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Population dynamics of sapota fruit mite, *Tuckerella kumaonensis* Gupta (Tuckerellidae: Acari) with relation to abiotic and biotic factors

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Abstract
Sapota, *Manilkara achras* (Mill.) Fosberg is an important tropical fruit crop of Navsari district of South Gujarat. The damage caused by insect pests and mite is considered as a major constraint which affect the economic yield and quality of fruit crops. The economic value of sapota fruits have been affected by *Tuckerella kumaonensis* Gupta especially on the basis of quality. The present investigation was carried out to overcome the problem of fruit mite in a comprehensive manner. The results of the present study revealed that the mite activity was started from first fortnight of January with 3.39 mites per 2 cm^2 area of fruit surface. Further, the population of mite increased gradually and reached to its first peak level (9.24 mites/2 cm^2 area of fruit surface) in the second fortnight of April and second peak level (6.69 mites/2 cm^2 area of fruit surface) during first fortnight of October. The correlation co-efficient study of the sapota fruit mite, *T. kumaonensis* with abiotic and biotic factors revealed that maximum temperature, bright sunshine hours and predatory mite had significantly positive correlation with sapota fruit mite population, whereas, it was significantly negative correlation with evening relative humidity, rainfall and rainy days. The multiple correlation coefficient (R) was found to be significant as total contributions of the abiotic factors on population buildup of sapota fruit mite to the tune of 76.40 per cent on the basis of regression equations developed for build-up of sapota fruit mite, *T. kumaonensis* population.

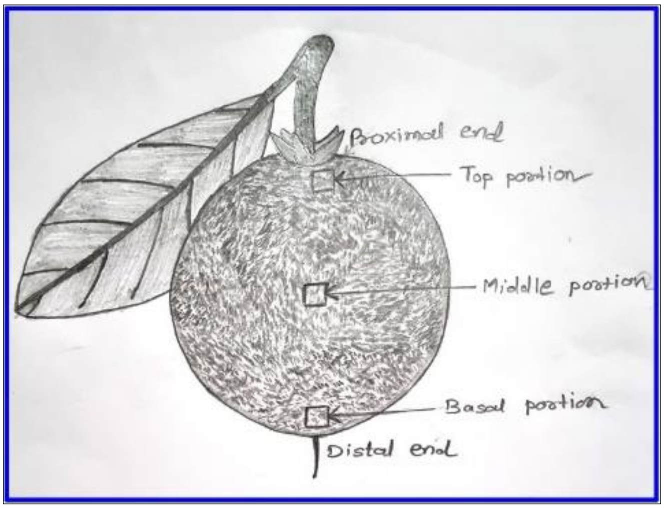
Keywords: *Tuckerella kumaonensis* Gupta, population, abiotic and biotic factors, etc.

1. Introduction

Sapota, *Manilkara achras* (Mill.) Fosberg belongs to family Sapotaceae is an important tropical fruit crop of Navsari district of South Gujarat. It is commonly known as chiku. It is a climacteric fruit. Fully ripen fruits are used as dessert fruits. The fruits are used for preparation of many value added products *viz*., sapota squash, sapota jam, sapota slices, sapota butter, sapota cheese, sapota candy, sapota milk shake, sapota powder, sapota biscuit, sapota ice cream, sapota shrikhand, sapota pulp, sapota juice, dehydrated sapota slices, sapota nectar, sapota lassie, sapota chocolate and sapota bar. The chewing gum is also prepared from the latex obtained from stems and immature fruits of sapota. The sapota fruits are also used in some ayurvedic preparations. Sapota seeds used as diuretic, bark as tonic, antipyretic, febrifuge and in curing biliousness and febrile attacks. The fruit is a rich source of digestible sugar (12 to 18%) and good source of protein, fat, fibre and minerals like calcium, phosphorous and iron (Chadha, 2001) [5]. In India, sapota is cultivated in 80 thousand hectare area with an annual production of 979 thousand MT and productivity is 12.2 MT per ha (Anon., 2020a) [1]. The major sapota growing states in India are Gujarat, Maharashtra, Andhra Pradesh, Kerala, Uttara Pradesh, Karnataka, Haryana, Punjab, West Bengal and Tamil Nadu while sapota is largely grown in Gujarat, Karnataka and coastal Maharashtra. In Gujarat, it is grown in an area of 27.83 thousand hectare with an annual production of 310.01 thousand MT with the productivity of 11.14 MT per ha (Anon., 2020b) [11]. The area under major sapota producing district in Gujarat is 21.65 thousand hectare with 247.44 thousand MT annual production and productivity 11.43 MT per ha (Anon., 2020b) [11]. In Gujarat state, it is cultivated in districts *viz*., Valsad, Navsari, Surat, Mehsana, Junagadh, Bhavnagar, Gir Somnath and Kachchh. The various factors affects the yield and quality of fruit crops. Among them, the damage caused by insect pests is considered as a major constraint. More than 25 insect pests have been reported to attack on sapota tree at different crop stages during both on season and off seasons (Butani, 1979) [4]. Among them, about 16 insect pests and mites were identified in last two decades from sapota orchards in Gujarat (Patel, 2002) [8] and there numbers reached to 33 insect pests and non-insect pests in sapota orchard with increase in the acreage (Bisane *et al*., 2018) [3]. Sapota fruit mite or peacock mite, *T. kumaonensis* is responsible for qualitative losses to sapota. The immature and adults of red coloured mite suck the cell sap from the fruit surface starting from marble size fruit stage thereby fruit surface become corky rough and black or dark colour with encrustation on fruits, which leads to qualitative loss of harvested fruits. The mite remains active throughout the year on sapota cv. Kalipatti under south Gujarat agro-climatic conditions. It is well known fact that in South Gujarat, the sapota crop has played a significant role in socio-economic upliftment of both marginal and big farmers. Due to the change in agronomic practices as well as increasing the area of double farming, creating microclimates favourable for pest population build up, indiscriminate use of nitrogenous fertilizers, the problem of fruit mite increasing day by day in recent past, thereby causing qualitative loss in sapota fruits. Thus, the present investigation was carried out to overcome the problem of sapota fruit mite in a comprehensive manner by considering proper tools of integrated pest management strategy.

