



Forecasting Model for Brown Wheat Mite, *Petrobia latens* (Muller) on Rainfed Wheat and Distribution in North-West India

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Abstract: Brown wheat mite *Petrobia latens* (Muller) (Family Tetranychidae), is a serious pest of rainfed wheat in India. Its infestation is confined to relatively dry regions. It remains active during winter season with peak activity in March. In current study, mite population was recorded in wheat fields from 2004 to 2022 at Ludhiana, India. The population was recorded at 7 days interval, from 30 days after sowing till crop harvest and, correlated with meteorological data through multi-linear models fitted using the REG procedure in SAS model. In addition, periodic surveillance was also carried out in rainfed areas of Punjab-Himachal Pradesh border areas and field areas of Rajasthan. The results revealed that, in general, mite population starts increasing from January-February onwards, reached highest in March and, declined thereafter near crop harvest in April. The mite population showed a positive correlation with maximum and minimum temperature, relative humidity and sunshine, and a negative correlation with rainfall. A distribution map of *P. latens* was prepared. The incidence of brown wheat mite was observed on other crops also, including spices, weeds and pulses. The natural enemies belonging to family Anystidae, Phytoseiidae grubs and adults of Coccinellidae were also recorded.

Keywords: Wheat, Brown wheat mite, Abiotic factors, Distribution

Wheat is the most widely cultivated cereal in the world with acreage of 225 million hectares (MHa) during 2020-21 with global production of 792 million tonnes (MT) (USDA 2021). India is the second largest producer of wheat in the world and its cultivation has traditionally been dominated by the north and north western regions of the country India, wheat occupied 31.8 MHa during 2020-21 with production of 108.7 MT and average productivity was 3424 kg/ha. In Punjab state of India, wheat occupied 3.0 MHa with total production of 17.1 MT in 2020-21 (www.agricoop.nic.in2021)

Insect and mite pests infest wheat crop (Farook et al 2019) and significant yield losses have also been reported in many countries (Zhang et al 2022). In North-western plains of India, 5-10 percent losses in wheat yield due to biotic and abiotic factors are quite common. Brown wheat mite (BWM), *Petrobia latens* (Muller), belonging to family Tetranychidae, is a serious pest of rainfed wheat and confined to relatively dry regions of the country, mainly north, north-west, central India. Although it is a pest of drier areas and is serious under rainfed condition but its incidence in the irrigated crops has also been reported (Sharma and Srinivasa 2004). The importance of this pest lies in its ability to infest large number of cultivated crops like wheat, barley, rapeseed, mustard, coriander, cumin, oats, maize etc, and also to survive in the egg stage during the hot summer months when wheat crop is not available. It remains active during winter with peak activity in March (Sharma and Srinivasa 2004, Bhullar et al 2014). The

weather or abiotic parameters play an important role in the build up of pest populations in the cropping systems, which, in turn, can affect the overall productivity and require timely interventions for control of the pest populations (Mukhtar et al 2023, Bhullar et al 2014). Forecasting system for the pests in agro-ecosystem has become a major component in integrated pest management programmes. Considering this, pest weather relationship was established and prediction model was developed for implementing it in rainfed wheat system on regional basis in north Indian states. Based on the mite incidence and meteorological data collected at Punjab Agricultural University, Ludhiana, from 2004 to 2013, pest incidence data was correlated with abiotic factors through multiple regression equation and a population prediction model was prepared during 2014-15 (Bhullar et al 2014). In continuity of these studies, the model was revalidated taking into account the data recorded thereafter in the recent years and more detailed observations on the bionomics of the pest. In the present studies, the revalidated population prediction model using SAS for the last 16 years, from 2004 to 2022, has been presented.

MATERIAL AND METHODS

The studies were carried out under the All India Network Project on Agricultural Acarology in collaboration with All India Coordinated Wheat and Barley Improvement programme during *rabi* (winter) seasons of 16 years viz. 2004

to 2022 at Punjab Agricultural University, Ludhiana (30°90'.88" latitude and 75°78'.81" longitude and 247 m above sea level). Rainfed wheat variety PBW-175 and PBW-660 were grown as per recommended agronomical practices of the University. The plot size was kept as 8 square meter with three replications. The sowing time for rainfed wheat in north-west India is End October - Early November while harvesting is done from 1- 15 April.

