The Pharma Innovation Journal 2022; SP-11(12): 1117-1129

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(12): 1117-1129

www.thepharmajournal.com
Received: 16-09-2022
Accepted: 23-10-2022

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Influence of resilient climate on population dynamics of major pests and natural enemies of rice in Cauvery delta zone of Tamil nadu

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Abstract
Real time pest surveillance was conducted in Cauvery Delta Zone of Thanjavur, Thiruvarur and Nagapattinam District, Thanjavur state in 20 fixed fields of one acre each over 30 villages to analyze the impact of weather on the incidence of insect pests of rice during kharif 2015-2016. Yellow stem borer (YSB), *S. incertulas*, incidence showed significant positive correlation with minimum and average temperatures, rain fall and wind velocity. Leaf folder (LF), *C. medinalis*, damage showed significant negative correlation with minimum and average temperatures, evening and average humidity and wind velocity. Rice hispa (RH) *D. armigera* damage was observed immediately after transplanting and showed positive correlation with rainfall and wind velocity. Brown planthopper (BPH), *Nilaparvata lugens* population had negative correlation with minimum temperature and average humidity whereas, whitebacked planthopper (WBPH), *Sogatella furcifera* incidence was negatively correlated with maximum temperature. The gundhi bug was significantly and negatively correlated with minimum temperature and wind velocity.

Keywords: *S. incertulas, C. medinalis, D. armigera*

Introduction
Rice is one of the important staple foods for half of the world population particularly Asian countries for their livelihood, socio-economic and nutrition. The International Food Policy Research Institute (IFPRI) report Climate Change: Impact on Agriculture and Costs of Adaptation forecasts that by 2050 rice prices will increase between 32 and 37% as a result of climate change. They also showed that yield losses in rice could be between 10 and 15%. Global warming may have been a contributing factor because steadily warmer autumns have occurred since the 1990s. Changed climatic conditions of particular interest are milder winters and warmer summers as well as changing patterns of precipitation. The latter includes increased risk of both extreme precipitation and severe dry spells. These conditions are predicted by the Inter-governmental Panel on Climate Change IPCC (2007) [6] to become more frequent due to changes in the global climate. Overall, temperature is predicted to increase 1.5-4.5 °C during the present century (Meehl GA, 2007) [8] and precipitation to rise 10 to 15% because a warmer atmosphere holds more water (Crosson, 1997) [1] and (Cannon, 1998) [2]. These changes could profoundly affect the population dynamics and the status of insect pests of crops (Woiwod, 1997) [11]. Climatic factors e.g., temperature and humidity/ rainfall are the key factors for development of any rice insect pest and their natural enemies (friendly arthropods). Temperature is probably the single most important environmental factor influencing insect behavior, distribution, development, survival and reproduction in rice (Ramya *et al.*, 2012) [10]. Porter *et al.* (1991) [9] listed the effects of temperature on insects which limit their range, overwintering, population growth rate, number of generations per annum, length of growing season, crop-pest synchronization, intraspecific interaction, dispersal, migration and availability of host plants and refugia. Rice production in parts of Thailand, Philippines, Indonesia, India, Bangladesh, Malaysia and China has been threatened during 2009–2010 due to outbreak of BPH (Heong, 2010) [4]. At the same time, migrant species may also change status to become major rice pests. Since ongoing climate change has a profound effect on insect pests and changes their pest status (Estay *et al.*, 2009) [3] and population dynamics (Karuppaiah and Sujayanad, 2012) [7], climate change probably

contributes to recent destructive outbreaks of brown planthopper (BPH) *Nilaparvata lugens* (Stål) (Homoptera: Delphacidae). Keeping in mind, a base line data generation was done for Cauvery Delta Zone of Tamil Nadu under National Initiatives on Climate Resilient Agriculture during a five year period, 2011-16.

Methodology

Real Time Pest Dynamics (RTPD) of National Innovations on Climate Resilient Agriculture (NICRA) was studied both in experimental station and villages every year from 2011 to 2016 and pest monitoring and surveillance was conducted during *Kuruvai* and *Thaladi* seasons. Ten villages in Valangaiman block of Thiruvarur district (2011-12), ten villages in Thiruvidaimaruthur (2012-13), Kumbagonam (2013-14), Pappanasam (2014-15) blocks of Thanjavur district and ten villages in Kuthalam (2015-16) block of Nagapattinam district were identified for fixed plot fields by the assistance of village level extension workers of state agriculture department. The selected villages are within the radius of 21 km from the experimental station. The GPS attributes were recorded for all 10 villages and surveillance plan was prepared every year. In the experimental station, two fields of each 1 acre size were maintained for taking observation both in protected and unprotected condition. Weekly pest and natural enemies population were recorded from 20 plants selected at random both in villages and experimental station and damage percentage/population number per hill were worked out. The pest observation was initiated at 20 DAT and prolonged upto maturity stage. Light trap catches were taken daily from a Robinson light trap with 125 Watts mercury bulb as lighting source and 12 hours lighting period. Pheromone monitoring for rice yellow stemborer was also carried out by installing polythene sleeve traps @ 12 /ha (lure blended at IICT, Hyderabad) from 20 DAT and weekly adult moth trap catches were observed. The standard week light trap catches and weekly pest and natural enemies observation were correlated with 5 major weather parameters *viz.*, maximum temperature, minimum temperature, Relative Humidity (Morning), Rainfall and sunshine hours. Similarly, the pest observation at various crop growth stages in the villages and fields were also correlated with five major weather parameters.

Results and Discussion

Light trap caches

Climate variables Vs Stemborer (Fig. 1)

Maximum temperature was negatively correlated with light trap catches of stemborer during 2011, 2014 & 2015 and it was non-significant during 2012 and 2013. It was evident that the light trap catches of stemborer was nil when the maximum temperature of 39.6ºC observed in April 2015. Minimum temperature has negatively correlated with light trap catches in all five years except 2012 which was non-significant. Rainfall was not significant on light trap catches during 2012, 2013, 2014 & 2015 except 2011 which was negatively correlated. Relative humidity was non-significant with light trap catches in all five years except 2013 which was positively correlated.

Climate variables Vs Leaf folder (Fig. 2)

The light trap catches of leaf folder was low when the maximum temperature was high relating negative correlation during 2011&2015 whereas it was non-significant during 2013. Minimum temperature was not affecting light trap catches during 2013 & 2015 and it has negative influence during 2011. Relative humidity has positive correlation with light trap catches during 2011 & 2015 and it was non - significant during 2013. During 2015, sunshine hours was negatively correlated with light trap catches and it was non - significant during 2011 & 2013. Rainfall was non-significant with light trap catches in all three years (2011, 2013, and 2015) except 2011 which was negatively correlated.

