first two weeks of November populations started declining as the harvesting time approaches. C. *medinalis* may complete two to three generations during the whole cropping season.

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