Observations: The observation plots were maintained as sick plots over the years, without any irrigation imitating the rainfed like situations. The mite population was recorded at 7 days interval, from 30 days after sowing (DAS) till harvesting of the crop, from five marked spots/plot, between 12.00hrs and 14.00hrs. A simple technique to assess the population of *P. latens* on wheat plants was followed. The mite population was recorded randomly from five marked spots i.e. from four corners and one from the center of the plot between 12.00 hrs to 14.00 hrs. The sampling was done by gently tapping the plants to dislodge the mites over four glycerin smeared slides (2.5 x 7.5 cm) held in a thermocole sampler. The sampler consisted of rectangular (15 x 25 cm) thermocole slab of even thickness, on which four cavities were scooped to hold the slides. The thermocole sampler, with glycerin smeared slides was placed gently on the ground near the plant base. The plant adjacent to the sampler, was then struck, towards the slides, with a uniform force by hand six times. The mites falling on the slides were removed and kept in a slide tray. Counting of mites was done in laboratory under stereoscopic binocular microscope. The data, thus, collected were computed to the number of mites/10cm² slide area (The observations on mite population were recorded weekly after one month of sowing and continued till the harvesting of the crop).

Statistical analysis: The mite incidence was correlated with meteorological data i.e. maximum and minimum temperature, maximum and minimum relative humidity (RH), rainfall (RF), sunshine (SS), through multi-linear models fitted using the REG procedure in SAS model.

RESULTS AND DISCUSSION

Population prediction model: For development of population prediction model for brown wheat mite, *P. latens*, the correlation coefficient between the population of mites per month (number of mites/10cm² area) and the climatic factors i.e. maximum and minimum temperature, maximum and minimum relative humidity, rainfall and sunshine was worked out for the period from 2004-2022 and multiple regression equations worked out. The maximum and minimum temperatures during the last 16 years showed a decreasing trend in severe winter months i.e. December-

January and start increasing from February onwards, whereas relative humidity is maximum in these months (Fig. 1). The winter rains are not very regular feature with intensity varying from negligible to moderate, and sunshine hours also vary greatly.

The general trend for seasonal incidence of *P. latens* pooled for 2004 to 2022 revealed that mite population starts increasing from January-February onwards reaching a maximum in March and declined thereafter near harvest of crop in April (Fig. 2). The mite population showed a positive correlation with maximum and minimum temperature and sunshine, whereas it showed a negative correlation with

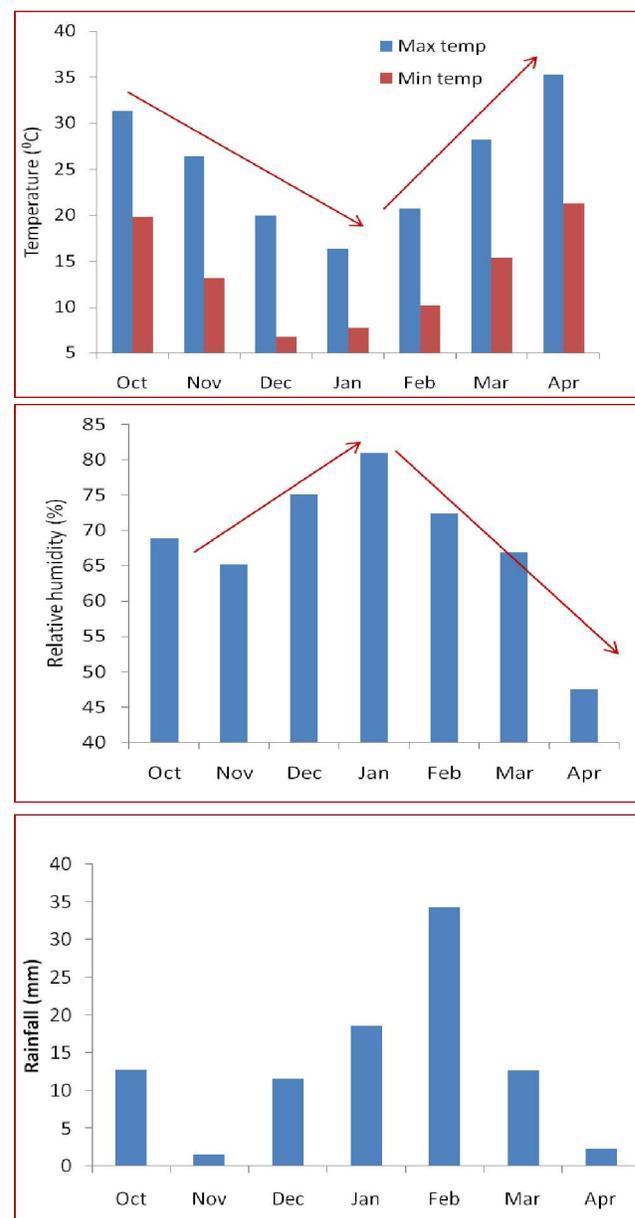
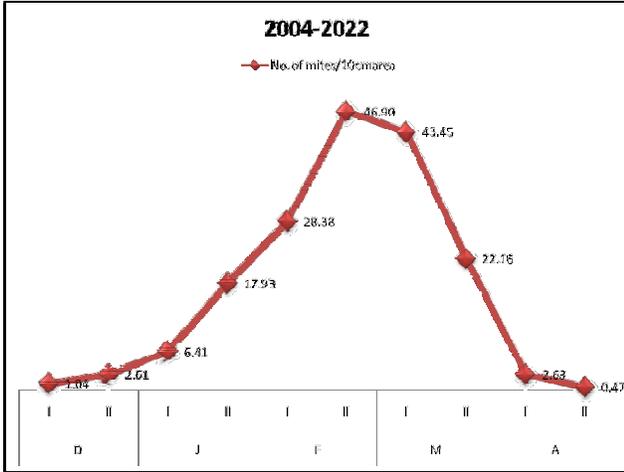