Climate variables Vs Green leafhopper (Fig. 3)

Maximum temperature was negatively correlated with light trap catches of green leafhopper during 2011, 2012, 2013 &2014 and it was non-significant during 2015. The trap catches was nil in June 2012 when the maximum temperature was 38.4 ºC. Negative correlation between minimum temperature and light trap catches was recorded during 2012, 2013, 2014 &2015 whereas it was non-significant during 2011. During 2011, 2012 & 2014 relative humidity was positively correlated with light trap catches and it was non - significant during 2013& 2015. Rainfall and sunshine hours have no significance with light trap catches during in all five years except 2014 during which sunshine hours alone has significant effect.

Climate variables Vs Brown planthopper (Fig. 4)

Negative correlation of light trap catches with maximum temperature was observed during 2011, 2013 & 2014 whereas it was non-significant during 2015. Minimum temperature was negatively correlated with light trap catches in all four years. Positive correlation between relative humidity and light trap catches was noticed during 2011&2014 and it was non - significant during 2013&2015. Rainfall and sunshine hours have no significant influence on light trap catches of BPH in all four years.

Climate variables Vs Black bug (Fig. 5)

All five parameters *viz.*, maximum temperature, minimum temperature, relative humidity, sunshine hours and rainfall were non-significant with light trap catches in all four years (2011, 2013, 2014 &2015) except sunshine hours which was significant during 2011 and it was positively correlated.

Climate variables Vs Coccinellids (Fig. 6)

Negative correlation between maximum temperature, minimum temperature and light trap catches was observed during 2012 and no influence was observed during 2013, 2014 & 2015. Relative humidity was positively correlated during 2012 and it was negatively correlated during 2014. Rainfall and sunshine was non- significant with light trap catches during 2012, 2013, 2014 & 2015.

Climate variables Vs Ground beetle (Fig. 7)

During 2012, 2014& 2015 maximum temperature and rainfall have no significant influence on light trap catches of ground beetle. Minimum temperature was negatively correlated with light trap catches during 2012&2015 whereas it was non-significant during 2014. Positive correlation between relative humidity and light trap catches was recorded during 2012 and it was non-significant during 2014 &2015. Sunshine has non-significant with light trap catches during 2012&2015 except 2014 which was negatively correlated.

Climate variables Vs Rove beetle (Fig. 8)
Maximum temperature and sunshine were negatively correlated with light trap catches during 2014 and it was non-significant during 2015. Minimum temperature was negatively correlated during 2014 & 2015. Positive correlation with relative humidity was noticed during 2014. Rainfall has no influence on light trap catches during 2014&2015.

Expermimenttal Station
Climate variables Vs Dead heart damage
Maximum temperature, minimum temperature, relative humidity and sunshine hours have no significant effect on stemborer damage during 2013-2014, 2014-2015&2015-2016. Rainfall was negative correlation with stemborer damage during 2014-2015 and it was non -significant during 2013-2014 & 2015-2016.

Climate variables Vs Silver shoot damage
During 2013-2014 & 2015-2016, maximum temperature and rainfall were negatively correlated with silver shoot damage and it was non -significant during 2014-2015. Relative humidity was non- significant with silver shoot damage in all three years. Positive correlation between minimum temperature and sunshine hours with silver shoot damage were recorded during 2013-2014& 2015-2016 whereas it was non- significant during 2014-2015.

Climate variables Vs Leaf folder damage
Negative correlation of leaf folder damage with maximum temperature was observed during 2013-2014 whereas it was non-significant during 2014-2015 &2015-2016. Minimum temperature, relative humidity and rainfall were non-significant with leaf folder damage in all three years. Positive correlation between sunshine hours and leaf folder damage was noticed during 2013-2014 and it was non -significant during 2014-2015 &2015-2016.

Climate variables Vs Brown planthopper
Rainfall has positive correlation with brown planthopper during 2015-2016 and it was non -significant during 2013-2014 &2014-2015.Maximum temperature, minimum temperature and relative humidity were non- significant with brown planthopper in all three years. During 2015-2016, sunshine hours was negatively correlated with brown planthopper incidence and it was non -significant during 2013-2014&2014-2015.

Climate variables Vs Green leafhopper
Positive correlation between sunshine hours and green leafhopper was recorded during 2015-2016 whereas it was non -significant during 2013-2014 &2014-2015. During 2013-2014, 2014-2015& 2015 -2016, maximum temperature, minimum temperature, relative humidity and rainfall were non- significant with green leafhopper.

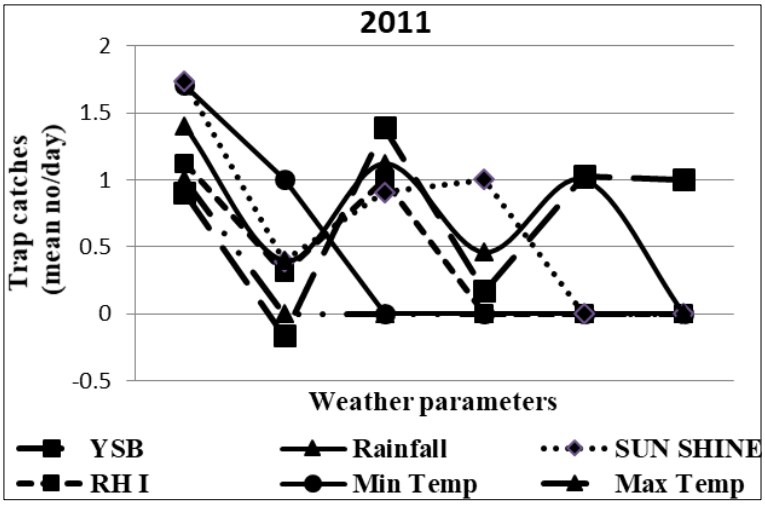
Climate variables Vs Coccinellids
Minimum temperature was negatively correlated with coccinellids population during 2015-2016 whereas it was non-significant during 2013-2014 & 2014-2015. Non- significant between maximum temperature, relative humidity, rainfall and sunshine with coccinellids were recorded in all three years.

Climate variables Vs Spider
All parameters were non-significant with spider population in all three years.

