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Influence of weather parameters on seasonal occurrence of aphids and Cucurbit aphid-borne yellows virus (CABYV) on bitter gourd, *Momordica charantia* L.

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ABSTRACT: Seasonal occurrence of aphids and the Cucurbit aphid-borne yellows virus in bitter gourd was studied at Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu from January to April, 2022. Aphids not only damaged the bitter gourd crop by sucking the sap, but also served as vector of Cucurbit aphid-borne yellows virus. The results revealed that incidence of aphids started during second week of February and their population peaked during the second week of April with the mean population of 14.5 to 148.57 aphids/three leaves/plant. Population of aphids was positively correlated with maximum (T_{max}) and minimum (T_{min}) temperature, morning and evening relative humidity (RH), but negatively correlated with rainfall, wind speed and sunshine hours. So, environmental variables (weather parameters) played a significant role in incidence and distribution of aphids on bitter gourd.

Keywords: Seasonal incidence, aphids, CABYV, Bitter gourd.

INTRODUCTION

Bitter gourd (*Momordica charantia* L.), a perennial herbaceous vegetable crop belonging to the family Cucurbitaceae is widely grown in tropical and subtropical climates. It is also known as bitter melon, balsam pear, pare or karela. More than half of the world's production is produced in India and China. The major bitter gourd producing states in India are Kerala, Tamil Nadu, Karnataka, Maharashtra and Uttar Pradesh. It is cultivated in an area of 107 thousand hectares throughout India with an annual production of 1296 thousand metric tonnes and a productivity of 12.11 metric tonnes per ha. In Tamil Nadu, the production and productivity of bitter gourd are 44.38 thousand metric tonnes and 18.81 metric tonnes per ha, respectively.

Immature bitter gourd fruits contain 2.1 g of protein, 1.0 g of fat, 1.4 g of minerals, 1.7 g of fibre, 10.6 g of carbohydrate, 0.07 mg of thiamine, 0.06 mg of riboflavin and 96 mg of vitamin A per 100 g of edible part of fruit (Gopalan *et al.,* 1982). Phytonutrients including dietary fibre, minerals like zinc, phosphorus, magnesium, iron and vitamins like B1, B2, B3 and C are abundant. Bitter gourd fruit juice and leaf tea were used to cure diabetes, colic sores, wounds, rheumatism, gout, worms, parasites, measles, hepatitis, fever, and tumours. It helps to purify the blood (Onkara Naik *et al.,* 2019). The presence of biologically active compounds such as triterpenes, proteins, steroids, flavonoids and acids give the plant antifungal, antibacterial, anti-parasitic, anti-viral, anti-fertility, hypoglycaemic and anti-inflammatory properties.

Red pumpkin beetles in the vegetative stage, aphids, jassids, whiteflies and thrips in both the vegetative and reproductive stages attack bitter gourd (Anitha Kumari *et al.,* 2021). Fruit fly is the most common pest that destroys fruits, causing bitter gourd farmers significant losses. Aphids are associated with Cucurbit aphid-borne yellows virus disease and are known to spread polerovirus in a persistent and non-propogative manner, in addition to inflicting direct damage to the crop by sucking sap. Cucurbit aphid-borne yellows virus which belongs to the *Luteoviridae* family and the genus *Polerovirus*, with virions ranging in size from 5.3 to 5.9kb and a diameter of about 25nm (Kassem *et al.,* 2007) is a large production constraint (King *et al.,* 2011).

Climatic conditions of a location as well as the weather pattern within a specific season in combination with

other factors substantially influence the intensity and area of occurrence of pest species (host plant abundance). While, inter-seasonal weather changes and the resulting fluctuations in specific pest species are quite common (Kocmankovai *et al.*, 2010). With this background, the present investigation was carried out to study the influence of weather parameters on the population of aphids and CABYV incidence in bitter gourd.

MATERIALS AND METHODS

A. Study period and area

A field experiment was carried out to study the influence of weather parameters on seasonal occurrence of aphids and CABYV in bitter gourd during the *rabi*, 2022 at Tamil Nadu Agricultural university, Coimbatore at 11.0131° N latitude, 76.9323° E longitude.

