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Original Research Paper

Weather-based forewarning model for the incidence of mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) in tomato

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ABSTRACT

Population dynamics of the two-spotted spider mite, *Tetranychus urticae* Koch was studied to develop forewarning models. Incidence of *T. urticae* peaked twice, the first was at 42^{nd} standard meteorological week, MSW (18 mites/leaflet) which is below the economic threshold and the second peak at 20^{th} MSW (60 mites/ leaflet). The population of mites was positively correlated with maximum temperature (r = 0.81), minimum temperature (r = 0.71), sunshine (r = 0.60), and wind speed (r = 0.58) and negatively correlated with RH I (r = -0.87) and RH II (r = -0.79). Step-wise regression equations revealed that maximum temperature, RH I, and wind speed had a great influence on the population build-up of mites. The developed model was validated satisfactorily with RMSE= 5.97 and R^2=0.84, this shows that weather factors had an 84% influence on mites infestation and its population dynamics.

Keywords: Population dynamics, temperature, *Tetranychus urticae*, tomato, weather

INTRODUCTION

Tomato, *Solanum lycopersicum* L., is one of the most valued and important vegetable crops in India. It is grown on 0.84 million hectares with a production of 20.3 million tonnes (Anon., 2023). The insect and non-insect pests are majorly acclaimed to the wider gap of production in India *viz.,* fruit borer, *Helicoverpa armigera* (Hübner); tobacco caterpillar, *Spodoptera litura* Fabricius; whitefly, *Bemisia tabaci* (Gennadius); thrips, *Thrips tabaci* Lindeman, *Frankliniella schultzei* (Trybom), *Thrips palmi* Karny, *Scirtothrips dorsalis* Hood and red spider mite, *Tetranychus urticae* Koch (Timmanna, 2020).

The two-spotted spider mite, (TSSM), *Tetranychus urticae* (Koch) is an important, cosmopolitan, and polyphagous pest of greenhouse, field, and orchard crops worldwide (Weintraub & Palevsky, 2008). It is known to infest >1000 plant species (Martel et al., 2015), especially solanaceous vegetables (Migeon et al., 2009). The TSSM is highly problematic to manage due to its high reproductive potential, short life cycle, broad host range, and wide adaptability to climate. Due to their small body size often their presence is unnoticed till their damage is evident. Difficulty in the monitoring of mites makes farmers take up calendar-based sprays of acaricides as soon as they notice a few mites in the field. Calendar-based sprays are very inaccurate as pest dynamics vary with seasonal variation, if the season is not favourable then the need for pesticides will be nullified. So there is a greater need to work on the influence of season on the population dynamics of pests (Bounfour & Tanigoshi, 2001; Riahi et al., 2013). Increased temperature and prolonged dry spells are known to influence the population of mites but there is an unclear view on what magnitude they affect the population build-up in tomato crop. With this background, the present study was formulated to understand the population dynamics of mites to establish their relationship with prevailing weather parameters and to develop forewarning model to facilitate farmers to take up management practices at the right time in tomato crop.

MATERIALS AND METHODS

The experiments were conducted on a tomato variety Pusa Ruby as it is susceptible to mites (Phukan et al., 2017). Observations on mite population (per leaflet) were drawn during three consecutive years of crops grown in *kharif* and *rabi* seasons in the open fields of

ICAR-Indian Agricultural Research Institute, New Delhi (28.6377° N, 77.1571° E latitude and longitude). All the conventional crop growing practices were followed except the acaricidal spray.

A sampling mite was done from the end of July to May. Leaf samples were taken from randomly selected ten plants, from each plant three leaflets were collected in poly bags and transported to the laboratory twice a week. After counting, slide mounts of mites were prepared in Hoyer's media for taxonomic identity. The two years population data was used for the development of the model by multiple regressions and validated with third-year populations. Weather parameters *viz.*, maximum temperature (Tmax), minimum temperature (Tmin), rainfall (RF), morning relative humidity (RH I), evening relative humidity (RH II), sunshine hours (SSH), and wind speed (WS) were collected from the Division of Agricultural Physics, ICAR-Indian Agricultural Research Institute, New Delhi and correlated using simple correlation co-efficient with the mites population. A multiple linear regression model was developed for significantly correlated weather factors then step-wise regression was done to know the magnitude of influence of different weather factors on the build-up of mite population.