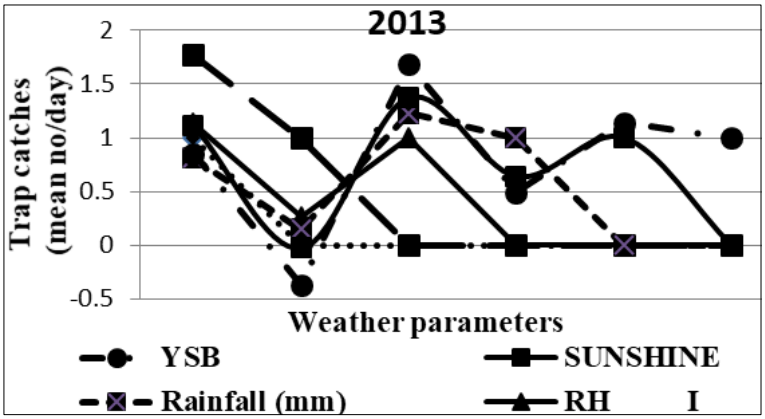
Climate variables Vs Ground beetle
Maximum temperature, minimum temperature, relative humidity, rainfall and sunshine have no significant effect with ground beetle during 2014-2015 & 2015-2016.

Climate variables Vs Black bug
All parameters were non-significant with black bug population during 2014-2015.

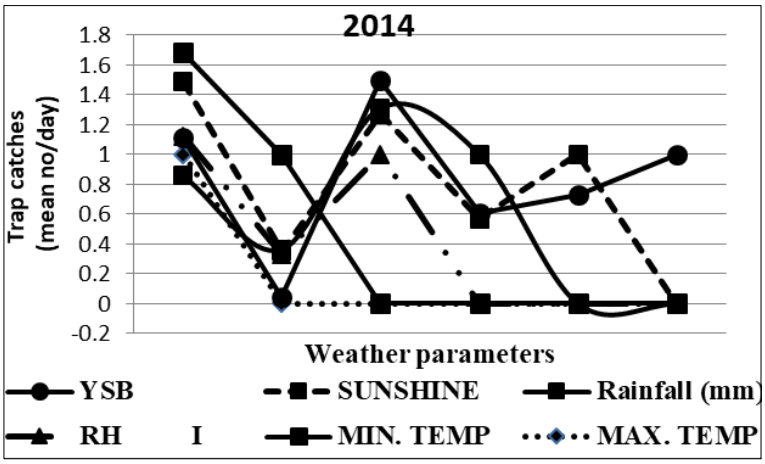
Climate variables Vs Gundhi bug
Maximum temperature, minimum temperature, relative humidity, rainfall and sunshine were non-significant with ground beetle during 2015-2016.



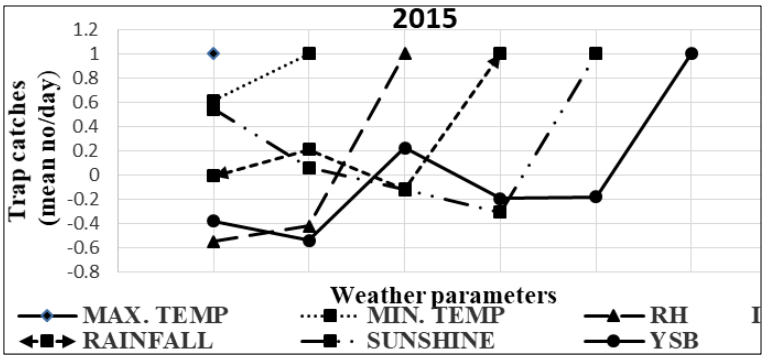
Sw	Max. Temp	Min. Temp	Rhi	Rainfall	Sunshine	Y sb
r	-0.4996	-0.5626	0.2678	-0.2873	0.0288	1
t (cal)	-4.0788	-4.8128	1.9658	-2.1209	0.2039	0
p=0.05	S	S	NS	S	NS	NS
	Negative correlation	Negative correlation		Negative correlation		



Sw	Max. Temp	Min. Temp	Rhi	Rainfall	Sunshine	Y sb
r	-0.2599	-0.3421	0.3095	-0.1483	0.1392	1
t (cal)	-1.9033	-2.5743	2.2994	-1.0604	0.9942	0
p=0.05	NS	S	S	NS	NS	NS
		Negative correlation	Positive correlation			

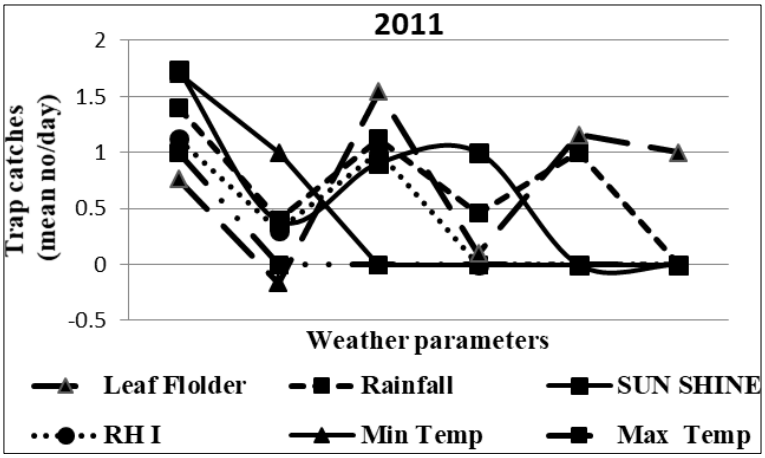


Yellow stemborer-2014						
Sw	Max. Temp	Min. Temp	Rhi	Rainfall	Sunshine	Y sb
r	-0.3724	-0.3122	0.2222	0.0344	-0.2660	1
t (cal)	-2.8379	-2.3240	1.6117	0.2434	-1.9516	0
p=0.05	S	S	NS	NS	NS	NS
	Negative correlation	Negative correlation				

