Sri Lanka Journal of Food and Agriculture 4(1): 1-8, 2018
DOI: http://doi.org/10.4038/sljfa.v4i1.52

Sri Lanka Journal of Food and Agriculture (SLJFA)

ISSN: 2424-6913
Journal homepage: www.slcarp.lk

Research Paper

Temporal distribution of rice sheath mite *Steneotarsonemus spinki* Smiley (Acari: Tarsonemidae) as influenced by the climatic parameters in the low-country wet zone of Sri Lanka

G.D.S.N. Chandrasena[1*], J. Ponnamperuma Arachchi[2], M.C. Millawithanachchi[2], M.G. Rupasinghe[3], P.M.H. Coorey[1], T.L. Kumarathissa and W.N.M. Madurangani[3]

[1] Regional Rice Research and Development Centre, Bombuwela, Sri Lanka
[2] Agriculture Research Station, Labuduwa, Sri Lanka
[3] Agriculture Research Station, Benthota, Sri Lanka
[*] Corresponding Author: susanthinilminic@gmail.com https://orcid.org/0000-0002-8648-5242

Article History:
Received: 1 February 2018
Revised form received: 1 May 2018
Accepted: 31 May 2018

Abstract: The rice sheath mite (RSM; *Steneotarsonemus spinki* Smiley) is considered as the most destructive mite pest of rice (*Oryza sativa* L) in most of the rice-growing countries including Sri Lanka. Under heavy infestation of RSM, yield losses could reach up to 95%. Intermittent heavy showers negatively affects the RSM population while prolong dry periods influence positively on its population growth. However, no detailed studies have been done in Sri Lanka to elucidate the influence of weather conditions on population dynamics. This study was conducted in three different locations in the low country wet zone (LCWZ; elevation < 300m amsl; annual rainfall > 2,200mm) from 2013-2015 to examine the relationship between selected weather parameters and population dynamics of RSM. An experiment was laid out in a randomized complete block design in three replicates where crop was planted in 15-day intervals under pesticide-free condition. In weekly intervals, 25 leaf sheaths from 10 randomly selected plants from each plot were observed under microscope to count the number of mites. Climatic data were collected from respective meteorological units for the study period. The results revealed that, rainfall (r=-0.543) during the 2013/2014 *Maha* season at Bombuwala and RH (r=-0.86) during the 2013 *Yala* season at Labuduwa have a negative correlation with the RSM population, while temperature between 29 – 32 °C (r=0.794 and 0.902 at Bombuwala and Labuduwa, respectively, during the 2013 *Yala* season) and more sunshine hours with dry weather conditions affected favourably. Abundance of RSM-infested host plants in the previous season had a significant influence on its occurrence in new rice crop under favourable environment conditions.

Keywords: *Steneotarsonemus spinki, Oryza sativa,* population dynamics

Introduction

Steneotarsonemus spinki Smiley (Acari: Tatsonemidae**)**, the rice sheath mite (RSM) or panicle rice mite (PRM) is a microscopic creature. The first published reference to *S. spinki* as a pest of rice crop was from southern China in 1968 and is considered a serious pest of rice in tropical Asia, Central America and the Caribbean (Hummel *et al.*, 2009). In Sri Lanka, RSM was first recorded in 2000 in the intermediate zone (Nugaliyadda *et al.*, 2005). Subsequently, it has become the most important and destructive mite pest in most of the rice-growing areas in the island.

The RSM lives in space between rice leaf-sheaths, but can also live under the hull of rice grains and survives in stubbles and ratoon during the off season. The RSM feeds on cells of leaf sheaths, stems and kernels at the reproductive stage of rice plant leading to impaired grain development with empty or partially-filled grains with brown spots and panicle standing erect. Among the mites, *S. spinki* (family Tarsonemidae) infests flag leaf sheath causing brown discoloration. Its damage at early reproductive stage of the crop develops chocolate-brown coloured lesions on the leaf sheath and the feeding on the floral parts causes considerable grain sterility (Mutthuraju *et al.*, 2014). It also damages the rice crop indirectly by vectoring and facilitating the establishment of pathogens such as sheath rot caused by *S. oryzae* and panicle blight causing *Burkholderia glumae* (Hummel *et al.,* 2009). Yield losses in rice due to RSM damage has been estimated as 5 - 95% in a number of countries including Sri Lanka (Navia *et al.,* 2010; Pushpakumari *et al.,* 2010). Hummel *et al*. (2009) reported that Japonica varieties in India are more susceptible to RSM than the Indica varieties, with a 20% yield loss.

