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Incidence of Rice Hispa, *Dicladispa armigera* (Coleoptera: Chrysomelidae) on *Kharif* paddy in the Agro Climatic Conditions of the Northern Parts of West Bengal, India

By Kaushik Chakraborty & Debes Chandra Deb

University of Gour Bang

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INCIDENCE OF RICE HISPA, DICLADISPA ARMIGERA COLEOPTERA CHRYSOMELIDAE ON KHARIF PADDY IN THE AGRO CLIMATIC CONDITIONS OF THE NORTHERN PARTS OF WEST BENGAL, INDIA

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Kaushik Chakraborty [α] & Debes Chandra Deb [σ]

Abstract - Incidence of rice hispa (RH), *Dicladispa armigera* population in paddy crop (*Oryza sativa* L.) field was assessed by sweep net estimation during four consecutive crop seasons (2005-2008) at Hemtabad, Uttar Dinajpur, West Bengal. The RH population was initiated at about 29 standard meteorological weeks (SMW), improved at first slowly up to 27 SMW then steadily up to 35 SMW attaining the maximum at about 36 SMW which was maintained up to about 38 SMW. The population then subsumed at first slowly up to 40 SMW then abruptly. After 43 SMW insignificant number of RH population was detected. Abiotic conditions such as maximum temperature, temperature gradient, maximum relative humidity, humidity gradient and average relative humidity had significant positive influence on *D. armigera* population. An insignificantly positive relation was also found with the average temperature. In case of minimum temperature, minimum relative humidity, sunshine hours and heavy rainfall, a negative influence on population development was observed. However drizzling rainfall imparted significant positive effect on population growth. Based on the nature of incidence and abundance of *D. armigera*, a package can be generated and accordingly time fitted seedling transplantation as the precautionary measure may be highlighted in the northern parts of West Bengal.

Keywords : rice hispa incidence, climatic factors, paddy crop, seasonality.

I. Introduction

The need for sustainable intensification in paddy production methods presents a considerable challenge as under the current situation, 'low-input' systems may not be able to deliver the required yields increases, while on the other hand 'high input' escalation often lead to cropping systems that are neither sustainable nor stable due to serious pest outbreak (Shepard *et al.*,1995; Sarma *et al.*, 2010). For this reason a comprehensive study on the pest life cycle at 'local level' aiming to develop a region specific pest control strategy is urgently required. Incidence of pest outbreaks in paddy field has increased with the change of pest complexities, in the last four decades (Rajek *et al.*, 1986; Karim, 1986). Some insects have gained momentum, whereas others have declined in importance. There are convincing documents that 'minor pest species' have been favoured by selective crop intensification (Alam, 1967; Pathak *et al.*,1994; Dhaliwal *et al.*, 1998). Intensification engrosses the changes in cultural practices such as (i) increase of crop-cycle per year (Dhaliwal *et al.*, 1998), (ii) augmentation of agricultural chemicals like fertilizers and pesticides (Karim, 1986), (iii) improvement of irrigation facilities (Sarma *et al.*, 2010), and (iv) enhancement of higher plant densities (Dutta *et al.*,1992; Deka *et al.*,1996).

Paddy (*Oryza sativa* L.) is the prime cash crop in West Bengal, India. The rice hispa, *Dicladispa armigera* (Coleoptera: Chrysomelidae) is regarded as one of the major paddy pest in some paddy growing areas of India (Deka *et al.*, 1996; Raman *et al.*,2001; Hazarika *et al.* 2005). Activity of *D. armigera* (RH) covers almost all the crop growing seasons: *aus* (summer rice), transplanted *aman* (monsoon rice), and *boro* (winter rice) (Prakasa Rao *et al.*, 1971; Budhraja *et al.*, 1979). Both upland and deepwater rice are affected by this pest (Reissing *et al.*, 1986; Wang, 1990). Damage especially at vegetative growth stage of the plant results in extensive loss (Islam, 1989). Infestation underscores the paddy yield attributing characters like plant height, tiller number, grain number per panicle and grain yield. Affected deep-water rice plants can hardly tolerate the rising flood water level (Islam, 1973; Khan, 1989). Losses that incurred to the growing paddy crop are insurmountable (Nath *et al.*, 2002; Dutta *et al.*, 2003).