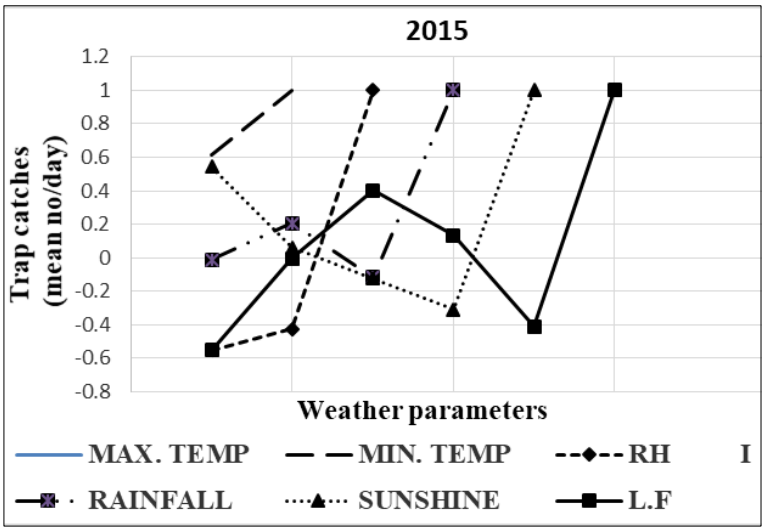


Yellow stemborer-2015						
Sw	Max. Temp	Min. Temp	Rhi	Rainfall	Sunshine	Ys b
r	-0.3852	-0.5432	0.2232	-0.1951	-0.1814	1
t (cal)	-2.9513	-4.5751	1.6193	-1.4062	-1.3045	0
p=0.05	S	S	NS	NS	NS	NS
	Negative correlation	Negative correlation				

Fig 1: Correlation of weather parameters with Yellow stemborer moth trap catches (Contd.)

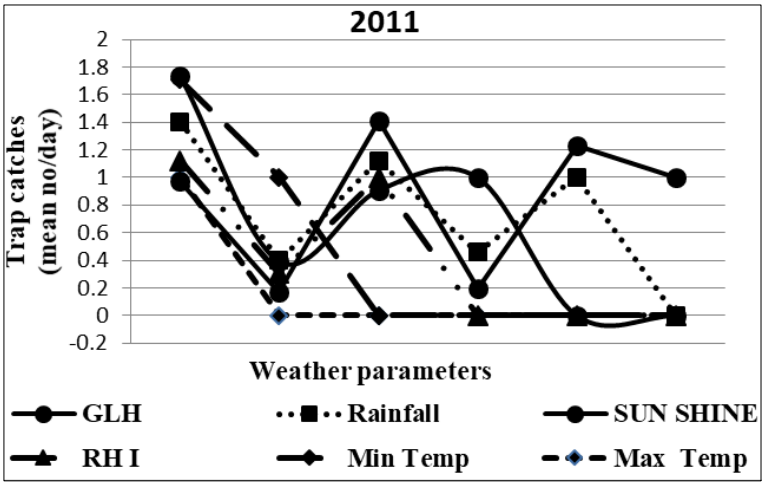


Leaffolder-2011						
Sw	**Max. Temp**	**Min. Temp**	**Rhi**	**Rainfall**	**Sunshine**	**Leaf Folder**
r	-0.6407	-0.5691	0.4230	-0.3607	0.1570	1
t (cal)	-5.9005	-4.8934	3.3016	-2.7342	1.1247	0
p=0.05	S	S	S	S	NS	NS
	Negative correlation	Negative correlation	Positive correlation	Negative correlation		

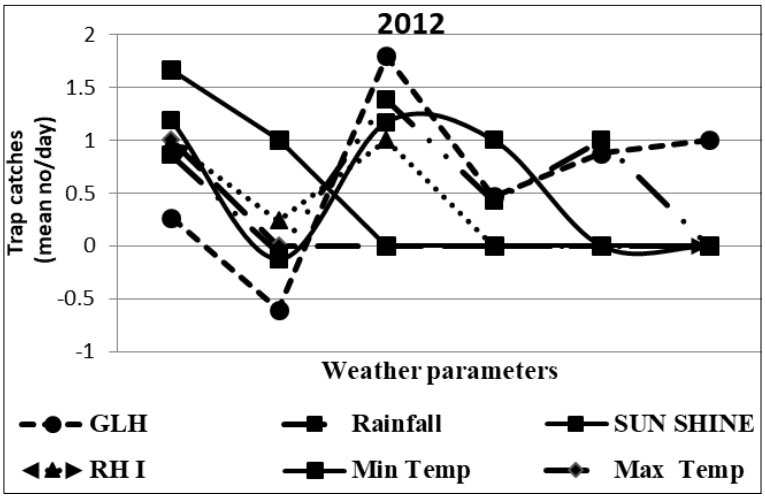


Leaffolder-2015						
Sw	**Max. Temp**	**Min. Temp**	**Rhi**	**Rainfall**	**Sunshine**	**Leaf Folder**
r	-0.5533	-0.0043	0.4024	0.1336	-0.4117	1
t (cal)	-4.6973	-0.0306	3.1083	0.9533	-3.1944	0
p=0.05	S	NS	S	NS	S	NS
	Negative correlation		Positive correlation		Negative correlation	

Fig 2: Correlation of weather parameters with Leaf folder moth trap catches

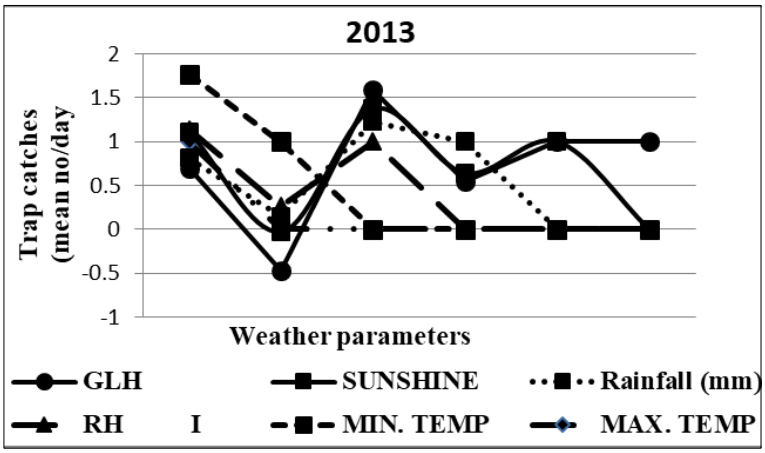


GLH-2011						
Sw	**Max. Temp**	**Min. Temp**	**Rh i**	**Rainfall**	**Sunshine**	**Glh**
r	-0.4250	-0.2305	0.2890	-0.2639	0.2349	1
t (cal)	-3.3207	-1.6756	2.1348	-1.9349	1.7090	0
p=0.05	S	NS	S	NS	NS	NS
	Negative correlation		Positive correlation			