B. Observations recorded

Weekly observations were made on ten plants chosen at random for eight hybrid derivatives and four parents. The aphid population was determined by counting the number of aphids on three leaves per plant, one on the top, middle and bottom. Disease incidence was recorded by counting the number of plants showing CABYV disease symptoms (chlorotic lesions on younger leaves, bright yellowing, dark green mottling and marginal yellowing of matured leaves, vein thickening, vein banding and orange discoloration of older leaves) and the total number of plants examined were used to calculate the percentage disease incidence (PDI) (Table 2, Fig. 2).

$$PDI = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

Weekly counts on aphid population were correlated with weekly weather parameters such as maximum and minimum temperatures, relative humidity, rainfall and bright sunshine hours received from the automatic weather station at Tamil Nadu Agricultural University, Coimbatore.

C. Statistical analysis

Weather factors such as maximum temperature (T_{max}), minimum temperature (T_{min}), morning and evening relative humidity (RH), rainfall, wind speed and sunshine hours, aphids, and CABYV incidence were statistically analysed by IBM SPSS Statistics 22.

RESULT AND DISCUSSION

Based on the observations made at weekly intervals, aphids were found feeding and damaging all the bitter gourd hybrid derivatives and parents. Incidence of aphids, *Aphis gossypii* Glover was recorded to be maximum in Preethi (parent). Aphids were mostly found on the terminal leaves. The highest numbers of aphids were recorded on fifteenth standard week and the lowest numbers were recorded on seventh standard week in all hybrid derivatives and parents. Aphids damaged the plants by sucking the sap which resulted in yellowing, crinkling of leaves and in severe cases withering of plants. This commenced from 15 DAS and continued up to harvest. The highest number of aphids was recorded on 90 DAS while the minimum numbers were recorded on 15 DAS (Table 1, Fig. 1).

A. Correlation between weather parameters and aphid population of bitter gourd

Correlation was made between the incidence of aphids and weather parameters *viz.*, maximum temperature, minimum temperature, morning and evening relative humidity, rainfall, wind speed and sunshine hours. Results of correlation analysis revealed that maximum temperature (T_{max}) was positively correlated with the population of aphids on the hybrid derivatives 2, 6, 7 and 8 with the r values of 0.664, 0.616, 0.592 and 0.700, respectively and were observed to be statistically significant at 1 percent level (Table 3).

Table 1: Seasonal incidence of aphids on bitter gourd during January to April 2022.

SMW	Number of aphids / 3 leaves / plant*											
	Hybrid 1	Hybrid 2	Hybrid 3	Hybrid 4	Hybrid 5	Hybrid 6	Hybrid 7	Hybrid 8	MCM 1	MCM 2	CO 1	Preethi
05	0	0	0	0	0	0	0	0	0	0	0	0
06	0	0	0	0	0	0	0	0	0	0	0	0
07	0.28	0.14	0.28	0.42	0.28	0.28	0.57	0.28	0.28	0.28	0.14	0.14
08	0.42	0.28	0.57	0.71	0.42	0.57	0.85	0.42	0.42	0.71	0.42	0.28
09	0.42	0.42	0.57	0.71	0.85	0.42	0.57	0.57	0.85	0.85	0.71	0.57
10	1.85	0.85	1.28	1.14	1.42	1.85	2.42	0.85	1.14	1.28	1.33	2.28
11	2.52	1.83	1.33	1.33	1.75	2.14	2.68	0.87	1.57	1.33	1.63	3.28
12	5.80	6.33	3.16	4.16	4.66	6.66	7.00	3.00	2.33	1.50	4.16	7.16
13	5.80	7.54	3.24	4.82	4.74	6.92	7.16	3.50	3.33	5.80	6.33	10.33
14	5.83	8.20	3.33	5.50	5.50	7.33	7.16	4.16	5.66	12.83	16.33	14.50
15	10.28	4.71	14.28	67.14	68.57	9.28	5.42	5.17	6.42	23.57	111.42	148.57
16	0.28	0.42	2.85	4.42	4.71	1.14	0.28	2.42	0.28	0.57	1.71	2.14
17	0.28	0.42	2.57	3.57	3.42	0.71	0.28	1.85	0.14	0.57	1.42	1.28

