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Seasonal incidence of insect pests on Khasi mandarin in East Khasi Hills districts of Meghalaya

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Abstract
Khasi Mandarin is well known for its sweetness and soft peel contrast to that it has the greatest cultural and economic value which is attached to the Khasi Hills of Meghalaya. Seasonal incidence of insect pests on Khasi mandarin has been carried out during the period between August 2018 and February 2019 in Mawryngkneng village of East Khasi hills district of Meghalaya for identifying potential threat of this valuable fruit crop. The fixed plot survey study revealed that about 7 insect species are predominant in occurrence out of 32 recorded. Among them citrus leaf miner (*Phyllocnistis citrella*) and hemipteran pests were occurred frequently. Lemon butterfly (*Papilio demoleus*) and citrus trunk borer (*Anoplophora versteegi*) are least concern.

Keywords: seasonal incidence, Khasi Mandarin, fixed plot survey

Introduction
Modern citrus species are now under cultivation, but is originally originated from either in and around of north eastern India or adjacent of northern Burma. Accordingly, there are variety of diversity can be noticed local citrus fruits throughout of North Eastern Region (NER) and also each state owned several Geographical Index(GI) tag [1]. Among them, GI tagged Khasi mandarin is one of the identities of the state which is called 'abode of clouds'- Meghalaya. In every Khasi mandarin season Shillong streets are fabricated with fascinating orange colour fruit. All these cultural heritages are diminishing by numerous factors gradually, among them insect pest were major reason for decline of Khasi Mandarin. The unpredictable weather of this state indulges the insect pest cause the decline on Khasi mandarin [2]. In this context, the investigation upon the damage of different insect pest took as a prerequisite tool for implementation of IPM programme rightly.

In North-Eastern region around 42 insect species are found assuming as major and minor pest status in the mandarin for aggravation as citrus decline [3]. Among them the citrus leaf miner (*Phyllocnistis citrella* Stainton) and lemon butterfly (*Papilo demoleus* Linnaeus) were common in occurrence. Citrus trunk borer (*Anoplophora versteegi* Ritzema) can cause the whole tree to get down. Sucking pests such as Aphids (*Toxoptera citricida* Kirkaldy) has vector importance; Blackfly (*Aleurocanthus woglumi* Ashby), mealybug (*Planococcus citri* Risso) and Psylla (*Diaphorina citri* Kuwayama) were causing severe citrus decline [4] by converting this loss into value it may cause greatest loss in economics as well culture. By this base knowledge, the study has been done for recording the existing and emerging pest complex in Khasi mandarin in the state of Meghalaya particularly in East and West Khasi hills districts.

Materials and Methods
The fixed plot survey was conducted for insect pests occurring on Khasi mandarin at Mawryngkneng village (25.562899 N & 92.56251 E) of East Khasi hills from the month of August 2018 to February 2019. The data recorded at fortnight intervals out of fifteen trees chosen at random over four directions of the orchard. The insect data recorded in consonance with weather parameters as well *i.e.*, maximum and minimum temperature, relative humidity morning and evening and rainfall. The assessment insect population was presented below [5, 6]

The assessment insect population was presented below

Insect pest	Method of assessment of population
Citrus leaf miner	No. of mining leaves in total number of leaves
Lemon butterfly	Larval population per tree
Citrus trunk borer	Presence of Living Boreholes
Citrus aphids	No. of Population in the twigs per tree
Citrus psylla	Affected twigs per tree
Citrus black fly	No. of leaves affected in total number of leaves
Mealybug	No. of twigs affected by mealybug per tree

The obtained data were analysed by one way ANOVA and Correlation studeis

Results and Discussion

Citrus leaf miner infestation level was recorded between 30.7% and 53.2%. The highest level of infestation by 53.2% was observed in 4th August 2018 when the mean temperature of maximum and minimum, percentage of relative humidity morning and evening and rainfall required as 27.9 °C, 21.0 °C, 88.1%, 78.7% and 8.8mm respectively and then gradually decreased to the least infestation level by 30.7% in 8th December 2018 when it had 23.1 °C, 8.9 °C, 83.1%, 49.1% and 0mm data respectively. Consequently, the next highest level by 50.5% in 19th January '19 onwards (20.6 °C, 6.1 °C, 83.8%, 45.3% and 1.5mm) and then it got declined. These results were compared with ETL in all intervals against percentage infestation of citrus leaf miner was found to be more. As well, it was more in rainy days between the month of August to September and Cold weather period between January to February by 47.5% and 44.8% respectively. In post rainy season, pest status showed at a least level of 37.6% (Table 2. and Fig. 1). It shows that the severe loss in terms of reducing photosynthetic area when the new flushes approaching during August and September while with mean temperature about 26 °C followed by in January. Similar kind of obtained by different authors as well on consonance with the present findings [7-11].