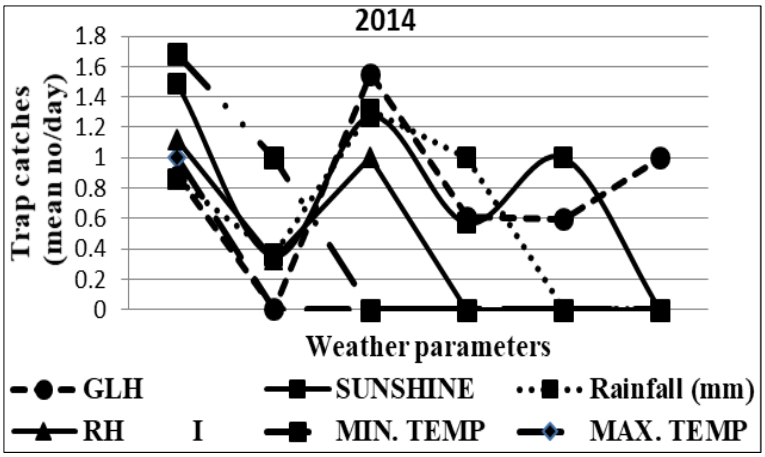


GLH-2012						
Sw	**Max. Temp**	**Min. Temp**	**RH I**	**Rainfall**	**Sunshine**	**GLH**
r	-0.5957	-0.5347	0.4150	0.0399	-0.1243	1
t (cal)	-5.2443	-4.4739	3.2247	0.2827	-0.8858	0
p=0.05	S	S	S	NS	NS	NS
	Negative correlation	Negative correlation	Positive correlation			

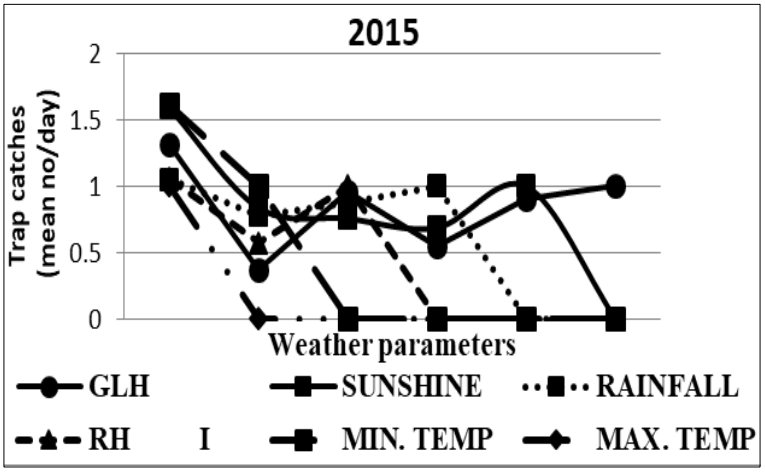
Fig 3: Correlation of weather parameters with Green leafhopper trap catches



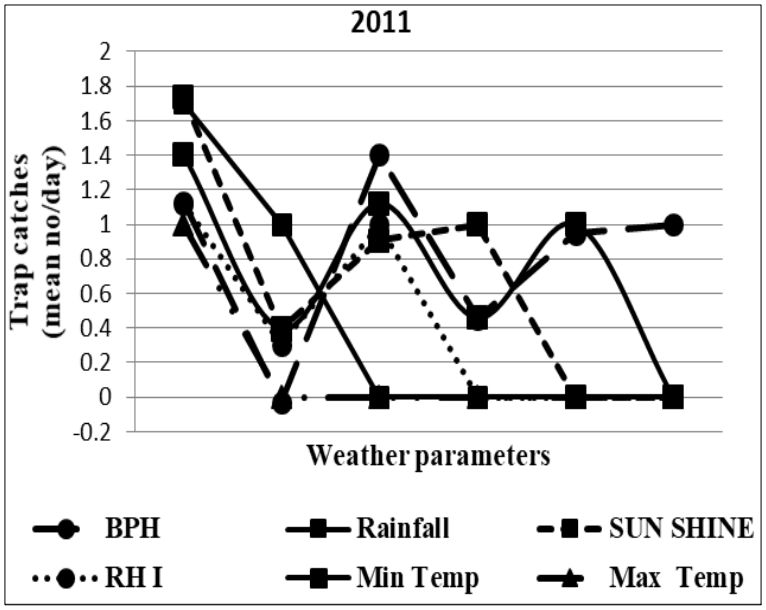
GLH-2013						
Sw	**Max. Temp**	**Min. Temp**	**Rh i**	**Rainfall**	**Sunshine**	**Glh**
r	-0.4173	-0.4411	0.2179	-0.0946	0.0058	1
t (cal)	-3.2468	-3.4754	1.5787	-0.6721	0.0410	0
p=0.05	S	S	NS	NS	NS	NS
	Negative correlation	Negative correlation				



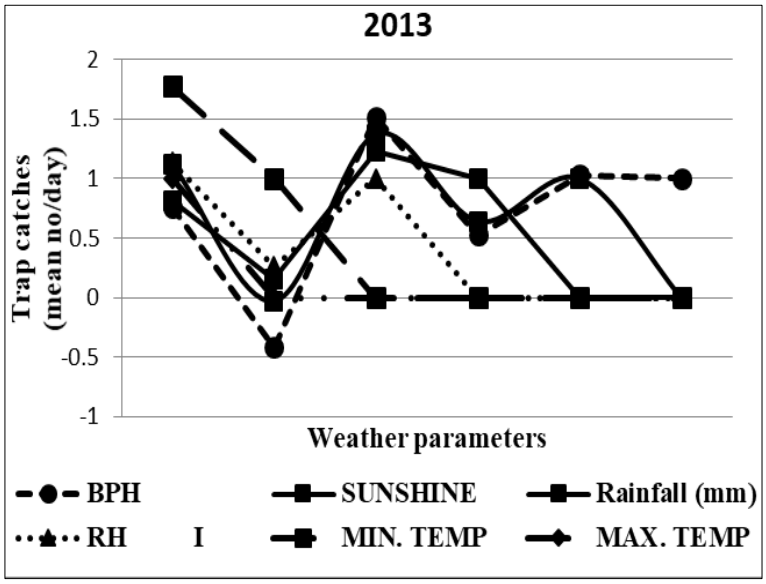
GLH-2014						
Sw	**Max. Temp**	**Min. Temp**	**RH I**	**Rainfall**	**Sunshine**	**GLH**
r	-0.6072	-0.3505	0.2786	0.0405	-0.4024	1
t (cal)	-5.4042	-2.6462	2.0518	0.2873	-3.1083	0.0000
p=0.05	S	S	S	NS	S	NS



