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Impact of abiotic factors on population build up of *Pyrilla perpusilla* and *Epiricania melanoleuca* on Sorghum

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Abstract
The field trial was laid out in the research area of Department of Entomology, University of Agriculture Faisalabad during 2010. Aim of this study was to evaluate impact of weather factors on population dynamics of *Pyrilla perpusilla*, *Epiricania melanoleuca* and percentage parasitism of *E. melanoleuca* on *P. perpusilla* in sorghum. The results revealed that maximum population of *P. perpusilla* and *E. melanoleuca* per plant was recorded in the 2nd fortnight of September and 1st fortnight of October, respectively. It was also observed that population of *P. perpusilla* and *E. melanoleuca* and percentage parasitism had negative and significant correlation with temperature and non-significant correlation with Relative humidity. Regression models indicated that maximum variation in *P. perpusilla* and *E. melanoleuca* population was contributed by temperature rather than relative humidity, while the relative humidity attributed maximum role in parasitism percentage variation.

Keywords: *Epiricania melanoleuca*, Parasitism, Population, *Pyrilla perpusilla*, Sorghum, Weather factors.

1. Introduction

Pyrilla perpusilla is one of the most destructive pests, widely distributed, and feeds on sugarcane, wheat, barley, oats, maize, sorghum and number of grasses [1]. *Pyrilla* adults and nymphs, both suck sap from underside of the leaves [2] but most of the damage is caused by the nymphs. Feeding spots turn yellow and with the loss of sap the leaves wilt, retarding plant growth. Sooty mould grows on honeydew produced by *Pyrilla* and this further reduces photosynthesis. About 80 percent losses have been estimated due to this pest in sorghum grain yield [3].

Epiricania melanoleuca was first recorded in India as the most important adult and nymphal parasitoid of *P. perpusilla* [4]. It's different life parameters such as short life cycle, higher reproductive potential and marvelous searching capability for host, enhances it's efficacy as a bio-control agent. It's larval body is covered by wax which protects it from insecticides allowing the chemicals to be used in IPM programmes of *Pyrilla* [5]. The feeding mechanism of larvae is not known completely, but it is suggested that the larva ruptures the host's cuticle with mandibles and parasitically sucks hemolymph [6]. Smaller, younger larvae feed near the head and hind leg of *Pyrilla*. It does not kill its hosts but makes them so weak that they can't reproduce [7]. *Pyrilla* can be effectively managed through the parasitoids, *Epiricania melanoleuca* and *Tetrastichus* sp without the use of insecticides [8].

Different weather factors are quite important in regulating the insect populations. Gupta and Ahmed (1983) [9] found in their lab experiment that temperature 29.4 °C and RH 75.84% are most suitable for proper growth and development of *Pyrilla*. Pest growth retards above 43 °C [10] and below 9.4 °C [11]. Rajak *et al* (1987) [12] concluded that high humidity leads to low *Pyrilla* population but Patil and Hapase (1992) [13] came to opposite conclusion. According to Ganehiarachchi and Fernando (2000) [4] *Pyrilla* abundance is negatively correlated with rainfall and humidity but positively with minimum temperature. They further concluded that egg parasitoid, predators and rainfall are the main factors responsible for fluctuating *P. perpusilla* population. Relative humidity had no effect on *E. melanoleuca* population and suitable temperature required for its proper growth is 25-32 °C [14]. Information regarding pest parasitoid abundance and distribution in relation to weather

parameters is a basic requirement for developing proper pest management strategy in a specific agro-system [15].
Thus the present study was planned to investigate the percentage impact induced by different weather factors on population of *Pyrilla perpusilla*, *Epiricania melanoleuca* and percentage parasitism of *Pyrilla* in sorghum in unsprayed condition.