Facultative pathogenesis is reported in S. *spinki*. All the descendants of virgin females are males. The mother female then mates with its male offspring's to produce both male and female mites. A mated female mite on an average could produce 55 eggs in the laboratory at 24.5 - 35 °C. The mites multiply during the whole year, with a minimum of 6 generations per month in spring and less than 3 in winter (Hummel *et al.*, 2009) while Increasing temperatures results in shorter generation times. Hence, the RSM is able to produce 48–55 generations per year under ideal climatic conditions. Three potential pathways of RSM entry have been identified *i.e. via* rice seeds (Rao *et al.,* 2000), natural means such as transfer by wind, water, insects and birds (Almaguel *et al.,* 2003) and mechanical means such as farming equipment (Pushpakumari *et al.,* 2010).

Studies on host range of S. *spinki* have been conducted only in few countries yet. American wild rice (*O. latifolia* Desv) is an alternate host for S. *spinki* in Costa Rica and Panama (Sanabria and Aguilar, 2005) while *Cynodon dactylon* (L.) Pers. (Poaceae) and *Schoenoplectus articulatus* (L.) (Cyperaceae) have been reported as alternate hosts for RSM in India (Rao and Prakash, 1996; 2002). In Sri Lanka, a wild rice species *O. nivara* L. and three weed species, namely, *Sacciolepis interrupta* (Willd) Stapf, *Echinochloa crus-galli* (L) Beauv, and *Leptochloa chinensis* (L) Nees have been identified as alternate hosts of RSM (Chandrasena *et al.,* 2016).

Application of chemical control measures after the heading stage of crop growth is not worth as the grain damage has already occurred. Identification of *S. spinki* damage at the early infestation stage is difficult and hence, most of the farmers tend to use different pesticides even after soft dough stage of the crop. Therefore, identification of its population dynamics is of significance as it help farmers taking prompt and correct decisions to manage the pest. This study was conducted in LCWZ for 40 consecutive months starting from December, 2012 to determine the temporal distribution of *S. spinki* in relation to climatic factors.

Materials and Methods

Experimental sites:

The studies were conducted at three research stations in the low country wet zone (LCWZ) *i.e.* Regional Rice Research and Development Centre (RRRDC) at Bombuwela (6.572° N, 80.01° E, 9.3 m amsl), Agriculture Research Station (ARS) at Labuduwa (6.070^0 N, 80.2335^0 E, 15m above mean sea level), and ARS at Bentota (6.4189° N, 80. 006° E and 3 m amsl). The RRRDC at Bombuwala is located in the Kalutara district and other two locations are in the Galle district.

Experimental design and crop sampling:

Experiments were laid out in a randomized complete block design replicated three times using the rice (*Oryza sativa*) variety Bg300 (three-months age class). Plot size was 5 m × 4 m. The crop was established at 15-day intervals by transplanting 18 to 21-days old seedlings. Experiment was repeated three times since 2013 where, every time after 3rd month of the study, the experimental field had six rice crops at different maturity levels. The trials were maintained under rainfed condition and was free of pesticide use. Fertilizer application and other agronomic practices were done according to the recommendations of the Department of Agriculture, Sri Lanka. Weed management was done manually.

Samples were collected at weekly intervals starting from 4 weeks after planting (WAP) and continued till harvesting. As the crop was established in 2-week intervals, different crop growth stages were found in the experimental field at each sampling time. Hence, all the plots existed at a given sampling time were considered for sampling, and the average value of a parameter was considered for analysis. Sample size was 10 tillers (approximately 30 sheaths) per plot. Then, 25 sheaths were taken from each sample to record the number of RSM and its eggs, which were observed under microscope.