GLH-2015						
Sw	**Max. Temp**	**Min. Temp**	**Rhi**	**Rainfall**	**Sunshine**	**Glh**
r	-0.2697	-0.4737	0.2021	-0.1437	-0.0969	1
t (cal)	-1.9801	-3.8034	1.4590	-1.0271	-0.6882	0
p=0.05	NS	S	NS	NS	NS	NS
		Negative correlation				

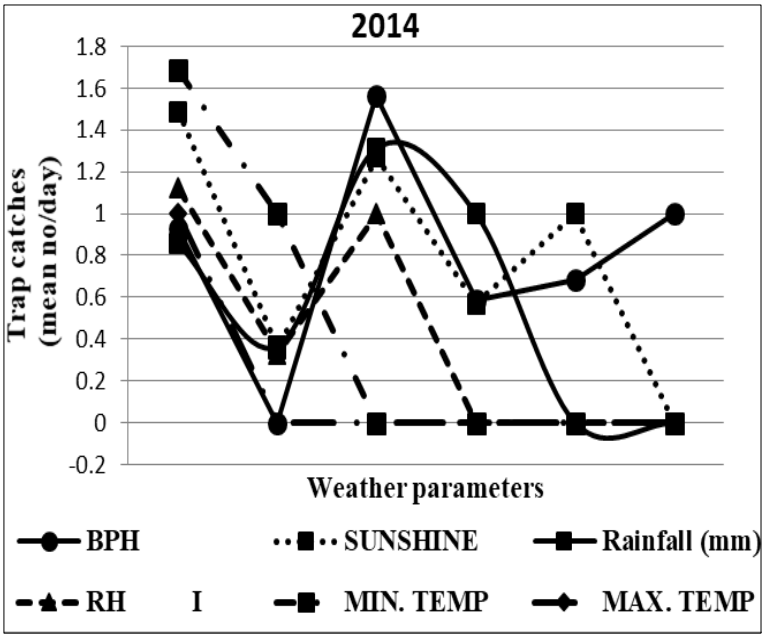


BPH-2011						
Sw	**Max. Temp**	**Min. Temp**	**Rhi**	**Rainfall**	**Sunshine**	**B ph**
r	-0.2741	-0.4281	0.2818	-0.0023	-0.0538	1
t (cal)	-2.0158	-3.3496	2.0772	-0.0166	-0.3815	0
p=0.05	S	S	S	NS	NS	NS
	Negative correlation	Negative correlation	Positive correlation			

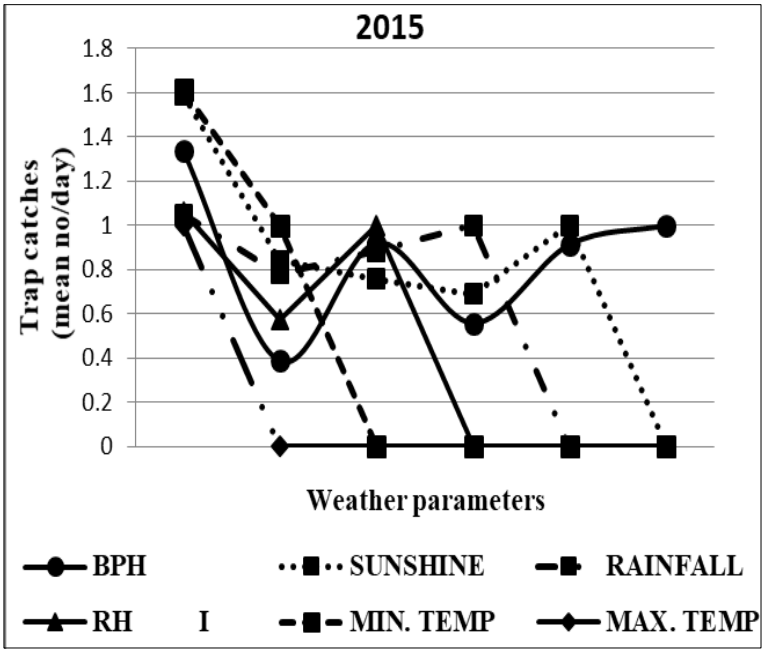


BPH-2013						
Sw	**Max. Temp**	**Min. Temp**	**Rh i**	**Rainfall**	**Sunshine**	**B ph**
r	-0.35599	-0.3923	0.1427	-0.1159	0.0267	1
t (cal)	-2.6936	-3.0159	1.0195	-0.8256	0.1891	0
p=0.05	S	S	NS	NS	NS	NS
	Negative correlation	Negative correlation				

Fig 4: Correlation of weather parameters with Brown leafhoppers trap catches (Contd.,)

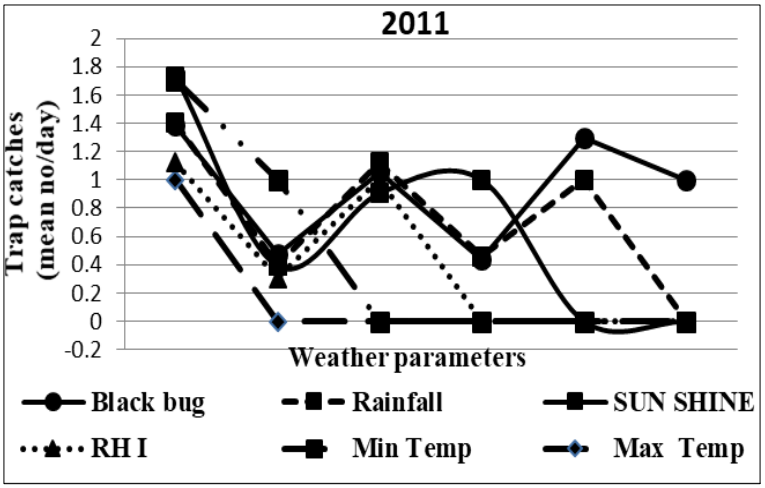


BPH-2014						
Sw	**Max. Temp**	**Min. Temp**	**RH I**	**Rainfall**	**Sunshine**	**BPH**
r	-0.5576	-0.3546	0.2931	0.0188	-0.3155	1
t (cal)	-4.7499	-2.6822	2.1683	0.1329	-2.3521	0
p=0.05	S	S	S	NS	S	NS
	Negative correlation	Negative correlation	Positive correlation			