2. Material and Methods
Sorghum seeds were sown in June, 2010 by pore method with plant to plant distance of 6 cm and row to row spacing of 30 cm at the research area of Department of Entomology, University of Agriculture Faisalabad. After germination, thinning of plants was done to maintain plant to plant distance. No plant protection measures were adopted for the management of sorghum pests.
Data regarding the populations of *Pyrilla perpusilla* and *Epiricania melanoleuca* and parasitism rate were recorded fortnightly, by observing five sorghum plants from each plot. Data of different physical factors like, temperature, relative humidity, pan evaporation, sunshine, evapo-transpiration and wind speed were obtained from Agricultural Meteorological Cell, Department of Crop Physiology, University of Agriculture Faisalabad. Data obtained regarding insects were correlated with abiotic factors by using Minitab statistical software.

3. Results and Discussion
3.1 Population fluctuation of *Pyrilla perpusilla*
Pyrilla perpusilla appeared in 2nd week of August; increasing continuously up to 3rd week of September (Fig. 1). Thereafter, a declining trend in the population was observed, However, average peak population of *Pyrilla perpusilla* was recorded on 3rd week of September (10.3 adults+numphs/plant) followed by 2nd week of September (9.9 adults+numphs/plant).

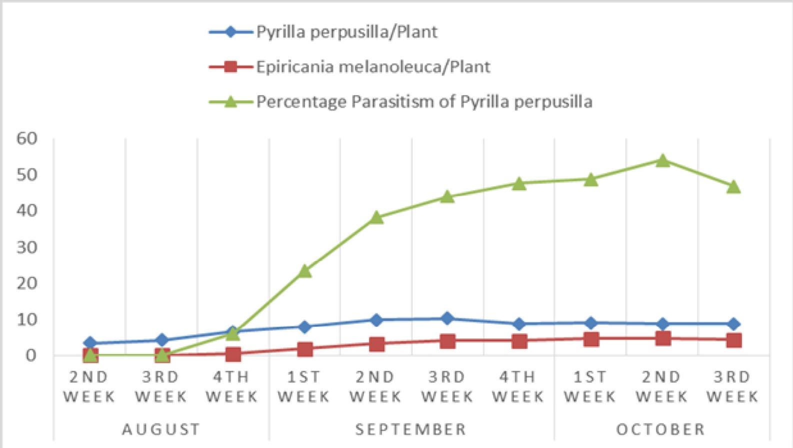

Fig 1: A graphical presentation of date wise fluctuation in the population of *Pyrilla perpusilla, Epiricania melanoleuca* and percentage parasitism of *Pyrilla perpusilla* on sorghum

3.2 Population fluctuation of *Epiricania melanoleuca*
Epiricania melanoleuca appeared in 4th week of August; increasing up to 3rd week of September. Thereafter, nominal but significant increasing trend was observed in the population of parasitoid up to 2nd week of October. After 2nd week of October a nonsignifcant declining trend was recorded in its population. Average peak population (4.7 nymphs + cocoons/plant) was observed in 2nd week of October followed by 1st week of October (4.5 nymphs + cocoons/plant), 3rd and 4th week of September. This may be due to high availability of the host.

3.3 Percentage parasitism fluctuation
Parasitism of *Pyrilla* by epipyrop was first recorded during 4th week of August. A tremendous increasing trend in the percentage parasitism was recorded up to 2nd week of October lowering the pest population to a great extent. Peak percentage parasitism was observed during 2nd week of October (54.18%) after which it slightly declined to 47.01% during 3rd week of October.

3.4 Correlation between *Pyrilla perpusilla, Epiricania melanoleuca,* percentage parasitism and abiotic factors
Correlation matrix for *P. perpusilla, E. melanoleuca*, percentage parasitism with abiotic factors (Table 1) indicates that *Pyrilla*, epipyrop and percentage parasitism had negative and significant correlation with temperature and non-significant correlation with relative humidity. Pan-evaporation and wind speed were found to be positively correlated with *Pyrilla* but negatively correlated with epipyrop and percentage parasitism. Sunshine and Evapotranspiration had non-significant and positive correlation with *Pyrilla*, epipyrop and percentage parasitism.