*Mean of observations taken on 10 randomly selected plants; SMW - Standard Meteorological Week

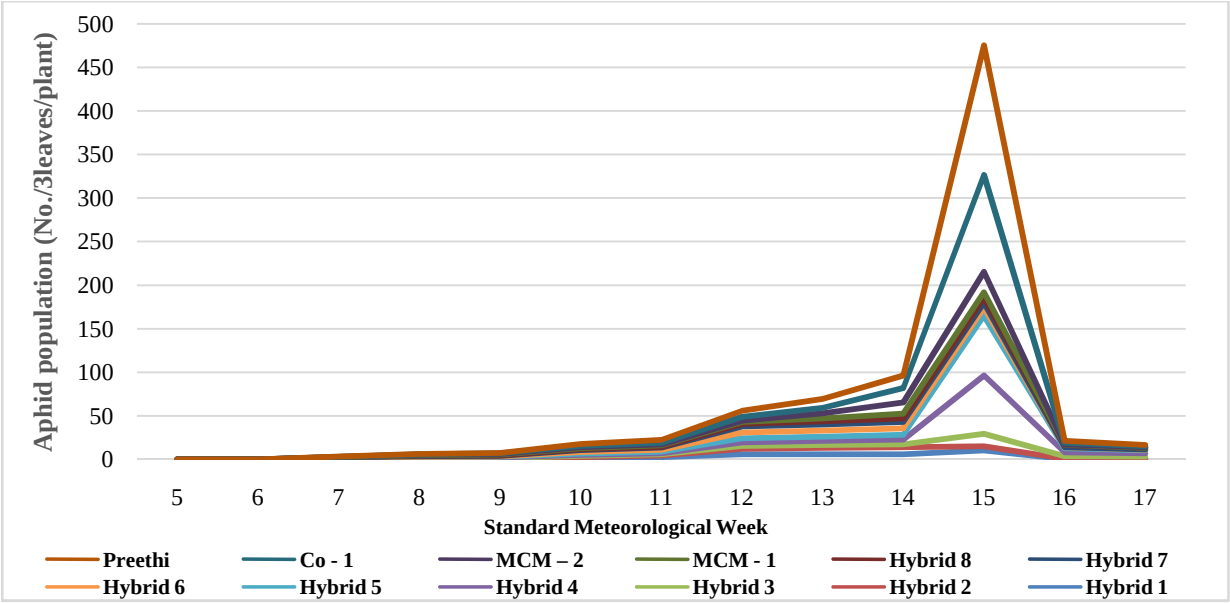

Fig. 1. Seasonal incidence of aphids on bitter gourd during January 2022 - April 2022.

Table 2: Percentage disease incidence of CABYV on bitter gourd during January to April 2022.

SMW	CABYV incidence (%)											
	Hybrid 1	Hybrid 2	Hybrid 3	Hybrid 4	Hybrid 5	Hybrid 6	Hybrid 7	Hybrid 8	MCM 1	MCM 2	CO 1	Preethi
05	0	0	0	0	0	0	0	0	0	0	0	0
06	0	0	0	0	0	0	0	0	0	0	0	0
07	28.57	14.2	28.57	28.57	28.57	14.20	42.80	14.20	28.57	28.57	14.20	14.20
08	42.80	28.57	57.14	57.14	42.80	42.80	57.14	42.8	42.8	57.14	42.8	28.57
09	42.80	42.80	57.14	57.14	57.14	71.42	71.42	57.14	57.14	71.42	57.14	71.42
10	71.42	57.14	71.45	71.45	71.45	71.45	85.71	57.14	71.45	71.45	71.45	85.71
11	85.71	71.45	71.45	71.45	71.45	85.71	85.71	57.14	71.45	71,45	71.45	85.71
12	100.00	100.00	100.00	100.00	100.00	100.00	100.00	85.71	85.71	71.45	100.00	100.00
13	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
14	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
15	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
16	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
17	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