Fig. 1. Mean monthly meteorological data during wheat growing season at Ludhiana (India) from 2004-2022



D-December; J-January; F-February; M-march; A-April

Fig. 2. Pooled seasonal incidence of Brown wheat mite from 2004-2022

rainfall and relative humidity. During the years 2006-07 and 2010-12, when there was moderate to heavy rainfall the population of mites was less while in the years, 2004-05, 2008-09, 2009-11, when there was comparatively very less rainfall and increase in temperature during February-March, the population of mites was more. The coefficient of determination was calculated to measure the contribution of linear function of independent variables i.e. abiotic factors on dependent variables i.e. mite counts. The multiple regression equation was calculated to be, $Y = 94.0941 - 8.207X_1 + 3.617X_2 - 0.355X_3 - 0.553X_4 - 0.300X_5 + 21.277X_6$ ($R^2 = 0.2536$). It was observed that as the number of factors varies from 3, 4, 5 and 6, there is half-percent increase in predictions and the environmental factors explained 22- 24% variation in brown wheat mite population. So, whenever there is winter drought i.e. there is very less rainfall during December – February, the population of *P. latens* is expected to increase along with the increase in the minimum temperature (Bhullar et al 2014).

Later on taking into account the meteorological data and mite incidence for the period 2014 to 2022, the model was revised and results interpreted for the period of 16 years viz. 2004 to 2022. The mite population showed a positive correlation with maximum and minimum temperature, relative humidity and sunshine, showed a negative correlation with rainfall (Table 1). The coefficient of determination (R^2) was calculated to measure the contribution of linear function of independent variables i.e. maximum temperature (X_1), minimum temperature (X_2), maximum relative humidity (X_3), minimum relative humidity (X_4), rainfall (X_5) and sunshine (X_6) on dependent variables i.e. mite counts. The multiple regression equation was also calculated:

$$Y = -79.1755 + 1.5203(X_1) + 0.9333(X_2) + 0.0493(X_3) + 0.8341(X_4) + 0.01628(X_5) + 3.5256(X_6)$$

$$R^2 \text{ (Coeff. of determination)} = 0.0609$$

The individual weather parameters were plotted in SAS and correlations and regressions worked out. Brown wheat mite showed a positive correlation with maximum temperature, relative humidity and sunshine, whereas it showed a negative correlation with minimum temperature (Fig. 3). Based on all these, Multi-linear models were fitted using REG procedure in SAS model and following equations were calculated, wherein Y is the population of mites and dependent variable:

Case I: $Y = 5.1316 - 0.5019(T_{max}) + 0.506$

(RH_{max}) + 2.7985(SS) ($R^2 = 0.0299$)

Case II: $Y = 3.9288 - 0.5128(T_{max}) + 0.0518 (RH_{max}) + 1.0176$

(RF) + 2.8913(SS) ($R^2 = 0.0315$)

Case III: $Y = 8.7953 - 1.2313(T_{max}) + 0.8941$

(T_{min}) + 0.0541(RH_{max}) + 0.7626(RF) + 3.2890(SS) ($R^2 = 0.0344$)

Case IV: $Y = -79.1755 + 1.5203(T_{max}) - 0.9332 (T_{min}) +$

$0.00493 (RH_{max}) + 0.8341 (RH_{min}) + 0.0162 (RF) +$

$3.5256(SS)$ ($R^2 = 0.0609$)