Collection of weather data:

Weather data for the whole study period was collected from the meteorological unit situated at each experimental site. Weekly total rainfall and weekly averages of maximum temperatures, rainfall, relative humidity, sunshine hours and wind velocity were recorded as meteorological data,.

Data analysis:

Pearson correlation analysis was carried out for whole study period and for each cropping season separately, to identify the correlation between the moving average of RSM and weather parameters. Then, multiple regression was carried out along with the testing of multicollinearity of predictor variables for the total evaluation period to find out the most contributing factors for the moving average of RSM. Furthermore, stepwise multiple regression was carried out for the whole study period and also for separate seasons by using SAS 9.1.3. to identify the most contributing factors for RSM counts.

Results and Discussion

During the whole study period at Bombuwela and Bentota, there were number of PRM population peaks indicating its population build up with the time (Figures 1 and 2). The results suggested that the RSM population in the previously planted crops in the experimental field would have influenced the population density in the subsequent crops. However, at the Labuduwa site, high population densities of *S. spinki* were seen only at the beginning of the experimental period. A low RSM population was experienced also in farmer fields during the year 2014 and 2015 in the region where Labuduwa site is located.

Effect of weather parameters on rice sheath mite population:

The results of multiple regression and multicollinearity analysis for the data from Bombuwela location showed that tolerance for the predictor variable ranged between 0.5 to 0.9 and variance inflation parameter ranged between 1.1 - 1.9. This indicates that there is no considerable multicollinearity in the predictor variables. Data on *S. spinki* at Labuduwa also indicated that there were no considerable multicollinearity as predictor variables resulting in 0.88 - 0.71 tolerance and variance inflation parameter was ranged in between 1.12 - 1.39. The stepwise multiple regression carried out for the whole evaluation period and also for each season separately. The results of stepwise multiple regression carried out for both locations and the Pearson correlation between *S. spinki* population and weather parameters are shown in Tables 1 and 2, respectively.