Lemon butterfly, *P. demoleus* larval infestation got reached at a peak status by 6.9/tree in 18th August 2018 onwards (28.8 °C, 20.3 °C, 88.1%, 68.5% and 24.3mm) and then gradually reduced and reached to the lowest level by 0.5/tree in 5th January 2019 (20.4 °C, 6.2 °C, 86.1%, 52.4% and 0.2mm) then again it increased. The occurrence of lemon butterfly larvae exceed at most of the intervals above ETL except four months from November to February. For rainy season it was found at high level by 5.5/tree and there were only least difference under post-rainy and cold weather seasons. It was found as highest level in August and January but remain prevalent throughout the year at low population and favoured to increase as when rainfall occurs. Similarly, in Maharashtra the occurrence of butterflies was noticed in the months of June, August and November when there were low temperature and high relative humidity prevailed [12,13]. Although, increase on larva population was noticed during June and July and August to September and then declined during winter months with 4 to 5 five overlapping generations in a year [14-16].

Citrus trunk borer, *A. versteegi* population of citrus trunk borer assumed to be around 0.27/tree by the observed mean of living boreholes per tree from the month of august to December and then increased to 0.33/tree in 5th January '19 (20.4 °C, 6.2 °C, 86.1%, 52.4% and 0.2mm) onwards. Shukla and Gangwar had reported earlier larval infestation occurring throughout the year and adults appeared in late March to mid-April in the state of Meghalaya. Hence, the borer considered as an important deadliest pests wherever ETL: 1 living boreholes/tree is exceeding which is succumbed to death within 2 years after its entry into the trunk region. During study period, trunk borer infestation was recorded in 4 trees out of 15 trees surveyed [17].

Citrus aphid, *T. citricida* was observed at high level by 15.1/1cm twig in 4th September '18 (28.4 °C, 18.8 °C, 87.6%, 74.5% and 2.8mm) onwards and then it slowly decreased and reached to a lower level by 2.5/1cm twig in 5th January '19 (20.4 °C, 6.2 °C, 86.1%, 52.4% and 0.2mm). Further, the population got increased on rest of intervals. The aphid population was found above of ETL in many fortnight intervals except in winter months *i.e.* November, December, January and February. The population was observed to be more in rainy season by 15.0 and lesser in post-rainy season by 5.4 and cold weather season by 3.8. Aphid occurrence found at that peak level in August and October and then got decreased in winter months. The reason being as it was supported by the study made by Komazaki [18] coincides with peak periods of flush availability during these seasons. A large proportion of available terminals may be infested during these periods and a significant more number of large colonies could be able to develop and the mean daily temperatures above 25 °C have adverse effects on aphid reproduction and survival.

Citrus psylla, *D. citri* were observed to be with the maximum level by 8.1/5cm twig in 29th September '18 (28.4 °C, 18.8 °C, 87.6%, 74.5% and 2.8mm) and then decreased and reached to a least level by 0.1/5cm twig in 2nd February '19 (22.3 °C, 7.3 °C, 82.5%, 44.4% and 0.1mm) and 16th February '19 (22.9 °C, 8.9 °C, 84.9%, 45.3% and 0.4mm). The population level of psylla was observed above ETL in all the intervals except in the month between December to February. Its populations were observed to be more in rainy season by 6.7/5cm twig and less in post-rainy by 3.2/5cm twig and cold weather by 0.4/5cm twig. Population obtain peak level at September and then reduced during cold temperature. The peak periods of the pest coincided with the emergence of new flushes, during months of August-September and March [19]. It was also observed that maximum population in September and November on sweet orange in Punjab [20].

Citrus blackfly, *A. woglumi* infestation was found at highest level by 22.9/leaf in 4th August '18 (27.9 °C, 21.0 °C, 88.1%, 78.7% and 8.8mm) and then got decreased up to 15.9/leaf 29th September '18 (28.4 °C, 18.8 °C, 87.6%, 74.5% and 2.8mm). Again it increased by 20.9/leaf in 13th October '18 (26.2 °C, 16.4 °C, 85.0%, 69.4% and 10.3mm) and reached to a lower level by 1.6/leaf in 24th November '18 (23.3 °C, 10.5 °C, 82.7%, 57.1% and 0.3mm). Further, the population was found decreased. The blackfly was founded at higher level of ETL in almost all fortnight intervals. Blackfly population was found quite high in rainy season by 19.2/leaf and less in other two season *i.e.* post rainy by 7.1/leaf and cold weather by 4.1/leaf. Sucking pest *A. woglumi* was found to occur more in August and October months and lesser in November. Chatterjee and co-workers [21] obtained similar result that the citrus black fly population significantly got increased with the increase in relative humidity and rainfall during July to September. Also several studies attained the same result as peak population during July-October months [19, 22].