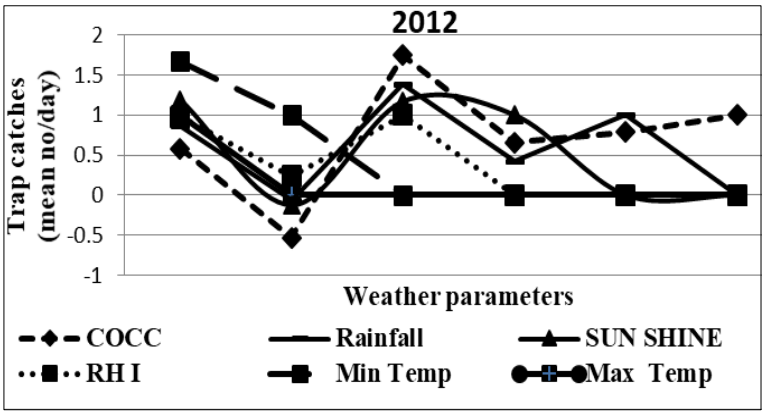


BPH-2015						
Sw	**Max. Temp**	**Min. Temp**	**Rhi**	**Rainfall**	**Sunshine**	**BPH**
r	-0.2553	-0.4532	0.1634	-0.1312	-0.0863	1
t (cal)	-1.8668	-3.5953	1.1709	-0.9359	-0.6124	0
p=0.05	NS	S	NS	NS	NS	NS
		Negative correlation				

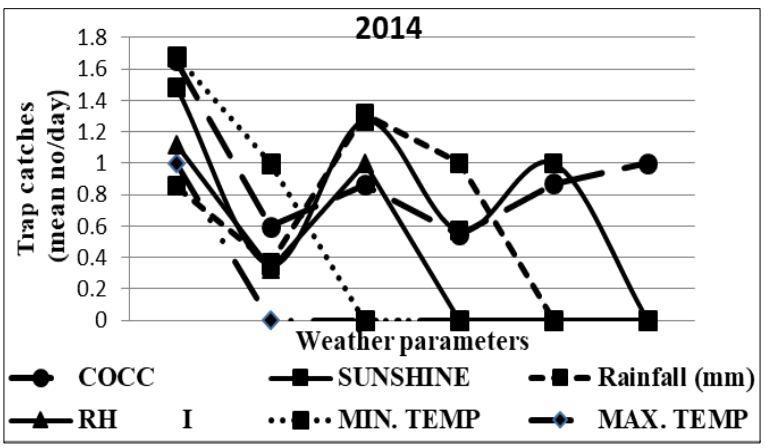
Fig 5: Correlation of weather parameters with Blackbug trap catches



Blackbug-2011						
Sw	**Max. Temp**	**Min. Temp**	**Rhi**	**Rainfall**	**Sunshine**	**Black bug**
r	-0.0174	0.0799	-0.0644	-0.0203	0.2970	1
t (cal)	-0.1231	0.5673	-0.4563	-0.1436	2.1995	0
p=0.05	NS	NS	NS	NS	S	NS
					Positive correlation	

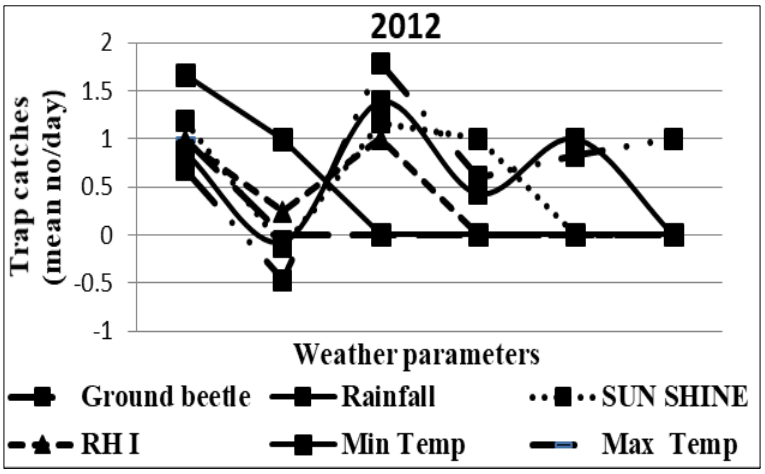


COCC-2012						
Sw	**Max. Temp**	**Min. Temp**	**Rhi**	**Rainfall**	**Sunshine**	**Cocc**
r	-0.2810	-0.4664	0.3614	0.224768	-0.2113	1
t (cal)	-2.0704	-3.7283	2.7411	1.6310	-1.5287	0
p=0.05	S	S	S	NS	NS	NS
	Negative correlation	Negative correlation	Positive correlation			

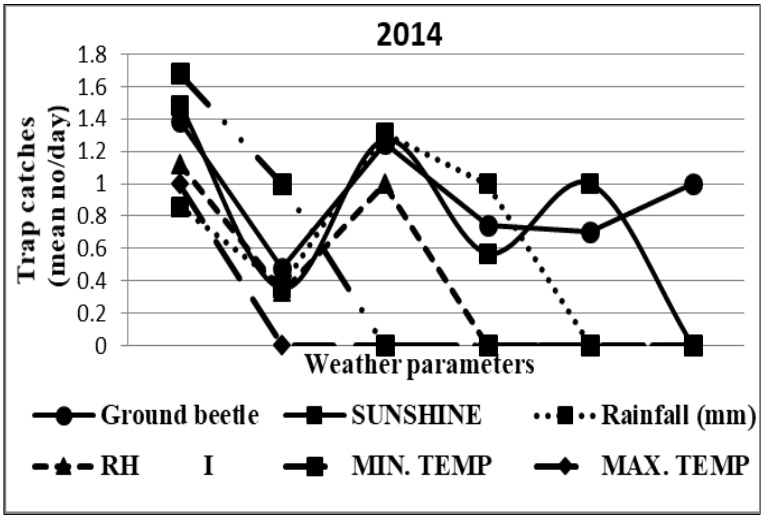


COCC-2014						
Sw	**Max. Temp**	**Min. Temp**	**RH I**	**Rainfall**	**Sunshine**	**Cocc**
r	0.1689	0.2450	-0.4098	-0.0247	-0.1292	1
t (cal)	1.2123	1.7871	-3.1768	-0.1749	-0.9218	0
p=0.05	NS	NS	S	NS	NS	NS
			Negative correlation			