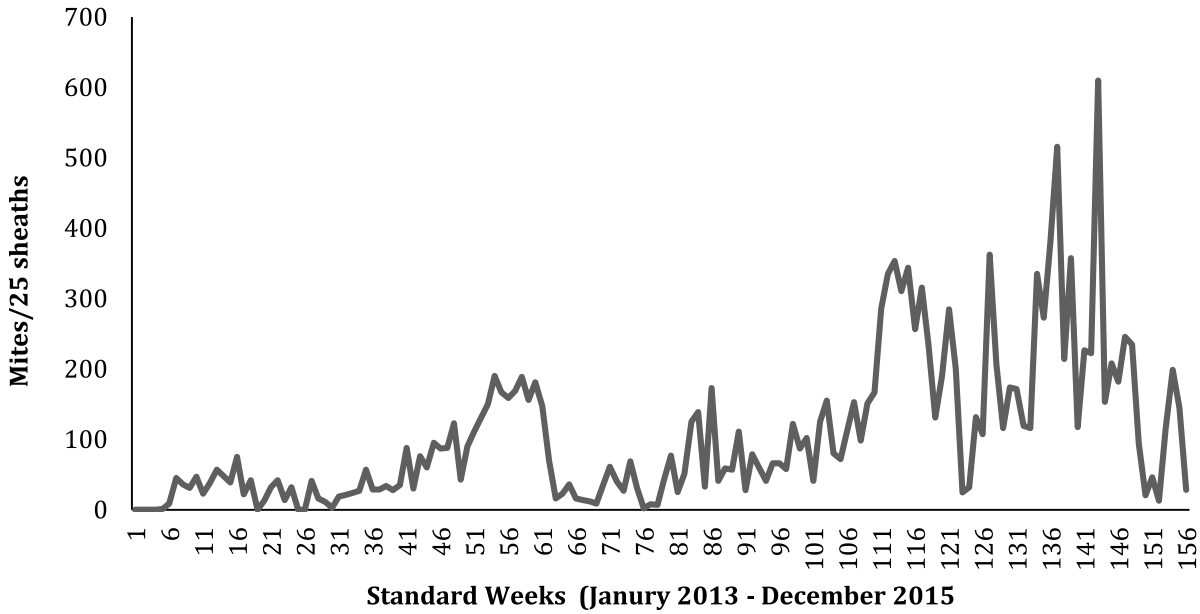

Figure 1. Fluctuation of RSM population in rice during 2013 -2015 at Bombuwela

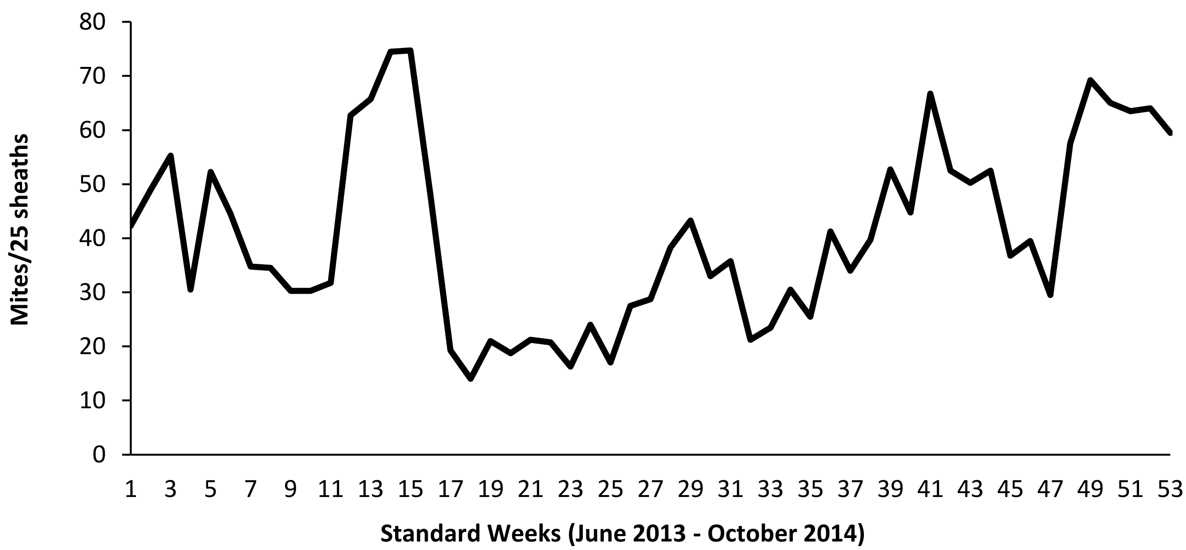

Figure 2. Fluctuation of RSM population in rice during 2013 -2015 at Bentota

Relative humidity:

A negative contribution of relative humidity on *S. spinki* population was observed during the whole study period (Table 1). The relative humidity (RH) was the only factor which was included to the regression model (Y= -4.37 RH + 482.54, R^2=0.326, P=0.024). However, there was no any predictor variable selected for regression equation with Labuduwa data for the whole study period. Pearson correlation with *S. spinki* population and relative humidity also indicated a negative correlation among the said factors (Table 2).

During the whole study period at Bombuwela and the 2013 *Yala* season at Labuduwa, a significantly negative correlation was observed between the relative humidity and mite population (Figure 3). In the other seasons, the correlation was not statistically significant. This could be due to the effect of other weather parameters. Further, *S. spinki* could survive in a wide range of relative humidity levels even from 77% to >92% depending on the availability of other weather parameters at favourable levels and the availability of the host crop (Figure 4). Thus, no conclusions could be drawn regarding the critical minimum humidity level they can survive as the RH values recorded during the whole study period were higher than 77%.