Extent of loss may extend up to 28% in India (Nath *et al.* 2002), 52% in Bangladesh (Karim, 1986; Islam *et al.*,1998; Islam 1989) and 30% in Nepal (Dhaliwal *et al.*, 1998). Rajek *et al.*, (1986) and Hazarika *et al.* (2005) have reported 35-65% grain loss from Assam province of India. But total crop failure, in occasional cases, was also noted from Assam (Hazarika *et al.* 1991). Activity of RH was recorded from Bihar (Agarwala, 1955), Himachal Pradesh (Thakur *et al.*1979; Choudhary *et al.*,2002), West Bengal (Basu *et al.*, 1957),

Author α : Department of Zoology, University of Gour Banga, Mokdumpur, Malda, West Bengal, India.
Author σ : Department of Zoology, University of North Bengal, Raja Rammohanpur. West Bengal, India.

Andhra Pradesh (Rao, 1977), Orrisa (Sontakke *et al.*, 1998), Tripura (Das, 1980) and Punjab (Dhahwal *et al.*,1978). From West Bengal considerable losses to paddy crop have been reported from the district of Burdwan (Banerjee, 1986). Injudicious application of insecticides of newer brand was found less prudent to control the pest menace (Karim *et al.*,1989; Budhraja *et al.*,1979). For this adoption of integrated pest management protocol in paddy is imperative for RH suppression (Dutta *et al.*,1992; Deka *et al.*,1997). To formulate a consistent pest forecasting equation for a particular zone, a holistic study on the field dynamic of RH population in relation to climatic parameters is urgently required (Khan, 1989; Dutta *et al.*, 2003). Detection of the field dynamics of RH population in relation to crop phenology and climatic conditions is considered as a prime requisite for the execution of the subsequent crop protection package in view of modern IPM practices.

Among the northern parts of West Bengal, India, the district Uttar Dinajpur offers a congenial environment for paddy cultivation. But the farmers do follow irregular planting dates disregarding the occurrence of RH incidence. Therefore understanding the recent trends of seasonal abundance of RH is the precondition to develop an integrated management system for this pest. Such time bound observation on population dynamics of RH in consideration of pest management decision making is thus found crucial. Grossly, there are three specific objectives of this study. (i) to define the basic population system of *D. armigera* during the five crop seasons at Hemtabad [26.62^0 N-88.12^0 E], Uttar Dinajpur, West Bengal, (ii) to consider the role of weather parameters on the incidence of RH population and (iii) to apply the generated information relating to RH population dynamics in integrated pest management decision-making.

II. Materials and Methods

Experimental layout: Field study was conducted during four consecutive *kharif* crop years (2005-2008) in insecticide untreated field of paddy cultivar *Swarna mashuri* (MTU 7029). Transplantation to main field was done with 35-day old seedlings at 10 x15 cm spacing on 20-22 standard meteorological weeks (SMW). The soil of the experimental field was sandy loam with PH value 6.2 and EC value 0.29 mmhs/cm. N, P_2O_5 and K_2O was 315, 67 and 367 kg/ha respectively. During land preparation, each plot received 150:60:60 kg/ha NPK as basal dose. Field management was done following national protocol with befitting modifications.

Assessment on pest incidence: Adult individuals of RH were counted by sweep net method.

a) Description of sweep net : Sweep net is a simple and inexpensive way to assess the insect abundance of paddy field ecosystem. The net is funnel-shaped and made up of nylon. The net is mounted on a rigid metal ring. This allows the net to be swept through paddy crop canopy, dislodging insects. For practical applicability the net's ring is attached to a 75 cm long wooden handle. Diameter (r) and length (l) of the net is 25 cm 70 cm respectively.
b) Operational principle: At every 7-day interval 30 sweeps in each plot was done whilst walking slowly through paddy field in diagonal fashion at early morning. Keep the circular frame of the open end of the net perpendicular to the ground and pointing to the direction of the sweeping. Sweep one stroke and one reverse stroke per step Attention was given that the net should not go more than 25 cm below the top of the paddy plants during sampling.

Transfer the collected RH to plastic vial with 70% alcohol. There were five replications (plot) for each experiment year. Incidence of RH was expressed as individuals/ 5 sweeps.