RESULTS AND DISCUSSION

Seasonal dynamics of *T. urticae*

The mean mite population was recorded from all the phenophases of tomatoes starting from transplanting till harvest for consecutive three years. The population of mites was noticed right after transplanting due to the availability of alternate hosts like brinjal, okra, French bean, and amaranths. Two peaks of *T. urticae* were noticed, one before the onset of winter below the economic threshold level during *rabi* season and another during summer above the economic threshold. The occurrence of mites started at 35th SMW with 1 mites/leaflets i.e. during September, the population peaked at 42nd SMW with 18 mite/leaflets i,e during mid of October and declined thereafter with a decrease in the temperature and increase in the morning relative humidity. Similar trend of the population fluctuation was noticed in brinjal ecosystem (Patel et al., 2020). Mites turned orange colour and entered into diapauses during November. From the 49th to 9th SMW population of mites was zero. The second peak initiated at 10th SMW i.e. during first week of March with 1 mite/leaflet. A rise in the temperature, made the population to increase and peaked at 20th SMW with 60 mites/leaflets (Fig. 1) i.e. during mid-May and continued till the harvest of the crop but did not cause economic loss as it was coinciding with the harvest of crop and plants tolerated the damage by having enough foliage to provide nutrition to sink. Build-up of the population could be due to high temperatures, dry weather, absence of predatory mites in the Delhi region. This trend is in agreement with the population dynamics of *T. urticae* in the brinjal ecosystem (Kumar et al., 2018b). Moanaro & Choudhary (2016) observed the occurrence of *Tetranychus* spp. of mites

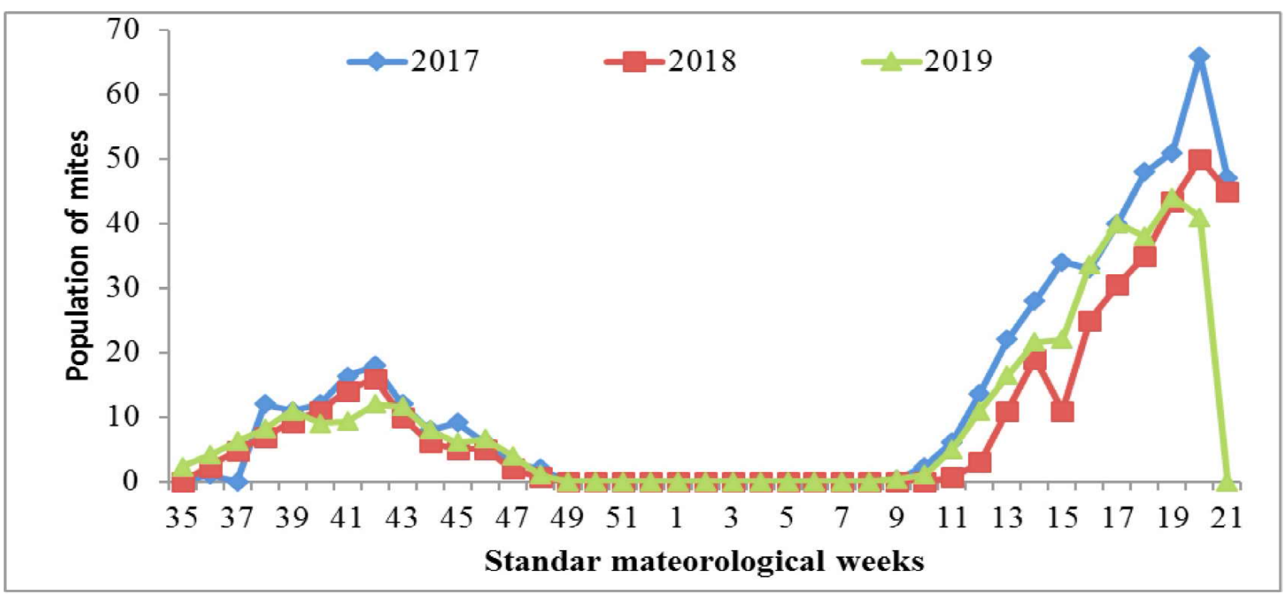

Fig. 1 : Population dynamics of Mite, *T. urticae* with respect to standard meteorological week in tomato