Based on this, it can be concluded that whenever there is winter drought i.e. there is very less rainfall and increase in the minimum temperature during December-February, the population of *P. latens* is expected to increase. It was observed that as the number of factors varies from 3, 4, 5 and 6, there is half-percent increase in predictions and the environmental factors explained 2-6% variation in brown wheat mite population under Punjab conditions. In winter drought i.e. there is very less rainfall during December – February, the population of *P. latens* is expected to increase along with the increase in the minimum temperature. Weather conditions, such as, heavy rainfall, can destroy most of the brown wheat mite populations and both dry and most conditions are needed by this mite to complete development. Singh and Jasrotia (2020) also observed that the incidence of brown wheat mite increased during February – March with peak intensity in March when the crop is around 120 days old.

A computer program based on Factor Analysis which could be used to analyze overall impact of weather parameters on aphid population dynamics was developed and integrated into APHID Sim simulation model successfully by Piyaratne et al (2014). Simulated results of the program showed that the catastrophe movements (sudden jumps) happening in growth of wheat aphid populations could be explained by considering overall weather effect as the weather factor for population analysis models. It cannot be explained clearly using only the single weather variable as a factor. Thus it was suggested that overall weather effect was

Table 2. Mean incidence of brown wheat mite, *Petrobia latens*, in different areas of north-west India in

Locality	GPS location	Mean number of mites/10cm ² area		
		Crops	Spices	Weeds
Punjab-H.P. border areas				
District Hoshiarpur				
Bassi Mustafa	31.51161° N and 75.991792° E.	Wheat-2.50		<i>Cannabis</i> -1.50, Anystids-5
Patirian link road		Wheat-0.0		
Kharkan	31.501094° N and 76.051958° E.	Wheat-3.45		
Mehlanwali	31.495814° N and 76.016654° E.	Wheat-2.50		Grasses-3.50 Sarkara grass-7.50 <i>Ageratum conyzoides</i> (Billi goat weed)-20-25
Jatpur, Chabewal, Garhshankar		Wheat-0.0		
District Ludhiana				
Sick plots of PAU campus, Ludhiana	30.908769°, 75.788117°	Wheat-45.75		
		Chickpea- 0.0		
Rajasthan				
District Churu				
Churu	28.366168° N and 75.092442° E.	Wheat-6.50		'Pohli'- 10.25
		Barley-3.00		
		Mustard -1. 15		
District Sikar				
Sikar RJ, Sabalpur rural	27.651485°N and 75.093591°E	Wheat-4.00		
Bhadala ki Dhani,RJ	27.472802°N and 75.380531°E	Wheat -0		
District Jaipur				
RARI,Durgapura	N26.843136°-E75.7836°	Wheat -50-60		<i>Solanum nigrum</i> -1.25
		Gram -0		Congress grass-0
		Linseed-2.0		<i>Rumex</i> -1.0
Dudu-Malpura road, farmer's field	N26.638877°-E75.266496°	Wheat-2.50		
		Gram -0		<i>Sisymbrium irio</i> -0.25
District Tonk				
V. Pachewar Karva	N26.48132° - E75.320893	Wheat-4.55		<i>Solanum nigrum</i> -0; <i>Ageratum conyzoides</i> -0
RRS, Diggji	N26°21'29"-E75°27'48"	Wheat-0.75		
		Mustard- 0		
		Chickpea - 0		
V. Kekri	N26°51'17"-E75°11'21"	Wheat -0		
Kekri bypass	N25°57'29"-E75°9'4"	Wheat -0		
Kota				
Agriculture University Kota and KVK, Kota	N25°10'53"-E75°52'55"	Wheat 4.75 Anystid mite-1 per beating	Coriander -1.0 Coccinellids in abundance	Parthenium-3.50 Anystids-5.0
		Wheat Raj.4037-14.25; Wheat Raj 4079-2.56; Wheat Raj 1482-3.57; Wheat HI-8759-0 ; wheat PBW 343-1.15; wheat PBW 502-0 ; Wheat C-306-10.0		

Cont...