Correlation and matrix analysis: Weekly noted RH population were correlated with the prevailing climatic factors such as maximum temperature (Tmax), minimum temperature (Tmin), temperature gradient (Tgr), maximum humidity (RHmax), minimum humidity (RHmin), humidity gradient (RHgr), sunshine hour (Shr) and rainfall (Rfall).Further inter relationship of the climatic factors was also worked out and then tabulated in matrix pattern.

Statistical analysis: All the data was subjected to the statistical analysis using the software INDOSTAT and Statistica.

III. Results

Population dynamics. No population was noted up to 26 SMW. Very low detectable population was noted at 27-29 SMW. The population then increases gradually and attains the maximum at about 37 SMW which was maintained up to about 38 SMW. High range of population persisted for a few weeks. The RH population then subsumed at first slowly and then rapidly (Table1). Grossly the incidence of RH population have noted from June to October with a very low population in early August which corresponds to the transitions between the *Aus* and *Amon* crop seasons. Observation revealed that early growth stage of the plant rather than the late growth stage were adversely affected by this pest. Extent of infestation was relatively more in September (33-36 SMW) when the RH incidence was comparatively higher. Infestation, at that time, in the field was found in patches. The patchy area then gradually increased in size and depressed due to the suntanned growth of the plant and can easily been identified as 'bowl'. The bowl if not managed properly acts as the reservoir for subsequent field infestation. Extent of infestation corroborates to RH incidence (Table1).

Correlation study : Maximum temperatures and high humidity are conducive to RH population growth and multiplication (Table 2 and 3). Present study portrayed that high winter humidity and high winter and summer temperatures tend to have higher hispa abundance. In all the experiment years except in 2007, the RH population showed a significant positive relation with the Tmax. While Tmin had imparted an insignificant positive effect on the incidence of RH in all the years except in 2007. Except in 2007, the incidence of RH population showed significantly positive relation with Tgr. An insignificantly positive relation was also found with the Tavg in 2006, 2007 and 2008, but in 2005 relations were significantly positive. Persistent RHmax (85-94%) exerted a significantly positive impact on the abundance of RH population in all the years, especially at the late tillering growth stage of paddy. A significantly negative relation between RHmin and the field RH population was found in all the years. Significant positive relations existed between the RHgr and the field RH population in all the years except in 2005 where the relation was insignificantly positive. Humidity conditions during November influences RH outbreaks. RH Incidence was positively influenced by RHavg almost in all the years. But the values of relation differed among the years, particularly in 2006 and 2008. RH population growth appears to be more related to winter humidity values. Bright sunshine hour for an average of 8.23 hrs/day had a significant negative effect on the RH population with the exception of 2005 where the relation though negative, was non significant. Drizzling Rfall had a significant positive effect on the pest structure. But heavy shour within a short time had significant negative effect on pest appearance in all the years. Continuous, heavy rain has a negative effect on adult feeding and egg lying. Egg hatching and the survival of larvae are greatly affected by critical level of moisture and thus heavy mortality with reduced population of RH was noted in dry conditions (Table 2).

Multivariate regression study : The results regarding multivariate regression models through steps between the *H.armigera* population and climatic factors along with the coefficient of determination values (Table 3). It is understandable from the results that maximum temperature alone contributed 7.69 % role in population fluctuation of *H.armigera.* This role was subsumed and restricted up to 4.77 % when the effect of minimum temperature was added to It. Subsequent addition of the effect of temperature gradient resulted in 4.61% effect. With for this addition the 100 R^2 value reached up to 63.01. It means that the average temperature had affected the buildup of *H.armigera* population considerably. Maximum relative humidity influenced the population considerably as the collective contribution was 44.51%. Combining the effect of average relative humidity, 100 R^2 value reached up to 59.40%. Furthermore, rainfall did not show a significant impact on population fluctuation of *H.armigera* which contributed only 3.01% role.

Matrix analysis : Matrix analysis of important climatic factors leads to determine the relative dynamic of the *H.armigera* population. As most of the climatic factors are interdependent, any change of single climatic factor will lead to multiple effects on pest structure. However impact of maximum temperature and humidity gradient were more profound (Table 4).