Table 1. Regression equation fit by stepwise multiple regression for weather parameters and RSM populations at Bombuwela and Labuduwa

Period	**Bombuwela**	**Labuduwa**
Whole study period	Y= -4.37 RH +482.54 R^2 = 0.326 , P = 0.024	No variable found
2013 *Yala* season	Y= 10.061 Temp. - 282.83 R^2 = 0.6315, P = 0.001	Y= 47.81Temp. – 1270.24 R^2 = 0.8136, P = 0.001
2013/2014 *Maha* season	Y= 18.44 SS-2.917 R^2 = 0.301, P = 0.01	No variable found
2014 *Yala* season	Y= -14.98 Temp.+ 503.05 R^2 = 0.346, P = 0.01	Y= - 0.235 RH + 21.518 R^2 = 0.125, P = 0.1
2014/2015 *Maha* season	No variable found	No variable found
2015 *Yala* season	Y= - 25.02 WV + 261.39 R^2 = 0.294, P = 0.048	Y= 0.042 RF + 4.91 R^2 = 0.281, P = 0.019
2015/2016 *Maha* season	Y= 154.54 WV + 10.82 R^2 = 0.37, P = 0.027	Y= 0.505 RH - 36.32 R^2 = 0.542, P = 0.004

RH = relative humidity; Temp. = temperature; SS = Sun shine; WV = wind velocity; RF = rainfall

Table 2. Pearson correlation between RSM population and weather parameters

Period	**Location**	**Average Wind Velocity**	**Weekly total Rainfall**	**Average Temperature**	**Average Relative Humidity**	**Sun Shine (hrs)**
Whole study period	Bombuwela	0.0031	-0.01	0.091	-0.180*	0.157*
	Labuduwa	-	-0.14	0.0097	0.143	0.1088
2013 *Yala* season	Bombuwela	0.375	-0.063	0.7946**	-0.397	0.376
	Labuduwa	-	-0.321	0.902**	-0.86**	0.254
2013/2014 *Maha* season	Bombuwela	0.0627	-0.543*	0.377	-0.078	0.548*
	Labuduwa	-	0.15	-0.12	-0.29	0.187
2014 *Yala* season	Bombuwela	0.024	0.37	-0.588**	0.382	-0.349
	Labuduwa	-	0.0147	0.336	-0.353	0.14
2014/2015 *Maha* season	Bombuwela	0.0239	-0.331	-0.17	-0.029	0.09
	Labuduwa	-	0.024	-0.217	0.156	0.0107
2015 *Yala* season	Bombuwela	-0.457*	0.0815	0.0948	-0.219	0.2016
	Labuduwa	-	0.53	-0.194	-0.103	-0.344
2015/2016 *Maha* season	Bombuwela	0.608*	-0.046	-0.393	-0.153	0.166
	Labuduwa	-	0.2604	-0.402	0.736	0.054