Table 2. Mean incidence of brown wheat mite, *Petrobia latens*, in different areas of north-west India in

Locality	GPS location	Mean number of mites/10cm ² area		
		Crops	Spices	Weeds
		Wheat Raj.4037-14.25; Wheat Raj 4079-2.56; Wheat Raj 1482-3.57; Wheat HI- 8759-0 ; wheat PBW 343-1.15; wheat PBW 502-0 ; Wheat C-306-10.0		
		Kota desi chana-1.0	Alsi - 0	<i>Lolium multiflorum</i> - 0
		Kota 'masar'-0.00	<i>Lepidium sativum</i> -0 'chandrashul'	
		Black gram-2.25	<i>Nizella saviva</i> -0 'kalonji'	
		Kabuli chana - 0	Garlic - 0	
		Chia (<i>Salvia hispanica</i>)-0	Fenugreek - 0	
		Quinoa (<i>Chenopodium quinoa</i>) -0	'Kalonji' (<i>Nileja sativa</i>)-0	
		Mustard - 0		
		Curry patta-0.25		
Deoli		Wheat-2.25		Grasses-2.50
Kuchalwara Kalan	25.741194°,75.377939°	Chickpea-0.0		Wild grass, <i>Polypogon</i> - 2.00 Parthenium-6.50
		Wheat-2.50		<i>Xanthocarpium</i> -10-50
Kekri rural	25.936553°,75.163875°			Grasses-1.50; Anystids-2.0
Ajmer				
NRCSS, Ajmer	N26°27'7.56"-E 74°38'19.21"	Wheat-3.50	Fennel, 'saunf'- 1.15	<i>Xanthocarpium</i> -1.50
		Barley-2.25	Coriander-1.50	
		Jojoba - 0	Cumin 'Jeera'-1.0	Grasses- <i>Cymbopogon</i> , <i>Citronella</i> - 0
			Dill -0	
			Ajwain - 0	
			Kasuri Methi -0	
			Celery-2.0	
			Nigella-0	
			Anise-0.0	
			'Kalonji' - 0	
			Ajmer ajwain-1.0	
Doomara	26.368109°,74.592874°		Isabgol-bitter cumin-0.0	
			Aphids & thrips	
		Taramira-1.25		
Sathani	N 26.599704° E 74.316469°	Taramira-0.0		
District Nagaur				
Farmer's field	26.888551°.74.001187°	Isabgol-1.15	Fennel-1.00	
District Bikaner	N28°1'12"- E 73°19'3"			
SKNRAU, Bikaner		Wheat - 0		

Cont...

Table 2. Mean incidence of brown wheat mite, *Petrobia latens*, in different areas of north-west India in

Locality	GPS location	Mean number of mites/10cm ² area		
		Crops	Spices	Weeds
		Mustard-1.0 Coccinellids in abundance Chickpea - 0 Wheat - 0 Carrot - 0	Onion - 0 Garlic-0	
Lunkarnsar, Hariasar	N28°31'20"-E73°45'40"	Wheat-5.85		
Near KVK, Bikaner university		Mustard-0.0		
District Hanumangarh	N29°34'48"- E 74°19'12"	Wheat-7.85		

Table 1. Correlation co-efficient, regression between abiotic parameters and mean number of brown wheat mite on rainfed wheat (2004-2022)

Weather factors	Correlation coefficient (r)	Regression equation value	R ²
Maximum temperature(°C)	0.04873	Y=0.213X+12.07	0.0024
Minimum temperature (°C)	-0.04291	Y=0.254X+14.48	0.0018
Maximum relative humidity (%)	0.05814	Y=0.031X+14.38	0.0034
Minimum relative humidity (%)	0.01779	Y=0.035X+15.60	0.0003
Rainfall (mm)	0.01425	Y=0.360X+17.04	0.0006
Sunshine (hrs)	0.12826	Y=1.527X+6.481	0.0165

more suitable for catastrophe theory applications in population dynamics analysis as the weather factor. Similarly in the present studies, single weather parameter cannot possibly explain the change in the mite incidence and multiple weather factors might play a role in affecting the brown wheat mite population. Multi locational and extensive data in true rain-fed areas of Northern and Central India may be required for better explanation of relationship of mite population with environmental factors.

Surveillance and distribution mapping: During surveillance in different rainfed areas of Punjab, Punjab-Himachal Pradesh border areas, Rajasthan (Table 2), incidence of brown wheat mite was also observed on crops like mustard, radish, black gram, Bengal gram, lentils, *Eruca sativa*, fodder oat (*Avena sativa*), spices like coriander, carom seed, fennel, cumin but their intensity was low to moderate (4.65 to 37.65 mites/10cm² area), and weeds like *Aegeratum cinyzoidis*, *Phalaris minor Avena ludoviciana*, *Phalaris minor*, *Amaranthus viridis*, *Chenopodium album*, *Rumex maritimus*, *Convolvulus arvensis*, *Sisymbrium irio*, *Malva* sp., *Medicago denticulata*, and lemon grass, found growing inside and near the wheat fields. The mite incidence of mite was more during February-march in various localities..