Principal component analysis : Principal component analysis of the important climatic factors was also done (Figure 1). Results showed the relative importance and prominence of a single climatic factor within the batches of the factors during the experimental weeks. During the *kharif* season the total variable was was71.24%.There was two principal components PC-1 and PC-2 respectively. Values of PC-1 and PC-2 were respectively 41.64% and 29.60%. As average temperature, gradient temperature, average humidity and gradient humidly are the byproduct of their original climatic component, it was excluded during such component analysis. Results showed that during *kharif* season impact of minimum temperature on *H.armigera* was negligible. Maximum relative humidity followed by maximum temperature significant imparted positive effect on pest incidence. Very low negative effect of rainfall on pest occurrence was noted. Effect of sunshine hours was however significantly negative.

Scree plotting: Scree plot expresses the eigen value of the different component factors (F1 to F7). Maximum value was noted for F1 while the minimum was scored for F7 (Fig.2). This has indicated that the prime factors belong to F1 and marginally in F2. Cumulative variability of all the factors, on the contrary was minimum in F1 and maximum F7. The extent of reduction of the eigen value across the F domains was significant (R^2: 0.827).Climatic factors of F1 domain thus influences much the distribution and abundance of *H.armigera* population.

Dendogram analysis: Depending on the similarity of the collective impact of the climatic factors during the experimental weeks, dendogram was drawn (Fig. 3). Weeks that belong to the same cluster have nearly same gross climatic condition. Abhorrently there were two mega-domains in the dendogram (A and B). Domain A includes 32, 33, 36 and 44 SMW respectively. While rest of weeks of the *kharif* season belongs to domain B. Domain B includes two sub-domains (Bi and Bii) each of which contains two micro-domains. Climatic conditions of the micro-domains differ insignificantly. So in each micro-domain the gross impact of the climatic component on *H.armigera* incidence was nearly same. Climatic components of the sub-domain differed marginally while that of mega-domain varied noticeably.

IV. Discussion

The intensity of outbreaks seems to increase following the large-scale adoption of high-yielding rice varieties and their associated newly adopted production technologies (Khan, 1989; Islam *et al.*, 2004). Karim (1986) have suggested that the warmer winter conditions to drive RH outbreak. Thakur *et al.* (1979) have documented that RH incidence is associated with high temperature and relative humidity. Rao (1977) from Andhra Pradesh have reported an incursion of RH at high humidity following heavy rain and during "intermittent bright sunshine". Prakasa *et al.*(1971) have mentioned that unusual high rainfall in August-September favoured RH out-break .Choudhary *et al.*(2001) have reported that RH started to appear as early as second fortnight of May and remain active on the paddy till to the second week of November. Contrary to these findings, in the present observation, incidence of RH population was initiated from the late May, which was then continued to build up slowly attaining the first peak at early June. The population then subsumed gradually. The next highest peak was noted at late August. High level of RH population persists till to the end of September. Though the population then decreased but RH activity was recorded till to the crop harvest.

Incidence of RH in the present findings partly corroborates to the observation of that of Deka *et al.* (1999) and Raman *et al.* (2001). They have observed nearly similar population dynamics of RH with the maximum abundance in the month of September. But the quantity of trap collection in the present experiment differed considerably from their experiments. This may due to the differences of the agro-climatic conditions of the two study area. Contrary to the present observation Sontakke *et al.* (1998) have reported that the maximum light trap collection of RH during October. Though there are substantial differences in the process of recording the pest incidence, the present study is primarily supported by Banerjee (1986). He observed that RH population was low in the first three months of cropping season, attaining the highest activity in the last week of October. From the eastern parts of India (Orrisa), Sontakke *et al.*(1998) have reported that RH population gradually developed reaching the maximum at about 33 SMW. This observation is fully supported by the present observation. Present result of impact of climatic parameters on RH population was also supported by the findings of Dutta *et al.* (2003). Dhahwal *et al.*(1978) from Punjab have reported that Tmin and Rfall had insignificant effect on RH population structure which partly matches with the present observation. Present finding was also supported by Karim (1986) and Islam *et al.*(2004). They too have commented that high humidity imparts positive impact on population development. Dutta *et al.*(2003) and Islam *et al.* (2004) have reported that early monsoonal rain followed by long dry spell and humid weather is conducive for RH multiplication which matches with the present observation. So, paddy seedling transplantation should be done in such time that the maximum crop growth stage and the maximum RH abundance do not coincide (Karim *et al.*1999). Highest level of RH population was noted at about 34-36 SMW. If the crop passes the vulnerable growth stage before the peak pest emergence, the crop is well protected (Rahman *et al.*2001). In this consideration early transplantation of paddy seedlings during *kharif* season is thus found prudent to minimize RH menace.