*P<0.05; **P<0.001

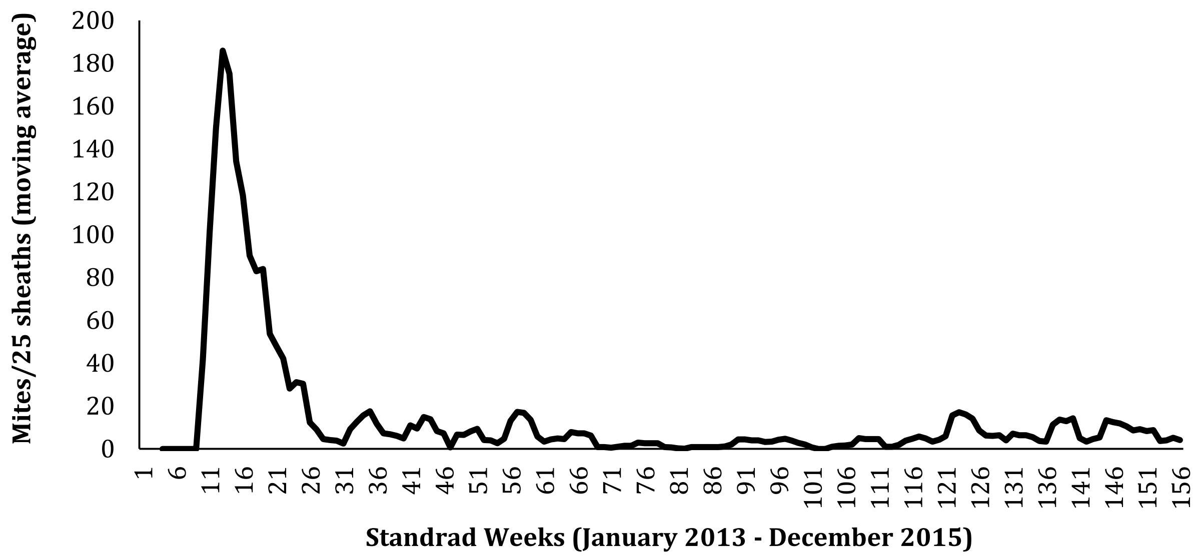

Figure 3. Fluctuation of RSM population in rice during January 2013 – December 2015 at Labuduwa

Temperature:

During the 2013 *Yala* season, regression equations for temperature at Bombuwela (Y = 10.061 Temp. - 282.83, R^2=0.6315, P=0.001) and Labuduwa (Y = 47.81 Temp. – 1270.24, R^2=0.8136, P=0.001) indicated that there is a positive contribution of the average temperature to *S. spinki* population (Table 1). However, the contribution of temperature on RSM population at Bombuwela during the 2014 *Yala* season showed a negative contribution (Y = - 14.98 Temp. + 503.05, R^2=0.346, P=0.01). Correlation results presented in Table 2 also indicated the same trend. Therefore, temperature could positively contribute to RSM population only until a certain level. The temperature variation prevailed at each location in the whole study period was low (28.6 °C – 32.7 °C; Figure 4). The results revealed that high RSM populations could be observed within the temperature range of 30 °C - 32 °C. However, future studies under a wider temperature variation are needed to determine the critical temperature for RSM.

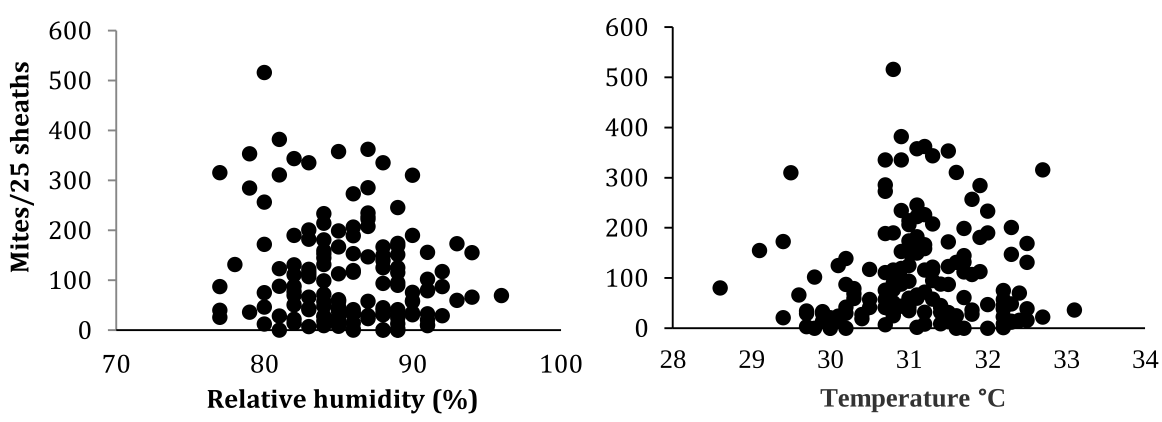

Figure 4. Relation between relative humidity and ambient temperature on RSM population at Bombuwela.

Rainfall:

The RSM population is widely known to have a negative correlation with rainfall. Like most of the delicate soft-bodied insects, sheath mites can also be flushed off by heavy rains other than the mechanical damage. Furthermore, heavy rains could negatively affect the egg development of sheath mites resulting in low population density. Figure 5 confirmed this by showing more *S. spinki* population towards periods with lower rainfall.