Table 1: The correlation coefficients (without brackets) and p values (in brackets) of *Pyrilla perpusilla, Epiricania melanoleuca* and percentage parasitism against abiotic factors

Abiotic factors	*Pyrilla perpusilla/* Plant	*Epiricania melanoleuca*/Plant	Percentage Parasitism (%)
Temperature (℃)	-0.74* (0.013)	-0.68* (0.031)	-0.71*(0.021)
Relative Humidity (%)	-0.49 (0.155)	-0.61 (0.067)	-0.62 (0.055)
Pan Evaporation (mm)	0.16 (0.667)	-0.17 (0.626)	-0.15 (0.687)
Sunshine (Hours)	0.30 (0.387)	0.06 (0.875)	0.09 (0.786)
Evapo-Transpiration (mm)	0.32 (0.376)	0.10 (0.821)	0.12 (0.776)
Wind Speed (Km/Hour)	0.06 (0.877)	-0.09 (0.793)	-0.07 (0.846)

3.5 Stepwise multivariate regression models between *Pyrilla perpusilla* and abiotic factors

The results regarding multivariate regression analysis between *P. perpusilla* and abiotic factors are presented in Table 2. It is evident from table that temperature alone contributed 55% role in the fluctuation of *P. perpusilla* population. The role was increased as the factors added and computed together. Similarly with the addition of RH, PE and sunshine the role enhanced to 65.7%, 73.1% and 73.2%, respectively. Significant contribution to the variation in population of *P. perpusilla* (81.7%) was attributed with the addition of evapo-transpiration to temperature, RH, pan evaporation and sunshine. Wind speed extended the role to 82.8% with other factors. Over all, all the abiotic factors demonstrated 82.8% variation in population of *P. perpusilla.* The maximum variation in population was contributed by temperature (55.0%) followed by RH (10.7%).

Table 2: Stepwise regression models between *Pyrilla perpusilla* and abiotic factors

Regression Model	P Value (T Value)	$100R^2$ (%)	Effect Induced
Y= 29.2 - 0.75 X1	0.01^{X1} (-3.13)	55.0	55.0
Y= 33.2 - 0.67 X1 - 0.09 X2	0.02^{X1}; 0.18^{X2} (-2.94; -1.48)	65.7	10.7
Y= 31.2 - 0.77 X1 - 0.07 X2 + 0.74 X3	0.02^{X1}; 0.33^{X2}; 0.25^{X3} (-3.32; -1.06; 1.28)	73.1	7.4
Y= 31.7 - 0.78 X1 - 0.07 X2 + 0.78 X3 - 0.03 X4	0.03^{X1}; 0.38^{X2}; 0.31^{X3}; 0.89^{X4} (-2.91; -0.97; 1.12; -0.14)	73.2	0.1
Y= 24.0 - 0.78 X1 - 0.01 X2 - 1.21 X3 + 0.06 X4 + 3.60 X5	0.04^{X1}; 0.93^{X2}; 0.49^{X3}; 0.82^{X4}; 0.25^{X5} (-3.12; -0.10; -0.76; 0.24; 1.36)	81.7	9.5
Y= 24.5 - 0.75 X1 - 0.03 X2 - 1.41 X3 + 0.02 X4 + 3.77 X5 + 0.12 X6	0.08^{X1}; 0.80^{X2}; 0.50^{X3}; 0.95^{X4}; 0.29^{X5}; 0.69^{X6} (-2.63; -0.28; -0.76; 0.07; 1.26; 0.44)	82.8	1.1

(Where: Y= Population of *Pyrilla perpusilla;* X1= Temperature; X2= Relative Humidity; X3= Pan Evaporation; X4= Sunshine; X5= Evapo-Transpiration; X6= Wind Speed)