2. Material and Methods

The population dynamics of sapota fruit mite, *T. kumaonensis* in relation to weather parameters was carried out at Fruit Research Station, Navsari Agricultural University, Gandevi during the year 2019-20 and 2020-21. To record the incidence of sapota fruit mite, five trees were randomly selected from 0.4 hectare untreated sapota orchard having Kalipatti variety. For this purpose, three fruits from each tree were randomly selected from east, west, north and south directions, thereby total 12 fruits were observed from each tree. The mobile stages (immature and adult stages) of sapota fruit mites were recorded with the help of 40X eye glass from 2 square cm epidermal area each at top, middle and basal portion of fruits at fortnightly interval (Photograph 1). Average number of sapota fruit mite per 2 square cm per sapota fruit was calculated. In order to study the influence of weather parameters *viz.*, maximum temperature, minimum temperature, average temperature, morning relative humidity, evening relative humidity, average relative humidity, rainfall, rainy days and sunshine hours as well as predatory mite on population of sapota fruit mite, the simple correlation coefficient and multiple correlation coefficient (R) was worked out.



Photograph 1: Sampling of *T. kumaonensis* from sapota fruit

3. Results and Discussion

The overall pooled data recorded at fortnight interval during the year 2019 to 2021 are presented in Table 1 and illustrated in Figure 1 indicated that the population of sapota fruit mite, *T. kumaonensis* fluctuated throughout the year and exhibited a trend of higher to lower level of population. The pooled data indicated that mite activity was started from first fortnight of January with 3.39 mites per 2 cm^2 area of fruit surface. Further, the population of mite increased gradually from the second fortnight of January to second fortnight of April and reached to its first peak level (9.24 mites/2 cm^2 area of fruit surface) during the second fortnight of April. Then after, the mite activity showed a decreasing trend from first fortnight of May to first fortnight of August. The fruit mite activity was found least during second fortnight of August with 0.33 mite per 2 cm^2 area of fruit surface. Similarly, the mite incidence starts to build up from first fortnight of September having 5.04 mites per 2 cm^2 area of fruit surface and gradually increased till the first fortnight of October and reached to its second peak level (6.69 mites/2 cm^2 area of fruit surface) during first fortnight of October. Under the present study it was observed that incidence of sapota fruit mite was lower during second peak *i.e.* 6.69 mites per 2 cm^2 area of fruit surface as compared to first peak *i.e.* 9.24 mites per 2 cm^2 area of fruit surface. Then after, the mite incidence showed a gradual decline from the second fortnight of October and reached to its lowest level *i.e.* 0.26 mite per 2 cm^2 area of fruit surface during second fortnight of December.