Punjab : Almost all stages of brown wheat mite could be seen

on soil clods, twigs of different crops, viz. pearl millet, maize, barley, wheat, weeds in the infested fields (Fig. 4). In Ropar, Hoshiarpur, and Ludhiana districts moderate to high infestation was observed on wheat and adjoining crops and weeds during second fortnight of March. In Anandpur Sahib, Hoshiarpur and Kiratpur areas, 35-137 mites/10cm² area were observed on wheat crop nearing maturity grown under rainfed conditions. Low intensity of mites (36.75 mites/10cm² area) was observed from second week of February to first week of March (99.38 mites/10cm² area) at Ludhiana campus of the University during different years when winter drought was there. Maximum mite population was observed during second week of March (824.47 mites/10cm² area) at the PAU Zonal Research Station, Kandi area, Ballawal Saunkhri (Dist. Hoshiarpur) in 2005. In recent years, however, the incidence of brown wheat mite has shown a declining trend as the area under rainfed wheat in Punjab has decreased drastically due to introduction of large number of submersible pumps in the area.

Himachal Pradesh: Mite incidence was found abundantly (15.35 to 46.50 mites/10cm² area) on local rainfed varieties in Kohari, Saidopol and Kandaghat in Solan district. Large number of mites was found on rainfed wheat even at a higher altitude of 1850 m in Village Barog of Solan district in 2004. In later years, mite infestation was observed in rainfed wheat,

barley, weeds only along the Punjab-Himachal Pradesh border areas only as no infestation was observed in higher altitudes.

Rajasthan: In Rajasthan, districts of Jaipur (Durgapura, Mehlan, Dudu, Ramnagar and Dantri), Ajmer (Pulnea and Gagaj) and Tonk (Dudu, Malpura Diggi, Beepur, Fagi,

Gopalnagar and Renwala), Churu, Sikar, Kota, Deoli, Bhilwara, National Research Centre on Seed Spices, Ajmer; Bikaner, Hanumangarh, Pratapgarh, Chittorgarh, Udaipur and adjoining areas were surveyed periodically. In the year 2000, the fields were heavily infested by mites. Tillers and in severe cases the earheads were also found infested. The