There was a significantly negative correlation among rainfall and RSM population during the 2013/2014 *Maha* season at Bombuwela (Table 2). Though there were occasions that showed negative correlation, such relationships were statistically not significant. This may be due to the influence of another parameter or due to unknown factors, which need to be studied further. A higher density of S*. spinki* was observed under rainy condition indicating the ability of the mites to adapt to a wider range of weather conditions.

W<u>ind velocity:</u>

According to the stepwise multiple regression analysis, wind velocity had a negative contribution to RSM population (Y = - 25.02 WV + 261.39, R^2=0.294, P=0.048) during the 2015 *Yala* season at Bombuwela while a positive contribution (Y = 154.54 WV + 10.82, R^2=0.37, P=0.027) during the 2015/2016 *Maha* season at the same location (Table 1). Pearson correlation analysis also showed a significantly negative correlation of wind velocity during 2015 *Yala* season and positive correlation during 2015/2016 *Maha* season at Bombuwela (Table 2). Therefore, there could be a critical range of wind velocity for the population build-up of RSM.

The *S. spinki* populations were highly concentrated within the wind velocity range of 1.5 – 3.5 km/h (Figure 5), providing some evidence on the favourable range of wind velocity for the mite species. However, further studies are needed to provide a firm conclusion on this. The RSM can be transferred by wind (Rao *et al*., 2000) and thus, there is a possibility of RSM moving away from the existing host under high wind velocity. This could be the reason for comparatively low population densities recorded under high wind velocity (> 3.5 km/h) than that of under moderate velocities (1.5-3.5 km/h).

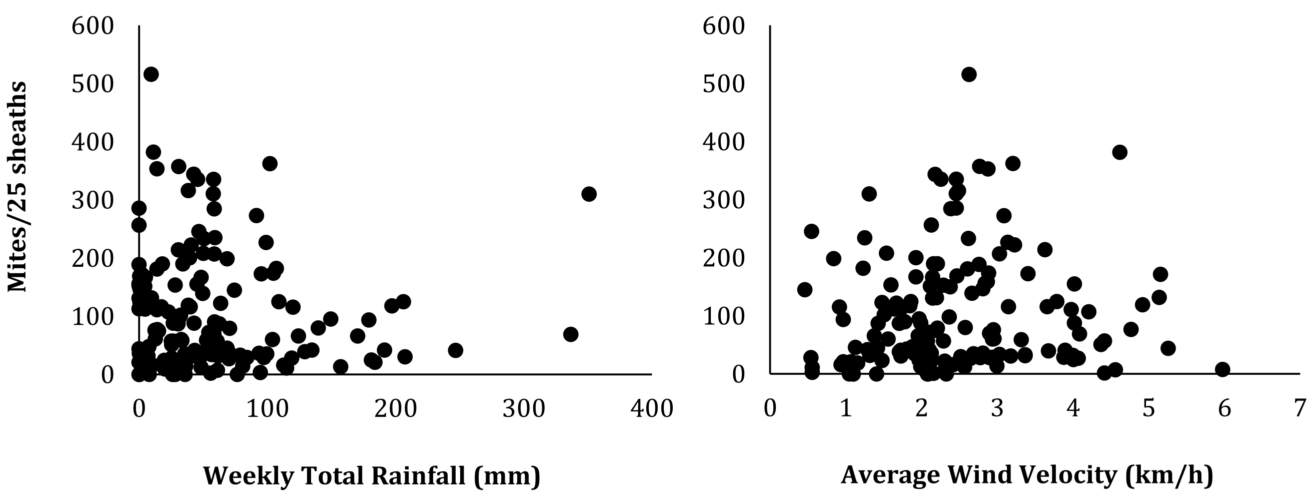

Figure 5. Relation between rainfall and wind velocity on RSM population at Bombuwela.