More or less similar findings were reported by different workers at various locations on different crops. Patel (1997) [7] reported that first peak of sapota fruit mite, *T. kumaonensis* was noticed during second fortnight of April (3.08 mites/cm^2 area of fruits) while the second minor peak was observed during second fortnight of October (1.44 mites/cm^2 area of fruits). Ghosh (2013) [6] noticed that the okra red spider mite, *Tetranychus urticae* Koch attained its peak during the last week of May (6.18 mites/leaf) *i.e.* 23rd SMW in the pre-*kharif* crop while, the peak population (7.56/leaf) was recorded during the first week of October *i.e.* 42nd SMW in the post *kharif*. Shukla *et al.* (2013) [14] from Navsari, Gujarat in a study revealed that the sapota fruit mite, *T. kumaoensis* was active throughout the year and reached to its peak level in 18th SMW (7.30 mites/fruit). Pokle and Shukla (2015) [9] observed the first and second peak of two spotted spider mite, *T. urticae* on tomato was noticed during 15th SMW (6.06 mobile sages/2 cm^2 leaf) while second peak *i.e.* 7.33 mobile stages per 2 cm^2 leaf during 24th SMW. In a study, Shwetha *et al.* (2015) [15] revealed that peak activity of mite on maize was observed during 43rd SMW (23.12 mites/cm^2 leaf) whereas during *rabi* sorghum, the peak activity of tetranychid mite was noticed on 11th SMW with 27.44 mites per cm^2 leaf. Recently, in a study from Navsari, Gujarat, Prajapati (2021) [10] noticed the peak (8.92 mites/2×2 cm^2 leaf area) activities of sorghum mite, *Oligonychus indicus* Hirst in 42nd SMW during *kharif*-2019 while it was 9.42 mites per 2×2 cm^2 leaf area in 41st and during 2020. Shinde *et al.* (2021) [13] revealed that the highest brinjal red spider mite, *T. urticae* population was observed during 3rd week of April (15.44 mite/cm^2 leaf area). Bamel and Gulati (2022) [2] noticed the maximum population of spider mite, *T. urticae* on marigold during 3rd week of April (144.95 mites/leaf). The present findings on population dynamics are in close conformity with the earlier reports of above scientist. The discrepancy in the population of sapota fruit mite, *T. kumaonensis* during present investigation might be due to the difference in varieties, crops, targeted pest and weather conditions prevailed in a particular locality.

The correlation co-efficient study of the sapota fruit mite, *T. kumaonensis* along with abiotic factors during the pooled of year 2019-20 and 2020-21 are presented in Table 2. The result revealed that maximum temperature (r=0.691**), bright sunshine (r=0.613**) and predatory mite (r=0.911**) had highly significantly positive correlation with the population of sapota fruit mite, whereas, it had significantly negative correlation with evening relative humidity (r=-0.449*), rainfall (r=-0.449*) and rainy days (r=-0.414*). The minimum temperature (r=0.154^{NS}) had positive non-significant correlation with the population of sapota fruit mite. The morning relative humidity (r=-0.247^{NS}) existed non-significant negative correlation with sapota fruit mite, *T. kumaonensis*.

In past, Patel (1997) [7] reported that the population of *T. kumaonensis* exhibited a highly significant positive correlation with maximum temperature (r=0.5158**) and sun shine hours (r=0.6460**), while highly significant negative correlation with minimum relative humidity (r=-0.5288**) and rainy days (r=-0.5675**). Moreover, a significant negative correlation was observed between average relative humidity (r=-0.4244*) and rain fall (r=-0.4596*). Shukla *et al.* (2013) [14] reported that significant positive correlation (r=0.4194*) of sapota fruit mite, *T. kumaoensis* with maximum temperature, whereas, it was negatively correlated with minimum temperature (r=-0.3040*), morning RH (r=-0.6256*) and evening RH (r=-0.5924*). In a study, Singh *et al.* (2018) [16] reported that the highly significant positive correlation between *T. urticae* and maximum temperature (r=0.682*) while, significantly negative correlation between morning relative humidity (r=-0.815*) and evening relative humidity (r=-0.527*). Sangavi *et al.* (2020) [12] noticed significant positive correlation of red spider mite, *T. urticae* with minimum temperature (r=0.947*), average temperature (r=0.940*), evening relative humidity (r=0.840*), average relative humidity (r=0.800*) and wind speed (r=0.880*). Prajapati (2021) [10] noticed significant positive correlation of sorghum mite, *O. indicus* with maximum temperature (r=0.854**), average temperature (r=0.540*) and sunshine hours (r=0.612*) while it was significant negative correlation with the morning relative humidity (r=-0.607*), evening relative humidity (r=-0.586*), average relative humidity (r=-0.606*), rainfall (r=-0.776**) and rainy days (r=-0.732**). Thus, all the earlier findings are in line with the present findings and closely support the present findings.