Citrus melaybug, *P. citri* population gradually increased and recorded at high level by 8.9/5cm twig in 13th October '18 (26.2 °C, 16.4 °C, 85.0%, 69.4% and 10.3mm) and then

slowly decreased to reached a low level by 1.5/5cm twig found in 5th January '19 (20.4 °C, 6.2 °C, 86.1%, 52.4% and 0.2mm). Reaming intervals the population was found increased. The mealybug population was recorded above the ETL in all fortnight intervals except one interval (5th January '18). This population were higher in rainy season (6.6) lesser in post rainy (4.9) as well as cold weather (4.7) season. The mealybug population recorded high in October and low in January and then started to increase from February inwards. Kriegler [23] also came to conclusions that the populations started developing on new growth and reached a population peak between the end of January and the beginning of February.

During the study period Citrus root-knot nematode, *Meloidogyne indica* has been reported on first time in Meghalaya. However, the obtained quantity of the nematode from soil and infected root samples not significance to cause damage [24].

Table 1: Mean weather data of August'18 to February'19

Fortnight Intervals	Max T (°C)	Min T (°C)	RH Mor. (%)	RH Eve. (%)	Rainfall (mm)
1 (Aug)	27.9	21.0	88.1	78.7	8.8
2 (Aug)	28.8	20.3	88.1	68.5	24.3
3 (Sep)	29.7	21.1	85.2	77.1	5.6
4 (Sep)	28.4	19.5	89.5	72.9	15.6
5 (Sep)	28.4	18.8	87.6	74.5	2.8
6 (Oct)	26.2	16.4	85.0	69.4	10.3
7 (Oct)	24.9	14.1	87.4	69.2	4.9
8 (Nov)	25.4	13.1	86.4	61.6	0.3
9 (Nov)	23.3	10.5	82.7	57.1	0.3
10 (Dec)	23.1	8.9	83.1	49.1	0.0
11 (Dec)	21.2	8.5	83.2	59.3	1.9
12 (Jan)	20.4	6.2	86.1	52.4	0.2
13 (Jan)	20.6	6.1	83.8	45.3	1.5
14 (Feb)	22.3	7.3	82.5	44.4	0.1
15 (Feb)	22.9	8.9	84.9	45.3	0.4

Table 2: Seasonal incidence of insect pests on Khasi mandarin

Date of Observation	Citrus leaf miner (% infestation/ 10 cm twig)	Lemon butterfly (Population/ tree)	Citrus trunk borer (living boreholes/ tree)	Citrus aphid (Population/ 1 cm twig)	Citrus psylla (population /5 cm twig)	Citrus blackfly (population/ leaf)	Citrus melaybug (population/5 cm twig)
4th Aug. 2018	53.2	3.5	0.27	11.3	6.3	22.9	7.3
18th Aug. 2018	45.6	6.9	0.27	11.2	5.7	22.0	6.6
1st Sep. 2018	46.9	4.8	0.27	9.5	6.2	18.9	7.1
15th Sep. 2018	44.1	6.3	0.27	7.6	7.2	16.4	6.3
29th Sep. 2018	47.5	5.9	0.27	15.1	8.1	15.9	5.6
3th Oct. 2018	40.1	5.6	0.27	12.5	5.4	20.8	8.9
27th Oct. 2018	41.9	3.7	0.27	7.0	3.4	9.5	6.8
10th Nov. 2018	45.9	3.2	0.27	3.9	3.1	5.7	4.3
24th Nov. 2018	34.7	1.2	0.27	2.7	3.5	1.6	3.4
8th Dec. 2018	30.7	0.6	0.27	2.9	2.7	1.9	3.3
22nd Dec. 2018	32.4	0.7	0.27	3.1	0.9	2.9	2.7
5th Jan. 2019	41.2	0.5	0.33	2.5	0.6	3.1	1.5
19th Jan. 2019	50.5	1.8	0.33	4.6	0.5	5.9	6.3
2nd Feb. 2019	44.7	1.8	0.33	3.6	0.1	3.5	5.1
16th Feb. 2019	42.7	2.1	0.33	4.5	0.1	4.1	5.9
Season wise incidence of insect pests on Khasi mandarin							
Rainy (Aug -Sep)	47.5	5.5	0.3	10.9	6.7	19.2	6.6
Post Rainy (Oct - Dec)	37.6	2.5	0.3	5.4	3.2	7.1	4.9
Cold Weather (Jan- Feb)	44.8	1.6	0.3	3.8	0.4	4.1	4.7