<u>Sun shine:</u>

Fluctuation of *S. spinki* population in relation to the number of sunshine hours per day during the whole study period at Bombuwela is illustrated in Figure 6 and Table 1. The results revealed high *S. spinki* populations during sunny days. This was confirmed by the significantly positive contribution of sun shine on *S. spinki* (Y = 18.44 SS - 2.917, R^2=0.301, P=0.01) during the 2013/2014 *Maha* season at Bombuwela.

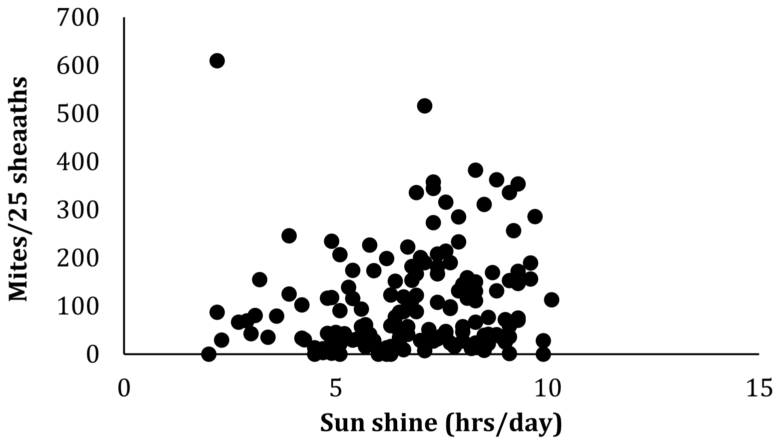

Figure 6. Relation between sun shine (hrs/day) on RSM population at Bombuwela

Conclusion

Multiplication of *S. spinki* is affected by the RH, ambient temperature, rainfall and sunshine. Rainfall and RH had a negative correlation with *S. spinki* population. There is a positive correlation of temperature and sunshine hours with *S. spinki* population. However, future studies under wide temperature variation are needed to determine the critical temperature for high RSM population.

References

Chandrasena, G.D.S.N., Jayawardane, J.D.K.M., Umange, S.D. and Gunawardana, A.D.B.U. (2016): Host range of panicle rice mite *Steneotarsonemus spinki* Smiley (Acari:Tarsonemidae) in Sri Lanka. Univers. J. Agric. Res. 4(1): 21-24.

Hummel, N.A., Castro, B.A., McDonald, E.M., Pellerano, M.A and Ochoa, R. (2009): The panicle rice mite, *Steneotarsonemus spinki* Smiley, a re-discovered pest of rice in the United States, Crop Protect. 28: 547-560.

Mutthuraju, G.P., Srinivasa, N. and Girish, R. (2014): Rice sheath mite, *Steneotarsonemus spinki* Smiley – An emerging pest of rice, Cur. Biot. 8(2): 197-212.

Navia, D., Mendonça, R.S. and Melo, A.M.P. (2005): *Steneotarsonemus spinki* - an invasive tarsonemid mite threatening rice crops in South America. Plant Protection and Plant Health in Europe: Introduction and Spread of Invasive Species. Berlin, Germany, 9–11 June, Symposium Proceedings 81: 267-268.

Pushpakumari, A.S., Nugaliyadde, L., Liyanage, K., Wickramasinghe, S. and Chandrasena, G.D.S.N. (2010): A review of the rice pest management of Sri Lanka. pp 89-106. Proceedings of Rice Congress of the Department of Agriculture, Sri Lanka, 1-2, Dec., Plant Genetic Resources Centre, Gannoruwa, Peradeniya.

Rao, J. and Prakash, A. (1996): *Cynodon dactylon* (Linn.) Pers. (Gramineae): an alternate host of rice tarsonemid mite, *Steneotarsonemus spinki* Smiley. J. Appl. Zoo. Res. 7: 50–51.

Rao, J. and Prakash, A. (2002): Paddy field weed, *Schoenoplectus articulatus* (Linn.) Palla (Cyperaceae): a new host of tarsonemid mite, *Steneotarsonemus spinki* Smiley and panicle thrips, *Haplothrips ganglbaureri* Schmutz. J. Appl. Zoo. Res. 13: 174-175.