Table 1 : Correlation coefficients between mite, *T. urticae* with weather factors

Year	Tmax	Tmin	MRH	ERH	RF	SS	WS
I	0.739**	0.658**	-0.755**	-0.520*	NS	0.386	0.574*
II	0.828**	0.757**	-0.835**	-0.795**	NS	0.590*	0.521*
III	0.770**	0.626*	-0.892**	-0.654*	NS	0.529*	0.376
Pooled	0.810**	0.715**	-0.878**	-0.790**	NS	0.600*	0.584*

Tmax (°C)-Temperature maximum; Tmin °C – Temperature minimum; RH1 (%)- Morning relative humidity; RH2 (%) – Evening relative humidity; RF (mm) – Rainfall; SS (hr)-Sunshine; WS (kmph)- Wind speed; ** Correlation significant at 1% and * Correlation significant at 5%.

from March to the last week of June in cowpea, peak occurrence during summer month was noticed in cowpea (Kumar et al., 2018a), brinjal (Kumar et al., 2018b), orchids (Meena et al., 2013) and French bean (Rinkikumari & Shukla, 2016).

Correlation of *T. urticae* with different weather factors

Correlation studies between *T. urticae* and the prevailing weather factors showed that the population of mites had a significant positive correlation with maximum temperature (r=0.810), minimum temperature (r=0.0.715), sunshine (r=0.600), and wind speed (0.58), whereas morning relative humidity (r= -0.878) and evening relative humidity (r= -0.790) are significantly negatively correlated (Table 1).

The correlation of weather parameters in relation to the seasonal abundance of mites showed that an increase in the maximum temperature and a decrease in the morning relative humidity triggered the population build-up. The findings of the present investigation are in agreement with Patel et al. (2020), reported a positive correlation of the mites population with maximum temperature, and minimum temperature, and a negative correlation with relative humidity in brinjal. In okra, Kumar et al. (2015) reported a positive correlation of mite population with temperature, sunshine hours, and wind velocity and a negative correlation with relative humidity and rainfall. In the case of other species like *Tetranychus ludeni* Zacher on cowpea, a similar response was reported by Kumar et al. (2018a). Life cycle studies of *T. urticae* revealed that with the increase in temperature, there will be faster development of mites (Margolies & Wrensch, 1996).

Development and validation of the weather-based model

A step-wise regression-based model was developed for significantly correlated weather factors *viz.*, temperature maximum, morning relative humidity, and wind speed turned out as mite population (Y) = 64.17+0.95 (temperature maximum) -0.88 (morning relative humidity) -1.14 (wind speed) (R^2=0.84; RMSE=5.97). Equation depicts that, for every unit increase in maximum temperature, the mite population increases by 0.95 folds. Whereas, for every unit increase in morning relative humidity and wind speed the population of mites decreased by 0.88 and 1.14 folds, respectively. The effect of weather parameters on the population of mite indicated that 84% of the change in their population was influenced by maximum temperature, morning relative humidity, and wind speed. During summer, the experimental field lacked the presence of natural enemies to regulate the *T. urticae* population, and with favourable weather conditions, mite numbers proliferated significantly. During the autumn season, for a short time, there was a favourable temperature without rainfall stimulating the incidence of mites, further with the decrease in the temperature, mites turned orange and underwent diapauses. At this stage, the climate is controlling the population of mites. Several authors reported that *T. urticae* goes through reproductive arrest/diapauses at low temperatures (Takafuji et al., 1991). The established model was validated by keeping the 2017-18 and 2018-19 predicted mites count with the 2019-20 count. The model was validated satisfactorily with RMSE= 5.97 (Fig. 2). The observed and expected population of mites followed the same trend (Fig. 3) showing that the developed model predicted the mite population accurately.