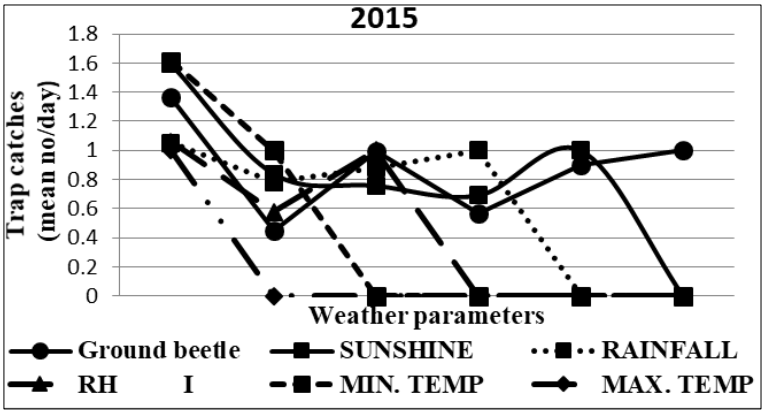
Fig 6: Correlation of weather parameters with Coccinellids trap catches



Ground beetle-2012						
Sw	**Max. Temp**	**Min. Temp**	**Rhi**	**Rainfall**	**Sunshine**	**Ground beetle**
r	-0.1803	-0.3970	0.4019	0.1736	-0.1719	1
t (cal)	-1.2965	-3.0590	3.1036	1.2469	-1.2345	0
p=0.05	NS	S	S	NS	NS	NS
		Negative correlation	Positive correlation			

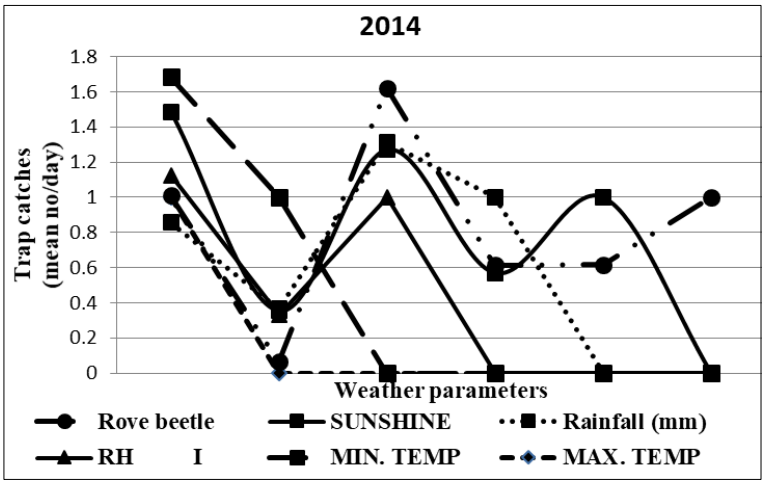


Ground beetle-2014						
Sw	**Max. Temp**	**Min. Temp**	**Rh i**	**Rainfall**	**Sunshine**	**Ground beetle**
r	-0.1001	0.1231	-0.0211	0.1761	-0.2960	1
t (cal)	-0.7119	0.8776	-0.1498	1.2656	-2.1912	0
p=0.05	NS	NS	NS	NS	S	NS
					Negative correlation	

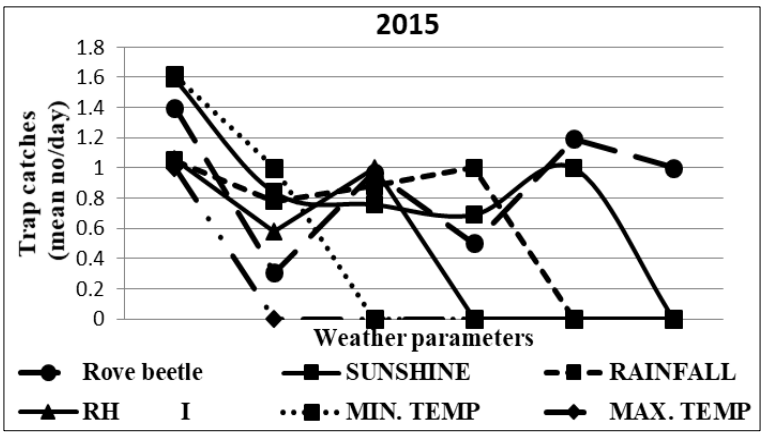


Ground beetle-2015						
Sw	**Max. Temp**	**Min. Temp**	**Rh i**	**Rainfall**	**Sunshine**	**Ground beetle**
r	-0.2294	-0.3931	0.2353	-0.1240	-0.0972	1
t (cal)	-1.6671	-3.0230	1.7121	-0.8839	-0.6911	0
p=0.05	NS	S	NS	NS	NS	NS
		Negative correlation				

Fig 7: Correlation of weather parameters with Groundbeetle trap catches



Rovebeetle-2014						
Sw	**Max. Temp**	**Min. Temp**	**Rh i**	**Rainfall**	**Sunshine**	**Rove beetle**
r	-0.4768	-0.2912	0.3510	0.0438	-0.3818	1
t (cal)	-3.8364	-2.1529	2.6511	0.3100	-2.9214	0
p=0.05	S	S	S	NS	S	NS
	Negative correlation	Negative correlation	Positive correlation		Negative correlation	



Rovebeetle-2015						
Sw	**Max. Temp**	**Min. Temp**	**Rhi**	**Rainfall**	**Sunshine**	**Rove beetle**
r	-0.1936	-0.5303	0.2154	-0.1884	0.1935	1
t (cal)	-1.3955	-4.4237	1.5598	-1.3570	1.3950	0
p=0.05	NS	S	NS	NS	NS	NS
		Negative correlation				

Fig 8: Correlation of weather parameters with Rove beetle trap catches

Conclusion

Among the climate variables, maximum temperature and minimum temperature have drastic influence on light trap catches of pests and this was followed by relative humidity except in case of black bug. Temperature is probably the single most important environmental factor influencing insect behavior, distribution, development, survival and reproduction in rice (Ramya *et al.*, 2012) [10]. Rain fall has negative correlation on trap catches of yellow stemborer and leaf folder. It should also be noted that most of insect pests can adapt to a wide range of environment through selection and evolution (Huang *et al.*, 2010) [5]. Among the climate variables, minimum temperature has influence on light trap catches of coccinellids, ground beetle and rove beetle whereas sunshine hours and rainfall have nill effect on the trap catches.

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