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Table 1 : Average climatic parameters and the incidence of rice hispa population during the period of study

SMW	Temperature				Relative humidity				Average sunshine hour [Sh Hr]	Rainfall (mm) (Rain F)	Individuals /5 trap
	[T(max)]	[T(min)]	[T(gr)]	[T(avg)]	[RH(max)]	[RH(min)]	[RH(gr)]	[RH(avg)]			
24	32.41	24.24	8.17	28.33	96.23	67.71	28.52	81.97	5.74	0.00	0.17±0.12
25	32.21	24.24	7.97	28.23	96.32	67.71	28.61	82.02	5.74	0.00	0.37±0.21
26	33.11	24.16	8.95	28.64	96.37	47.25	49.12	71.81	5.78	0.00	0.50±0.24
27	32.85	24.81	8.04	28.83	95.47	46.38	49.09	70.93	1.84	9.87	0.76±0.37
28	33.76	24.13	9.63	28.95	94.57	47.14	47.43	70.86	5.17	0.00	1.09±0.87
29	34.32	24.56	9.76	29.44	96.53	47.12	49.41	71.83	8.47	2.03	1.57±1.05
30	34.22	23.21	11.01	28.72	96.22	65.01	31.21	80.62	2.29	2.17	2.58±1.12
31	34.82	24.65	10.17	29.74	95.53	56.27	39.26	75.90	2.04	1.09	3.98±1.53
32	33.85	24.13	9.72	28.99	95.47	44.53	50.94	70.00	3.48	65.32	4.33±1.71
33	32.72	25.35	7.37	29.04	95.84	46.12	49.72	70.98	6.47	47.32	5.21±2.47
34	34.58	25.25	9.33	29.92	94.63	40.12	54.51	67.38	6.94	11.98	6.45±2.03
35	33.72	25.89	7.83	29.81	94.76	41.79	52.97	68.28	8.69	56.87	6.87±2.78
36	32.23	25.85	6.38	29.04	94.91	48.41	46.5	71.66	7.35	62.12	7.45±2.61
37	32.81	25.34	7.47	29.08	96.04	41.59	54.45	68.82	8.51	12.11	7.28±2.05
38	32.15	24.72	7.43	28.44	84.53	39.25	45.28	61.89	5.61	7.12	7.04±3.97
39	30.69	24.92	5.77	27.81	85.42	47.41	38.01	66.42	8.53	2.09	6.53±1.03
40	29.97	21.39	8.58	25.68	87.89	53.53	34.36	70.71	8.73	0.00	6.07±1.19
41	29.48	20.39	9.09	24.94	88.31	57.12	31.19	72.72	6.12	0.00	4.51±2.13
42	29.98	19.83	10.15	24.91	86.35	53.24	33.11	69.80	4.08	0.00	2.87±1.12
43	28.94	18.68	10.26	23.81	90.75	57.13	33.62	73.94	6.27	0.00	0.62±1.08
44	28.94	18.68	10.26	23.81	90.89	57.13	33.76	74.01	6.27	0.00	0.32±0.12

Table 2 : Correlation coefficient of incidence of rice hispa population with the climatic factors indicating the level of significance

Climatic parameters	Years of observation			
	2005	**2006**	**2007**	**2008**
Maximum temperature [T(max)]	0.502*	0.645*	0.481	0.711*
Minimum temperature [T(min)]	0.367	0.311	0.525	0.351
Temperature gradient [T(gr)]	0.508*	0.578*	0.420	0.721*
Average temperature [T(avg)]	0.518*	0.358	0.375	0.265
Maximum humidity [RH(max)]	0.575*	0.525*	0.501*	0.534*
Minimum humidity [RH(min)]	-0.795*	-0.891*	-0.748*	-0.605*
Humidity gradient [RH(gr)]	0.379	0.528*	0.623*	0.828*
Average humidity [RH(avg)]	0.701*	0.556*	0.887*	0.519*
Sunshine hours / day[Sh Hr]	-0.435	-0.752*	-0.578*	-0.831*
Rainfall (Rain F)	0.329	0.345	0.267	0.415