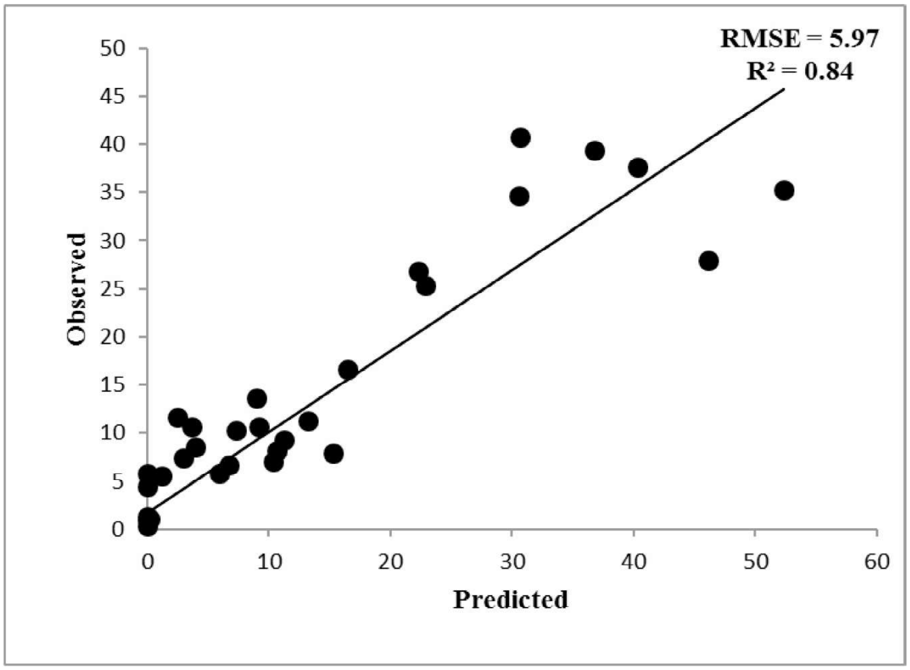

Fig. 2 : Validation of Mite, *T. urticae* weather-based forewarning model

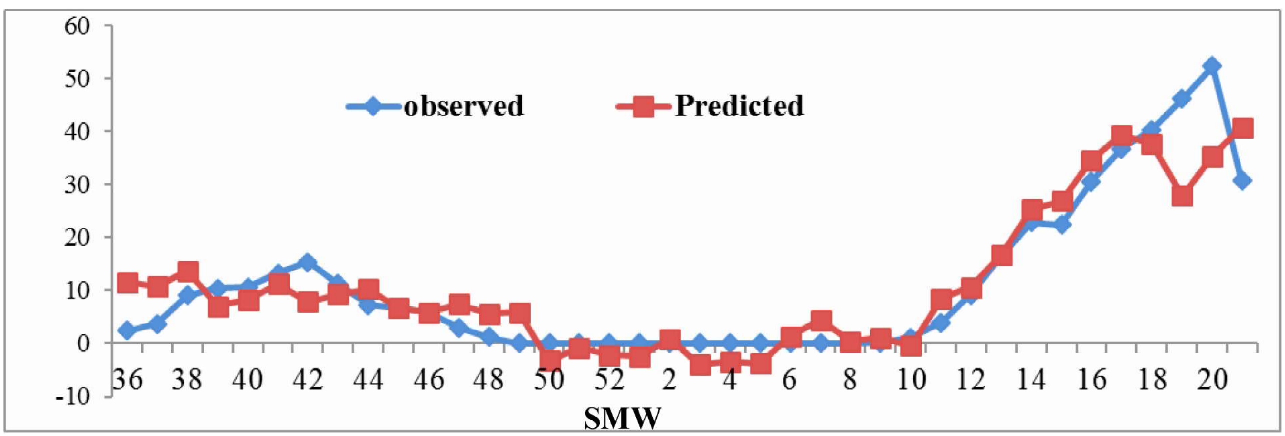

Fig. 3 : Observed and expected population of mites, *T. urticae* with respect to standard meteorological week.

To address the mite problem of tomato growers, in this study we recorded the dynamics of *T. urticae* populations during the growing seasons of tomato crops for consecutive three years. We identified the importance of the temporal distribution of mites in tomato cropping systems and the possibilities for using them in IPM. In this study, based on the existing weather conditions, we developed a regression-based forewarning model which will help to predict the mite population in the tomato ecosystem for taking up timely management.

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