The multiple correlation coefficient (R) was found to be significant in pooled data (2019-21). The regression equations developed for build-up of sapota fruit mite, *T. kumaonensis* population are presented in Table 3. Total contributions of all the abiotic factors on the population buildup of sapota fruit mite was to the tune of 76.40 per cent.

Earlier, Patel (1997) [7] reported that the multiple regression exhibited 61.09 per cent variation in build-up of sapota fruit mite population due to weather parameters. Further, Shukla *et al.* (2013) [14] found that the impact of weather parameters on the population buildup of fruit mite, *T. kumaonensis* was 51.19 per cent. The findings of these workers support the present investigation.

Table 1: Population dynamics of sapota fruit mite, *T. kumaonensis* during the year 2019-20 to 2020-21

Sr. No.	Months	Fortnight	Mean No. of mites/2 cm^2 area of fruit surface Pooled (Year 2019-20 to 2020-21)
1.	January	I	3.93
2.		II	4.64
3.	February	I	7.66
4.		II	7.84
5.	March	I	8.02
6.		II	8.25
7.	April	I	8.72
8.		II	9.24
9.	May	I	8.62
10.		II	8.04
11.	June	I	7.67
12.		II	5.98
13.	July	I	3.92
14.		II	1.92
15.	August	I	1.42
16.		II	0.33
17.	September	I	5.04
18.		II	5.76
19.	October	I	6.69
20.		II	4.41
21.	November	I	1.59
22.		II	1.38
23.	December	I	0.72
24.		II	0.26

Fig 1: Population dynamics of sapota fruit mite, *T. kumaonensis*

Table 2: Correlation coefficient between abiotic and biotic factors and activity of sapota fruit mite, *T. kumaonensis* during the year 2019-20 to 2020-21

Tuckrellid mite	Year	Parameters	Correlation co-efficient								
			Temperature (^{0}C)		Rainfall (mm)	Rainy days	Bright sunshine hours	Relative humidity (%)		*Octobdellodes sp.*	*T. kumaonensis*
			Max.	Min.				Mor.	Eve.		
T. kumaonensis	Pooled (2019-20 to 2020-21)		0.691**	0.154^{NS}	- 0.449*	- 0.414*	0.613**	- 0.247^{NS}	- 0.449*	0.911**	1.000

Note: *Significant at 5% (r = ± 0.404), **Significant at 1% (r = ± 0.515), N= 24

Table 3: Multiple regression equation to predict population of sapota fruit mite, *T. kumaonensis* on the basis of weather parameters during the year 2019-20 to 2020-21

Tuckrellid mite	Year	'a' Value	Estimated regression coefficient (r)								
			Temperature (^{0}C)		Rainfall (mm)	Rainy days	Bright sunshine hours	Relative humidity (%)		R^2 value	Multiple R
			Max.	Min.				Mor.	Eve.		
			X_1	X_2	X_3	X_4	X_5	X_6	X_7		
T. kumaonensis	Pooled (2019-20 to 2020-21)	- 14.473	- 0.396	0.871	- 0.005	0.028	- 0.047	0.445	- 0.378	0.764	0.874
	$\hat{Y}$= - 14.473 - 0.396 (X_1) + 0.871 (X_2) - 0.005 (X_3) + 0.028 (X_4) – 0.047 (X_5) + 0.445 (X_6) – 0.378 (X_7)										

Prediction equation: $\hat{Y}$= a + bx_1…….+bx_n

Where, $\hat{Y}$= Predicted sapota fruit mite population as dependent variable, X_1= Maximum temperature, X_2= Minimum temperature, X_3= Rainfall, X_4= Rainy days, X_5= Bright sunshine hours, X_6= Morning relative humidity and X_7= Evening relative humidity are the independent variables, and 'b' is the coefficient of each variable with 'a' is constant. R^2= Coefficient of determination, R= Multiple Correlation Coefficient

4. Conclusion

The present investigation indicated that the mite activity was started from first fortnight of January and reached to its first peak level in the second fortnight of April. The pest activity was found least during second fortnight of August. Again, the mite incidence starts to build up from first fortnight of September and attained to its second peak level at first fortnight of October. Thus, implementation of management tactics at proper time as well as creating unfavourable microclimates for mites are the most important factor for the effective management of sapota fruit mite.

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