Significant at 5% level

Table 3 : A Step down multiple regression model showing the influence of various abiotic factors on hispa abundance

Step wise regression model	R^2	$100R^2$	% Contribution
Y = 10.50 + 1.52 X1– 7.43 X2 + 5.66 X3+2.17X4 – 5.41X5 + 4.18 X6 – 0.40X7 + 0.62 X8– 0.47 X9– 0.17 X10	0.998	59.8	3.01
Y = 9.52 + 1.52 X1– 7.43 X2 + 5.66 X3+2.17X4 – 5.21X5 + 4.18 X6 – 0.40 X7 – 0.52 X8– 0.42 X9	0.68	76.8	3.54
Y = 10.20 + 1.52 X1– 7.41 X2 + 5.66 X3+2.17X4 – 4.21X5 + 2.18 X6 – 0.59 X7 + 1.72 X8	0.430	59.4	6.63
Y = 11.51 + 1.52 X1– 7.53 X2 + 5.66 X3+2.17X4 – 5.76X5 + 3.08 X6 – 0.49 X7	0.594	43.0	3.22
Y = 14.57 + 1.52 X1– 7.43 X2 + 5.56 X3+2.17X4 – 5.43X5 + 2.18 X6	0.511	11.31	8.21
Y = 13.48 + 2.84 X1 + 3.06 X2 – 6.06 X3 + 2.32 X4 + 4.15 X5	0.998	99.8	44.51
Y = 20.13 + 1.16 X1 + 1.13 X2 – 2.50 X3 – 0.39 X4	0.968	90.81	13.81
Y = 13.56 + 2.28 X1 +2.45 X2 + 4.87 X3	0.930	63.01	4.61
Y = 8.24 + 2.03 X1 +1.05X2	0.594	59.4	4.77
Y = 5.76 + 0.20 X1	0.411	21.35	7.69

Y= H.armigera incidence (%), X1 = maximum temperature, X2 = minimum temperature, X3 = gradient temperature, X4 = average temperature, X5 = maximum relative humidity (%), X6= minimum relative humidity, X7 = average relative, X8 = humidity average relative humidity, X9= gradient relative humidity, X10 = rainfall (mm)

Table 4 : Correlation matrix [Pearson (n)] showing correlation coefficient of important climatic factors in relation to hispa incidence

Variables	T(max)	T(min)	RH(max)	RH(min)	Sh Hr.	Rain F	Pest
T(max)	1.000						
T(min)	0.794	1.000					
RH(max)	0.696	0.483	1.000				
RH(min)	-0.292	-0.448	0.100	1.000			
Sh Hr.	-0.250	0.093	-0.194	-0.304	1.000		
Rain F	0.292	0.450	0.288	-0.435	0.117	1.000	
Pest (Hispa)	0.505	0.211	0.580	-0.512	-0.431	0.293	1.000