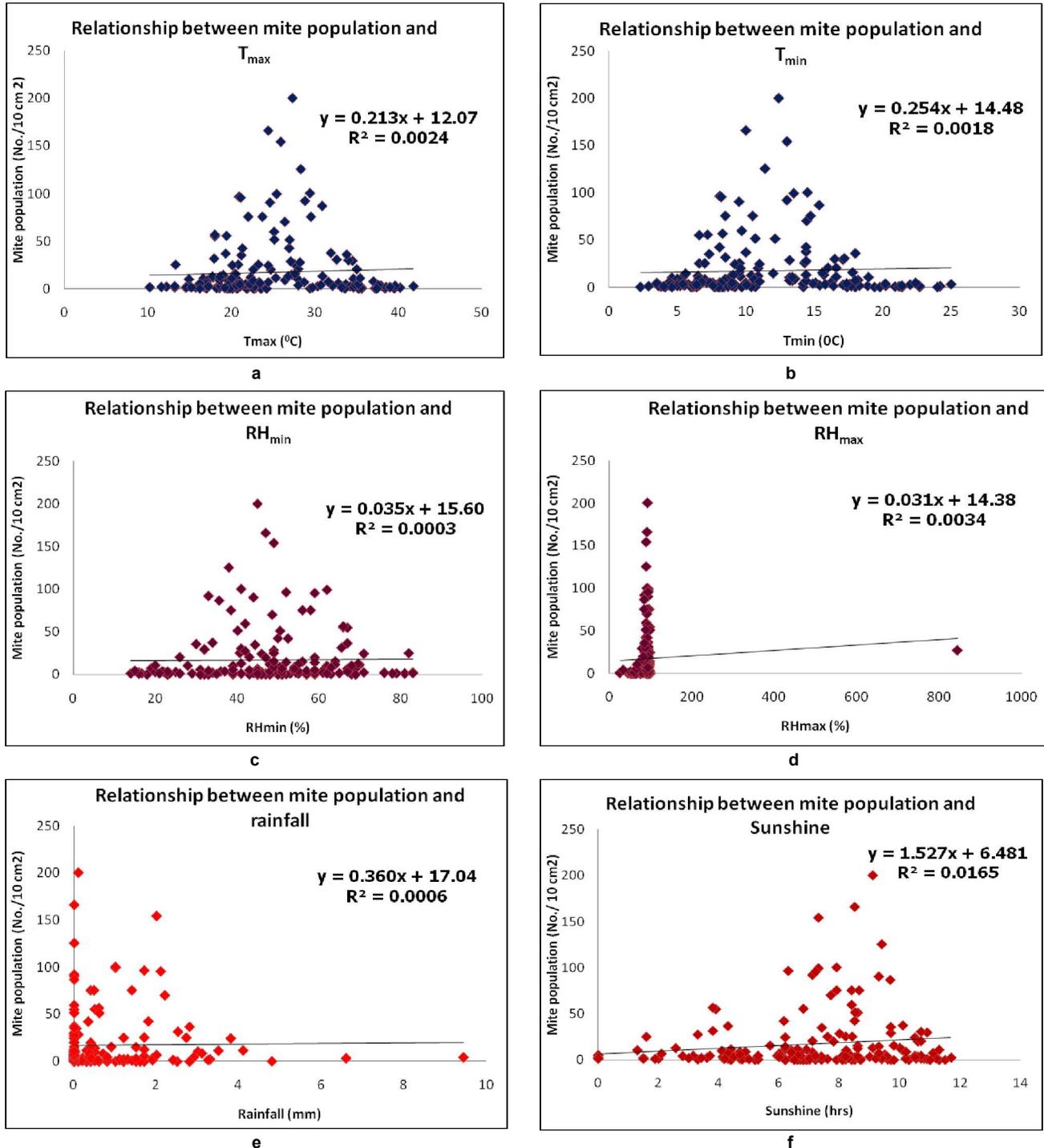


Fig. 3(a-f). Relationships between weather parameters and population of brown wheat mite, *Petrobia latens*

infested plants turned yellowish. Heavily infested rainfed varieties were C-306 and Lok – 1 with 10-30% leaf damage in many areas. At RAU Research Station, Durgapura, Jaipur even the irrigated varieties were found heavily infested. The severely infested varieties were PBW-502, HP-1731, CBW-

13, HD-2824, Raj – 4033, Raj – 4029, Raj – 3765 and Raj – 3077. On variety Raj-3765, severe mite infestation was seen on earheads (87.95 mites/10cm² area) also and even the flag leaves were damaged. Heavy infestation of mite was seen on adjoining weeds. By March end, the mite shifted to other non-host crops and survived there till the next wheat crop. Large number of eggs were found in the soil, where they remained in diapause state till the favourable conditions prevailed for further infestation on wheat (Bhullar et al 2022).

In the studies in later years, especially the last 7-8 years, incidence of brown wheat mite has shown a varying pattern. Although the majority of the area in Rajasthan is rainfed, but still wheat crop is given 3-4 irrigations in many areas mostly by sprinkler system or drip irrigation, and the incidence of brown wheat mite has also been changing in the last few years. Low to moderate incidence (1.25 to 60.75 mites/10cm² area) of *Petrobia latens*, on wheat was observed in different areas of Rajasthan in the third week of February which increased to 85.25 – 92.65 mites/10cm² area in the first week of March. In addition, low incidence (1.0 to 3.25 mites/10cm² area) of BWM was also observed on barley; Linseed; Kota *desi chana*; Kota *Masur*; *Eruca sativa*, *Avena sativa* and spice crops like coriander in Ajmer, fennel in Nagaur, cumin in Ajmer. Weeds like *Polypogon* grass, wild grass, *Parthenium*, *Xanthocarpium*; *Aegeratum cinyzoidis*, *Phalaris minor*, *Avena ludoviciana*, *Convolvulus arvensis* and *Sisymbrium irio* found growing inside and near the wheat fields.