*Mean of observations taken on 10 randomly selected plants; SMW - Standard Meteorological Week

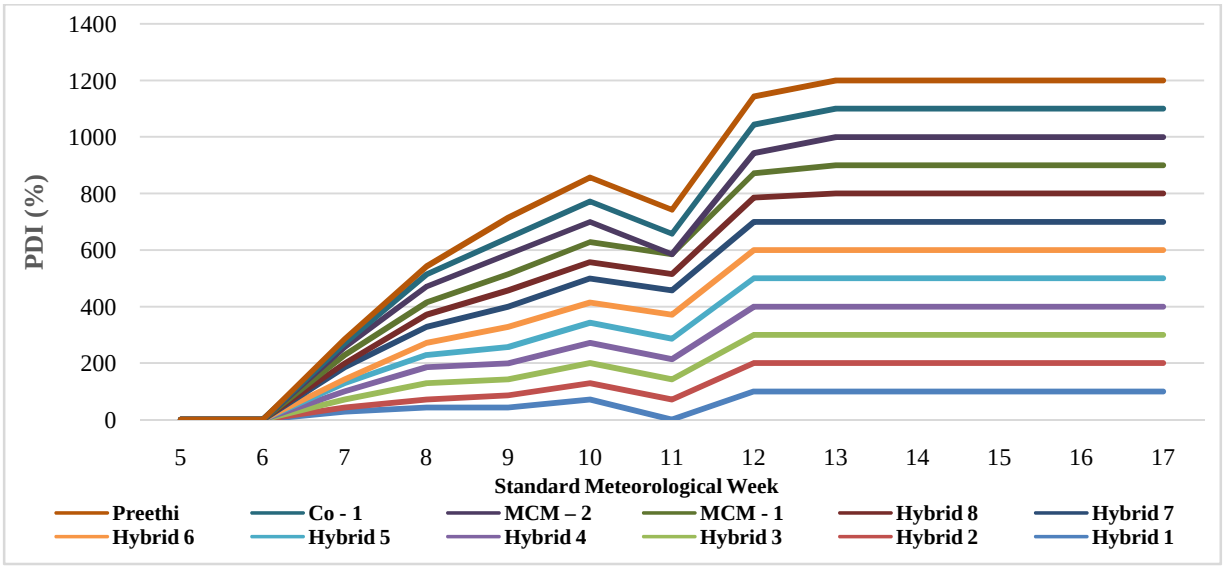

Fig. 2. Percentage Disease Incidence of CABYV on bitter gourd during January 2022 - April 2022.

Minimum temperature (T_{min}) was recorded to be positively correlated with the population of aphids on hybrid derivatives 2, 3, 6 and 8 with the r values of 0.575, 0.679, 0.610 and 0.779, respectively (Table 3). Morning and evening relative humidity was positively correlated with the aphid population while rainfall was negatively correlated with the r values of -0.034 and -0.074 on the hybrid derivatives 1 and 6 (Table 3). Aphid population on the hybrid derivatives 4 and 5 and evening relative humidity were found to be statistically significant at 1 percent level with the r values of 0.605 and 0.590. Wind speed and sunshine hours were recorded to be negatively correlated with the population of aphids. The hybrid derivatives 1, 2, 3, 6 and 8 (-0.564, -0.583, -0.595, -0.596 and -0.602, respectively) were recorded to be statistically significant at 1 percent level with wind speed and the hybrid derivatives 4 and 5, CO 1, Preethi were significant recorded to be statistically significant at 1 percent level with sunshine hours.

The results were in partial consonance with Gangurde *et al.* (2021) for maximum temperature, but minimum temperature, relative humidity, wind speed and rainfall were contrary to this. The results were quite congruence with the findings of Ghosh (2017) for maximum and minimum temperature but contrary to morning and evening relative humidity. According to Shukla (2014) and Dhandge *et al.* (2018), the aphid population peaked during 14th standard week after sowing. The findings of the aforementioned correlation analysis between weather parameters and aphid abundance on bitter gourd revealed that temperature and relative humidity had a significant positive influence on the aphid population. This could be due to the increased reproductive potential of aphids when temperature, relative humidity, and sunshine hours are high. This finding is in line with the results of Mahato *et al.* (2008) and Meena *et al.* (2009) who found that minimum temperature was positively associated with the population dynamics of sucking pests.