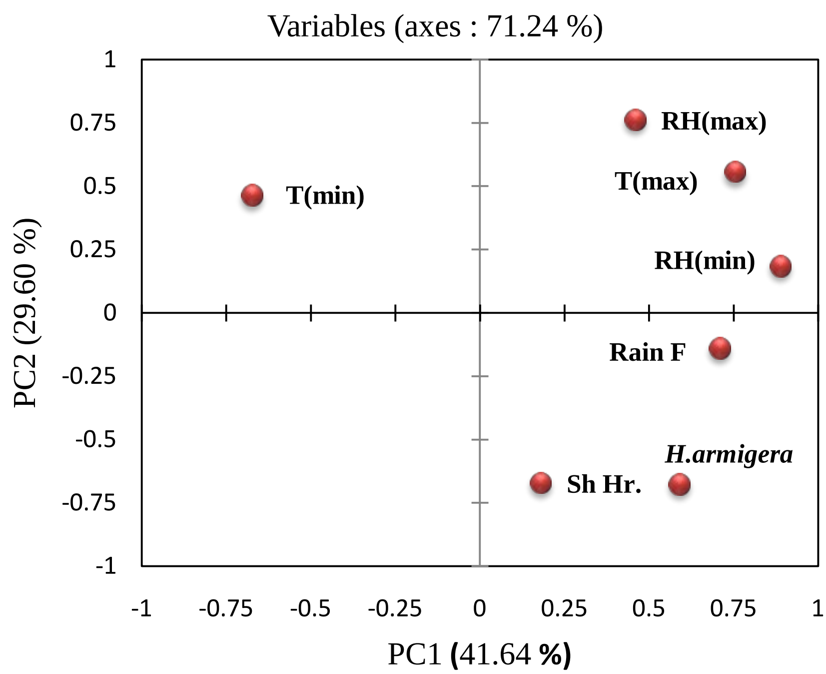

Figure 1 : Principal component analysis of the importance of the climatic factors showing their relative importance

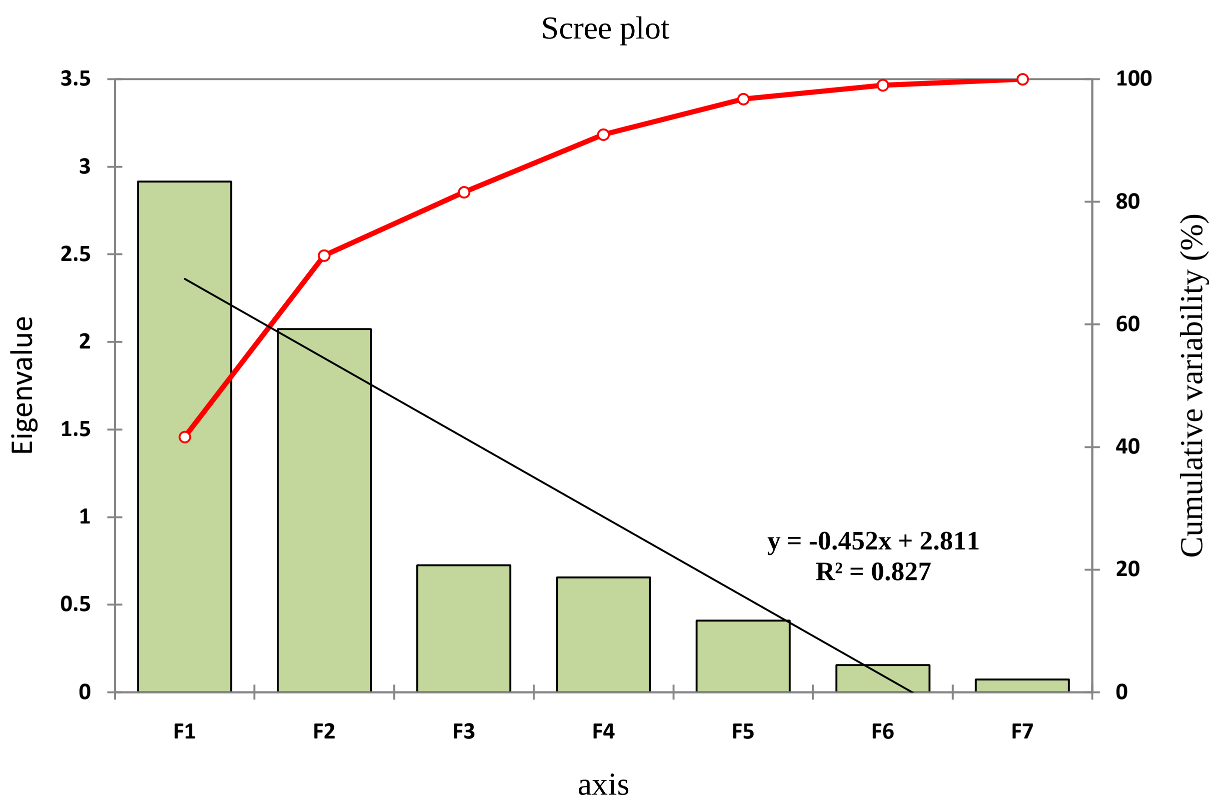

Figure 2 : Scree plot showing the eigen value of the principal components and their relative importance