3.6 Stepwise multivariate regression models between *Epiricania melanoleuca* and abiotic factors

The results regarding multivariate regression analysis between *E. melanoleuca* and abiotic factors are presented in Table 3. It is evident from table that temperature alone contributed 46.2% role in the fluctuation of *E. melanoleuca* population. The role was increased as the factors added and computed together. Similarly with the addition of RH, the role enhanced to 67.2%. Significant contribution to the variation in the population of *E. melanoleuca* (69.7%) was attributed with the addition of pan evaporation. The role in parasitoid population fluctuation reached upto 71.1% when sunshine was computed together with temperature, RH and pan evaporation. With the addition of wind speed, factors accumulative role enhanced to 89.8% in population fluctuation of parasitoid. Over all, all the abiotic factors demonstrated 89.8% variation in population of *E. melanoleuca.* The maximum variation in population was contributed by temperature (46.2%) followed by RH (21%).

Table 3: Stepwise regression models between *Epiricania melanoleuca* and abiotic factors

Regression Model	P Value (T Value)	$100R^2$ (%)	Effect Induced
Y= 19.5 - 0.59 X1	0.03^{X1} (-2.62)	46.2	46.2
Y= 24.2 - 0.49 X1 - 0.12 X2	0.04^{X1}; 0.07^{X2} (-2.59; -2.12)	67.2	21
Y= 25.2 - 0.45 X1 - 0.12 X2 - 0.36 X3	0.08^{X1}; 0.07^{X2}; 0.51^{X3} (-2.12; -2.16; -0.70)	69.7	2.5
Y= 26.7 - 0.49 X1 - 0.12 X2 - 0.23 X3 - 0.11 X4	0.09^{X1}; 0.09^{X2}; 0.72^{X3}; 0.64^{X4} (-2.04; -2.03; -0.37; -0.50)	71.1	1.4
Y= 19.6 - 0.49 X1 - 0.07 X2 - 2.27 X3 - 0.03 X4 + 3.63 X5	0.08^{X1}; 0.34^{X2}; 0.17^{X3}; 0.89^{X4}; 0.17^{X5} (-2.34; -1.08; -1.68; -0.14; 1.65)	82.8	11.7
Y= 20.6 - 0.43 X1 - 0.11 X2 - 2.74 X3 - 0.11 X4 + 4.06 X5 + 0.26 X6	0.11^{X1}; 0.18^{X2}; 0.11^{X3}; 0.58^{X4}; 0.13^{X5}; 0.25^{X6} (-2.28; -1.74; -2.21; -0.62; 2.05; 1.44)	89.8	7

(Where: Y= Population of *Epiricania melanoleuca;* X1= Temperature; X2= Relative Humidity; X3= Pan Evaporation; X4= Sunshine; X5= Evapo-Transpiration; X6= Wind Speed)

3.7 Stepwise multivariate regression models between percentage parasitism of *Pyrilla perpusilla* and abiotic factors

The results regarding multivariate regression analysis between percentage parasitism and abiotic factors are presented in Table 4. It is evident from table that temperature alone contributed 1.6% role in fluctuation of percentage parasitism. Significant contribution to the variation in the percentage parasitism (69.5%) was attributed with the addition of RH. Similarly, with the addition of pan evaporation, the accumulative role of these factors was found to be 70.5%. The accumulative effect on percentage parasitism increased from 70.8-93.5 when sunshine and evapo-transpiration were included with other factors. Wind speed did not attribute any effect on percentage parasitism. Over all, all the abiotic factors demonstrated 93.5% variation in percentage parasitism. The maximum variation in percentage was contributed by RH (67.9%) followed by ET (22.7%).