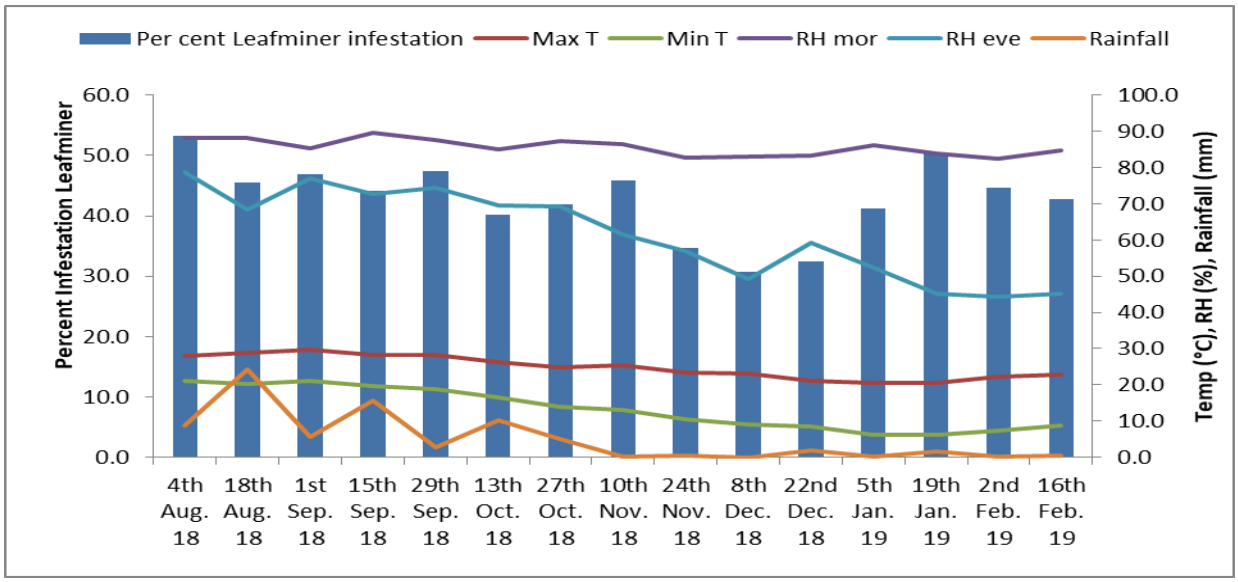

Fig 1: Citrus leaf miner infestation with weather parameters

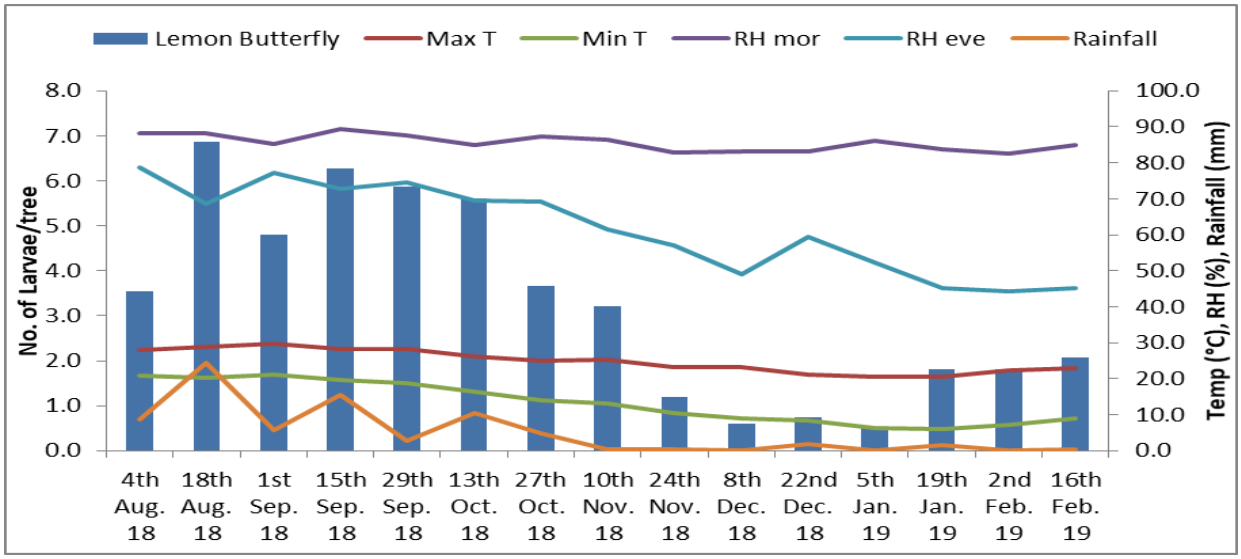

Fig 2: Lemon butterfly infestation with weather parameters

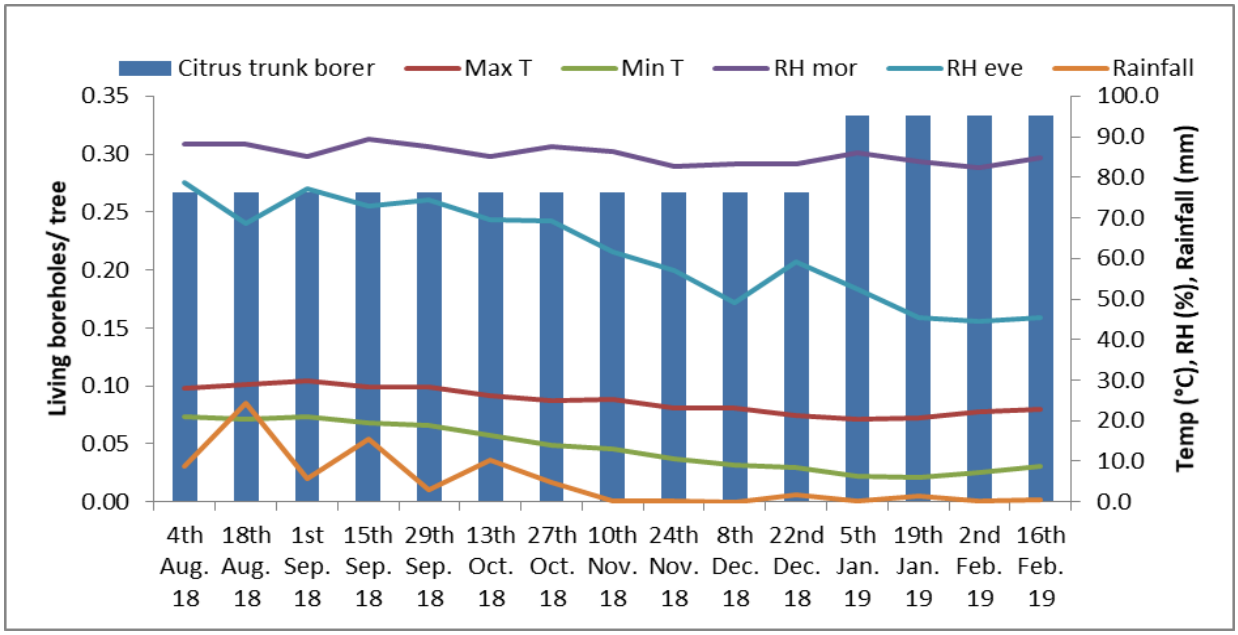

Fig 3: Citrus trunk borer infestation with weather parameters

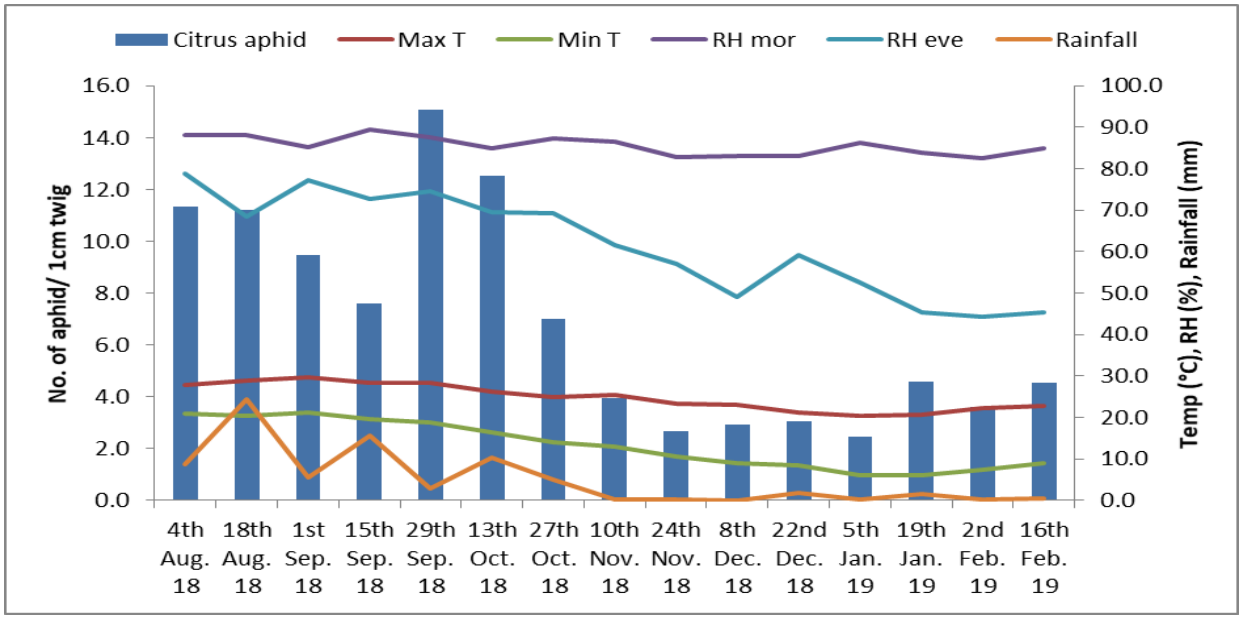

Fig 4: Citrus aphid infestation with weather parameters