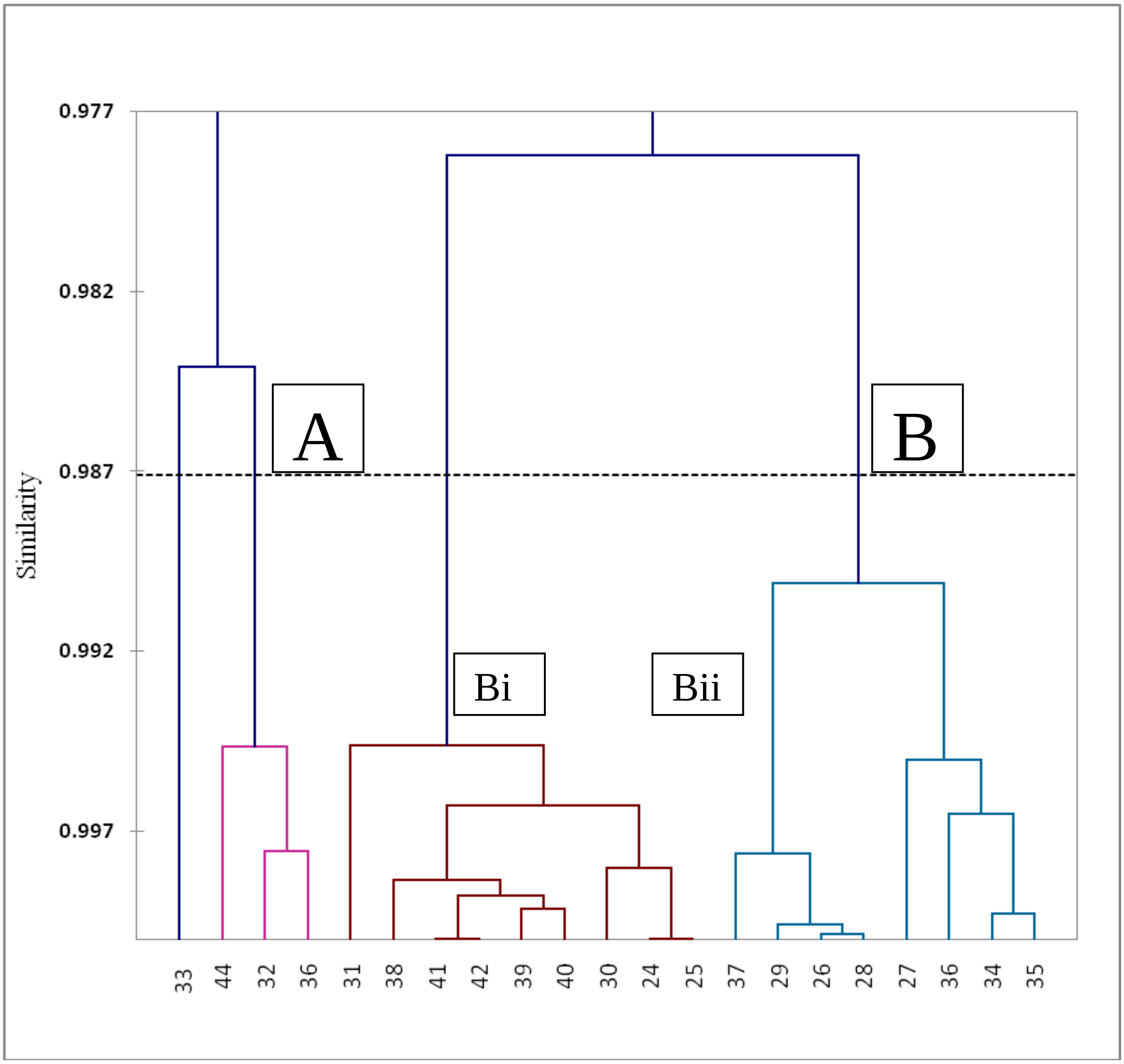

Figure 3 : Dendogram showing the assemblage of the experimental weeks (SMW) depending of the similarity of the important climatic factors