Table 4: Stepwise regression models between percentage parasitism of *Pyrilla perpusilla* and abiotic factors

Regression Model	P Value (T Value)	100R² (%)	Effect Induced
Y= 56.7 - 0.90 X1	0.73^{X1} (-0.36)	1.6	1.6
Y= 208 - 2.74 X1 - 1.56 X2	0.12^{X1}; 0.01^{X2} (-1.76; -3.94)	69.5	67.9
Y= 200 - 1.89 X1 - 1.57 X2 - 3.63 X3	0.48^{X1}; 0.01^{X2}; 0.67^{X3} (-0.75; -3.72; -0.45)	70.5	1
Y= 208 - 2.09 X1 - 1.60 X2 - 2.64 X3 - 0.59 X4	0.49^{X1}; 0.02^{X2}; 0.79^{X3}; 0.81^{X4} (-0.73; -3.36; -0.27; -0.25)	70.8	0.3
Y= -2.6 + 3.72 X1 - 1.00 X2 - 55.8 X3 + 2.31 X4 + 66.7 X5	0.16^{X1}; 0.03^{X2}; 0.02^{X3}; 0.19^{X4}; 0.02^{X5} (1.71; -3.36; -3.68; 1.57; 3.72)	93.5	22.7
Y= 5.3 + 3.40 X1 - 1.02 X2 - 54.7 X3 + 2.10 X4 + 66.0 X5 + 0.27 X6	0.38^{X1}; 0.07^{X2}; 0.06^{X3}; 0.39^{X4}; 0.05^{X5}; 0.89^{X6} (1.02; -2.76; -2.86; 0.99; 3.12; 0.14)	93.5	0

(Where: Y= Percentage Parasitism of *Pyrilla perpusilla;* X1= Temperature; X2= Relative Humidity; X3= Pan Evaporation; X4= Sunshine; X5= Evapo-Transpiration; X6= Wind Speed)

Pyrilla perpusilla is becoming a major pest and serious measures should be taken for its management. Usually it appears in March on sugarcane crop and its population goes on increasing till September and then falls down in October [16]. In the present study, it was first observed during first fortnight of August, population continued to grow till September and decreased thereafter. Variation in results regarding appearance of *Pyrilla* may be attributed to difference in host plants and area. However, these results are in line with that of Parihar *et al* (2000) [17]. Its attack may have been delayed due to heavy rains in the month of July, 2010 as its eggs may lodge in rain but according to Brar and Bains (1980) [18] its egg masses did not vary with season i.e. pre-monsoon, monsoon and post-monsoon. In the present study *Pyrilla* population ranged from 1.5-21 adults + nymphs/plant during the whole growing season. During September 2010, *Pyrilla* nymphs's population was higher than adults but lower in October 2010. Zulfiqar *et al* (2010) [19] stated that the *Pyrilla* population was highest at 36.5 °C temperature and 68% RH and lowest at 31.5 °C temperature and 75% RH. According to Gangwar *et al* (2008) [20] temperature more than 40 °C and RH less than 50% are very drastic for *Pyrilla*. But in this study, its population was found to have negative and significant correlation with temperature and non-significant correlation with RH. Regression analysis showed that population was mostly i.e. 55% affected by temperature followed by RH i.e. 10.7%.

In the present study, *E. melanoleuca* appeared in last week of August, increased gradually and reached the peak in September. These results are similar in line with those of Ullah and Mahmood (2007) [21], they also reported the insect population peak in September.

Madan and Chaudhary (1990) [14] stated that RH had no effect on *E. melanoleuca* population and suitable temperature is 25-32 °C. Its development is delayed below 20 °C. In the present study epipyrop population was negatively correlated significantly with temperature and non-significantly with RH and wind speed.

E. melanoleuca is considered to be effective bio-control agent. It was successfully introduced in Srilanka from Pakistan to control *Pyrilla* [22]. Ullah and Mahmood (2007) [21] reported 94% percentage parasitism by epipyrop of adults + nymphs in *Pyrilla*. In the present study percentage parasitism was ranged between 3.1-66.5%. Rajak *et al* (2008) [23] studied the fluctuations in percentage parasitism of *Pyrilla* by parasitoids in sugarcane field with no insecticide usage and found that parasitism ranged from 4.8 to 78.7% during 2004 and 2005.

Percentage parasitism had negative and significant correlation with temperature and varied non-significantly with RH and wind speed. Highest effect was of RH followed by evapo-transpiration and temperature.

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