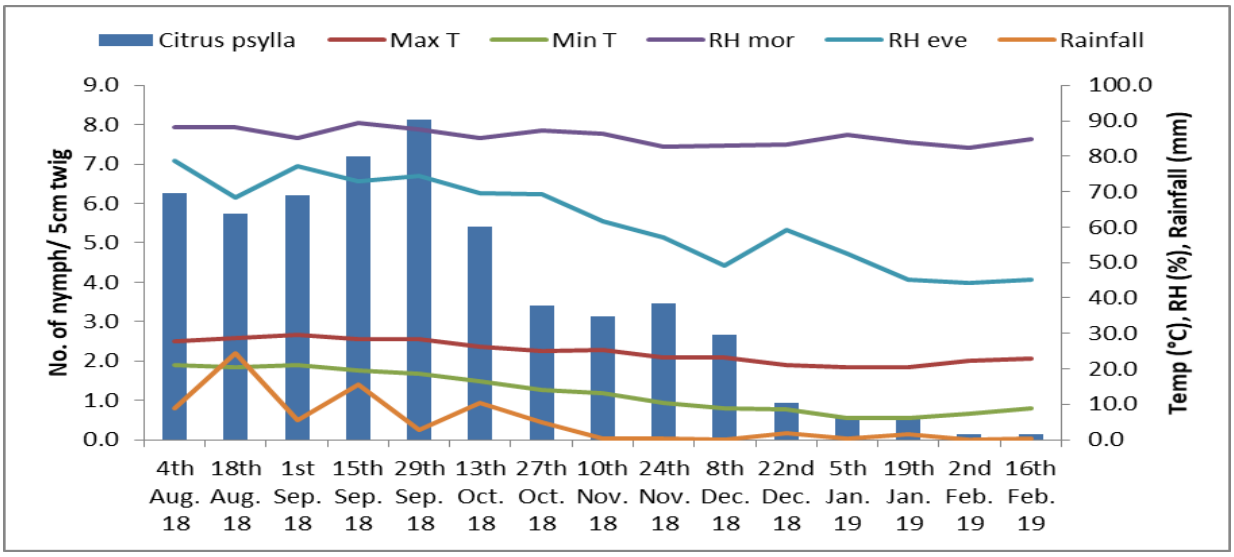

Fig 5: Citrus psylla infestation with weather parameters

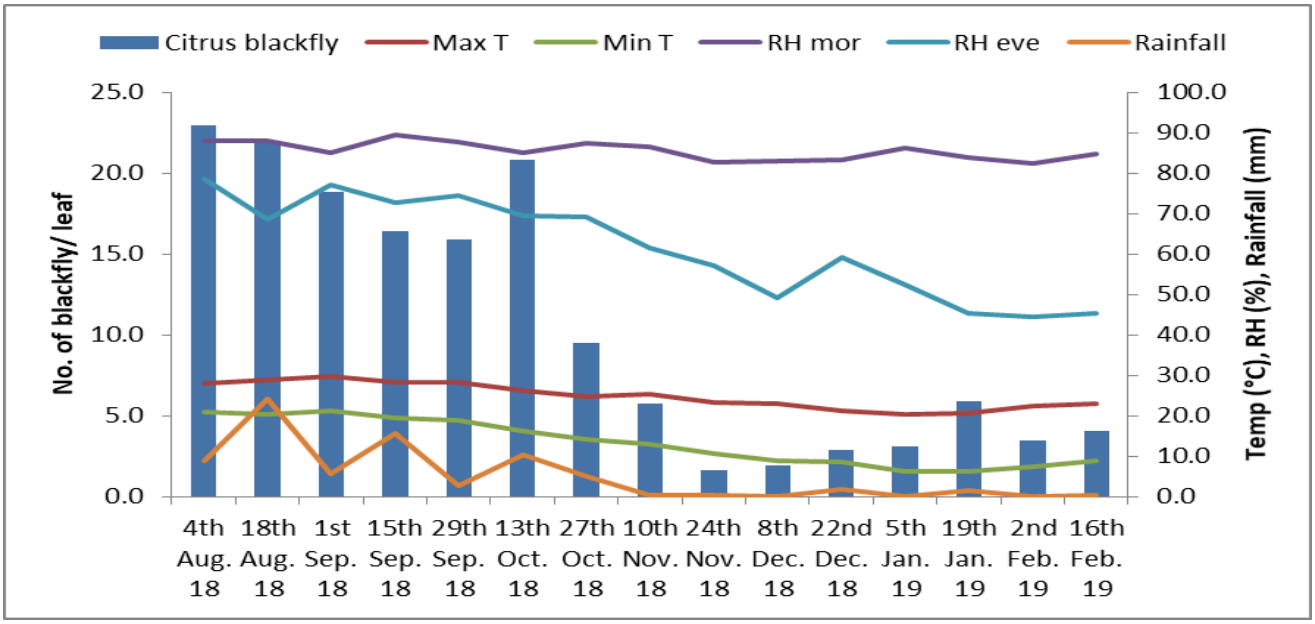

Fig 6: Citrus blackfly infestation with weather parameters

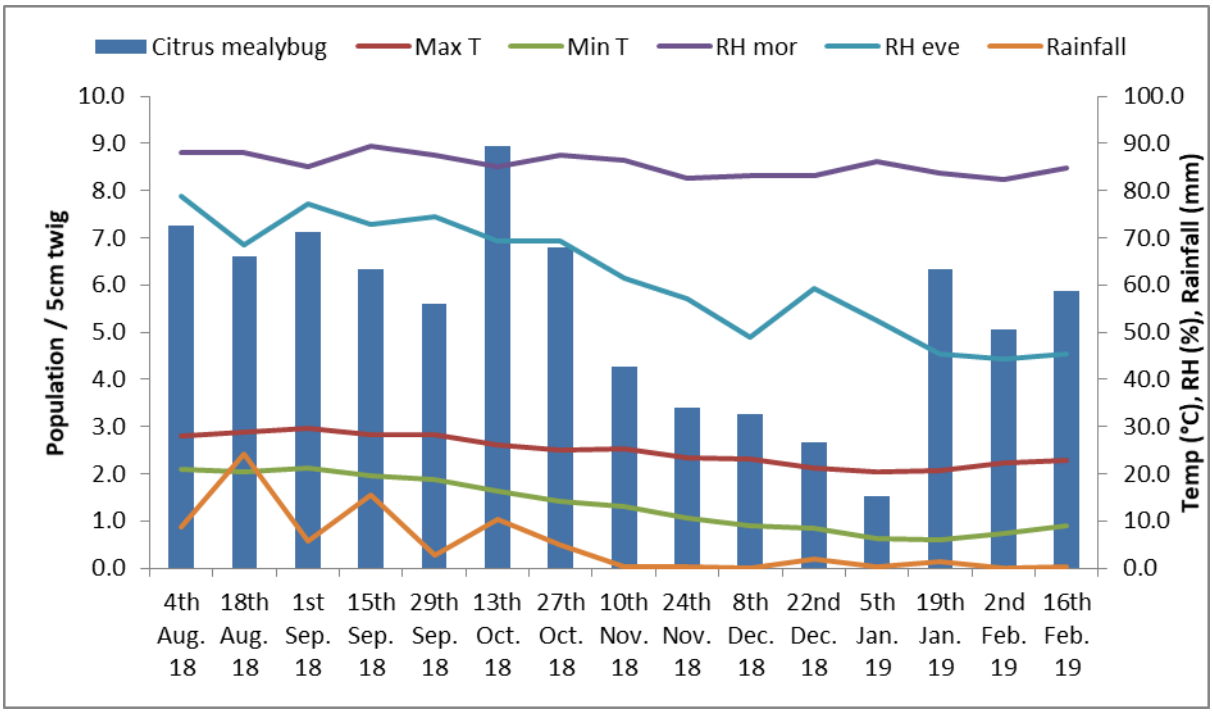

Fig 7: Citrus melaybug infestation with weather parameters

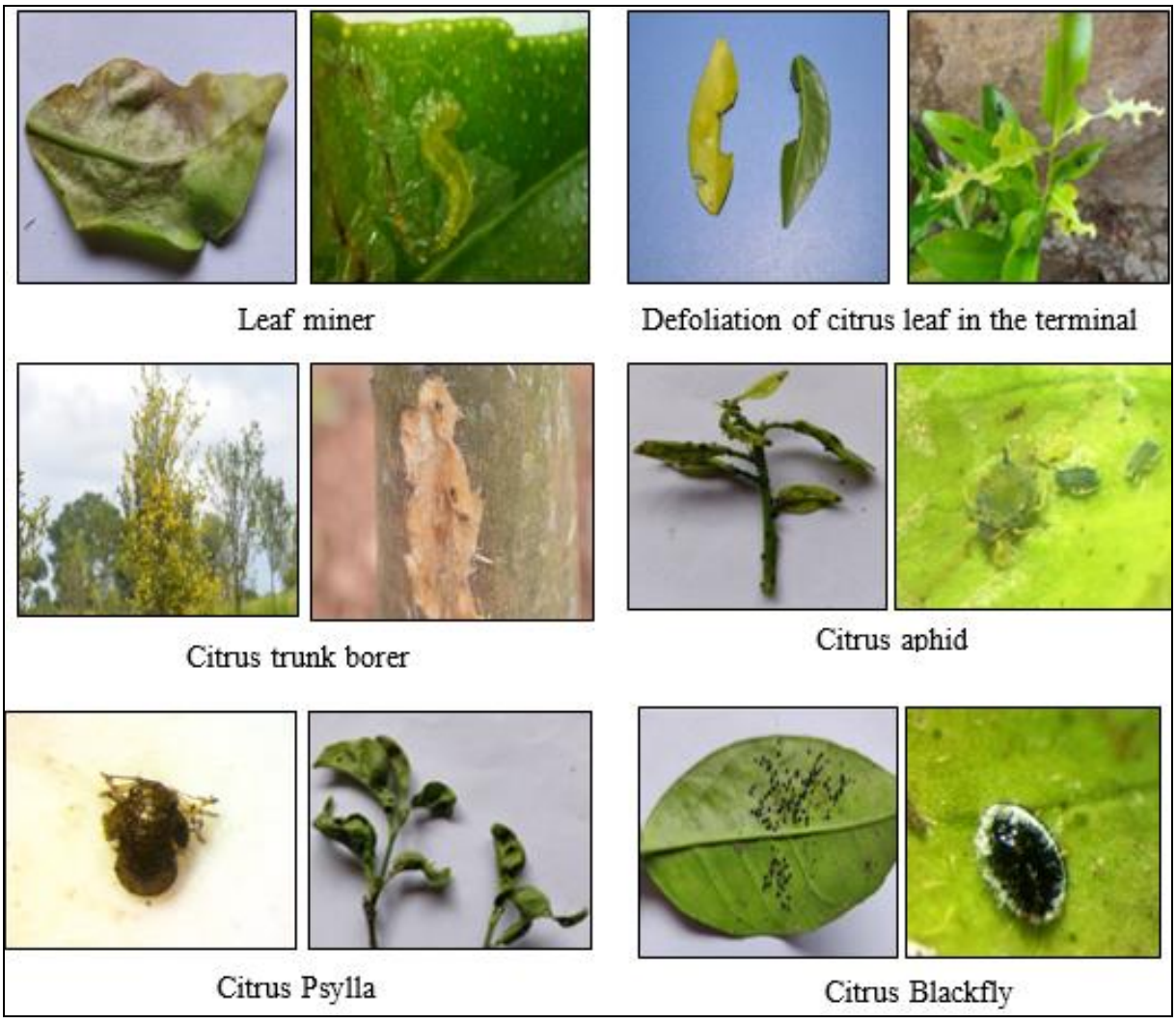

Fig 8: Damage on Khasi mandarin

Conclusion

Khasi mandarin the name itself denotes the value of Khasi hills region as though it originated in South East Asian zone during silent barters period and become of the ancestor species of citrus. However, there are a several insect pests that are affecting citrus plantation leading to economic loss. Among them, major insect pests are citrus leaf miner, lemon butterfly and citrus trunk borer minor pests such as citrus psylla, aphids and mealybug. Their populations could be controlled by following package of practices such as use of high yielding varieties, proper plantation management (including clean cultivation by pruning trees time to time and removal of weeds), providing fertilizers supplement, efficient drainage and irrigation system, and integrated pest and disease management. As less availability of chemical insecticides in the market, farmers go for locally prepared botanicals such as NSKE and neem oil spray. Although, the government should take initiative to extension programmes in different blocks to educate the khasi mandarin growers and farmers to maximize its production as makes the Khasi mandarin remains a much valuable GI product in Meghalaya.

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