Natural enemies: During survey, predatory mites belonging



Fig. 4. Diapausing and non-diapausing eggs on stalks of pearl millet and soil

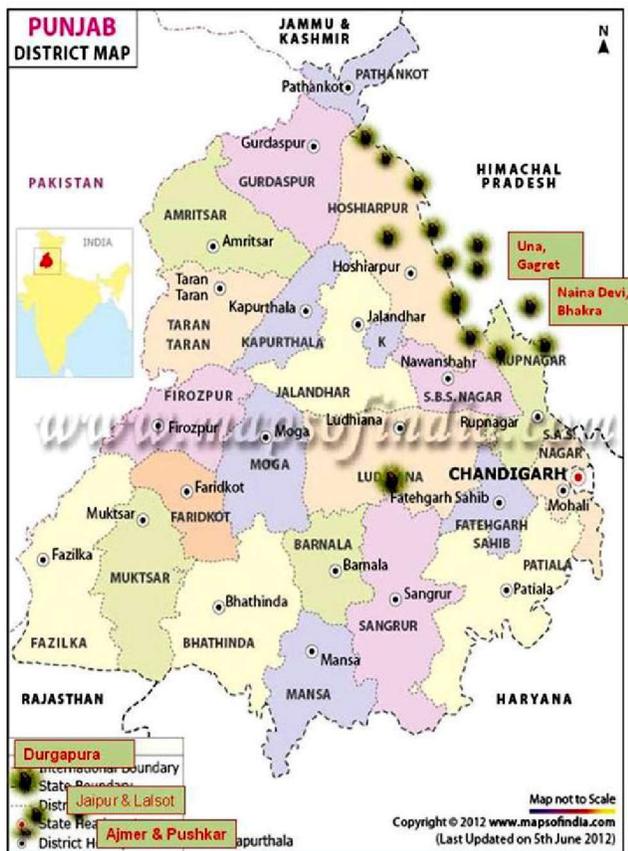


Fig. 5. Distribution map of Brown wheat mite in Punjab

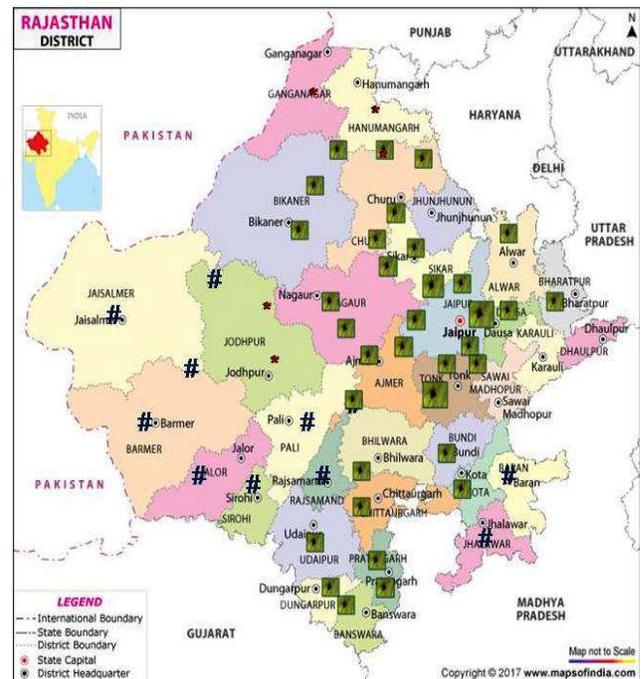


Fig. 6. Distribution map of brown wheat mite in Rajasthan

to family Anystidae (*Anystus baccarum*, *Tencatia villosa*) and Phytoseiidae (*Neoseiulus imbricatus*) were observed in almost all the localities of north-west India associated with the brown wheat mite. In addition, grubs and adults of coccinellid, *Coccinella septempunctata* were found abundantly in association with wheat mite on wheat and adjoining weeds in March.

Distribution map: A distribution map of *P. latens*, based on surveys of different rainfed areas of Punjab – H.P. border areas, Rajasthan has been prepared (Fig. 5 and 6).

CONCLUSIONS

Studies carried out during *rabi* (winter) seasons of 16 years viz. 2004 to 2022 at Punjab Agricultural University, Ludhiana (30°90'.88" latitude and 75°.78'.81" longitude and 247 m above sea level). Brown wheat mite showed a positive correlation with maximum temperature, relative humidity and sunshine, whereas it showed a negative correlation with minimum temperature. Environmental factors explained 2-6% variation in brown wheat mite population under Punjab conditions

AUTHORS CONTRIBUTION

MBB – conceptualized the research topic, recorded data and conducted surveys in Punjab, H.P. and Rajasthan; BS – raising and maintenance of crop; PK – recorded data, conducted survey in Punjab; PKB – data analysis; JT –

conducted field surveys in Rajasthan

ACKNOWLEDGEMENT

The authors are grateful Indian Council for Agricultural Research, New Delhi for the financial support under the All India Network Project on Agricultural Acarology. The authors also acknowledge the facilities used under the Fund for Improvement of S&T infrastructure in universities & higher educational institutions (DST-FIST) project (DST-FIST (project no SR/FST/LSI/636/2015(c)).

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