B. Multiple linear regression analysis between weather parameters and aphid population on bitter gourd

According to the results of multiple linear regression analysis between weather parameters and aphid abundance, the maximum temperature had considerable contribution towards the aphid population in the hybrid derivatives 1, 2, 6 and 7, with the R^2 values ranging from 0.911 to 1.079. When the maximum temperature increased by 1°C the mean number of aphids per three leaves per plant increased by 0.7 (Table 4). Minimum temperature had significant contribution towards the aphid population in the hybrid derivatives 4 and 5, MCM 2, CO 1 and Preethi with the r^2 values ranging from 0.682 to 1.244. When the minimum temperature increased by 1°C the mean number of aphids per three leaves per plant increased by 0.783 (Table 4). Both the morning and evening relative humidity and rainfall played a significant role in the population dynamics of aphids with the R^2 value of 0.750. Wind speed also had a significant contribution towards the aphid population in the hybrid derivatives 1, 2, 6 and 7 with the R^2 value of 0.631 to 0.950. When the minimum temperature increased by 1°C the mean number of aphids per three leaves per plant increased by 0.707 (Table 4). Ghosh *et al.* (2017) indicated that when the temperature rises, the activity of the aphid population increases. Under warm and humid conditions, aphids caused more damage and heavy rain reduced the population build up of aphids.

Table 3: Correlation between weather parameters and seasonal abundance of aphids in bitter gourd during January to April 2022.

Variables	Hybrid 1	Hybrid 2	Hybrid 3	Hybrid 4	Hybrid 5	Hybrid 6	Hybrid 7	Hybrid 8	MCM 1	MCM 2	CO 1	Preethi
Maximum temperature (T_{max}) (°C)	0.516	0.664*	0.490	0.214	0.231	0.616*	0.592*	0.700*	0.491	0.341	0.177	0.178
Minimum temperature (T_{min}) (°C)	0.489	0.575*	0.679*	0.532	0.520	0.610*	0.464	0.779**	0.449	0.525	0.472	0.450
Morning Relative Humidity (%)	0.109	0.214	0.239	0.261	0.237	0.192	0.068	0.281	0.024	0.162	0.214	0.209
Evening Relative Humidity (%)	0.268	0.160	0.523	0.605*	0.590*	0.302	0.117	0.392	0.170	0.377	0.542	0.549
Rainfall (mm)	-0.034	0.023	0.278	0.197	0.202	0.095	-0.074	0.345	0.017	0.086	0.112	0.092
Wind speed	-0.564*	-0.583*	-0.595*	-0.540	-0.539	-0.596*	-0.492	-0.602*	-0.444	-0.465	-0.498	-0.525
Sunshine hours	-0.334	-0.106	-0.405	-0.607*	-0.595*	-0.242	-0.153	-0.151	-0.254	-0.386	-0.603*	-0.623*

* Correlation coefficient significant at 1% level; ** Correlation coefficient significant at 5% level

Table 4: Multiple linear regression analysis on seasonal occurrence of aphids on bitter gourd during January to April 2022.

Variables	Hybrid 1	Hybrid 2	Hybrid 3	Hybrid 4	Hybrid 5	Hybrid 6	Hybrid 7	Hybrid 8	MCM 1	MCM 2	CO 1	Preethi
Constant	-27.409	-43.334	-0.677	29.730	26.834	-33.668	-39.685	-16.223	-9.042	23.236	48.102	43.361
Maximum temperature (T_{max}) (°C)	0.911**	1.056**	0.277	-0.121	0.019	0.962**	1.079**	0.455	0.403	-0.257	-0.373	0.002
Minimum temperature (T_{min}) (°C)	-0.136	-0.196	0.285	0.795**	0.682*	-0.120	-0.229	0.133	0.163	0.858**	1.244**	0.964**
Morning Relative Humidity (%)	0.004	0.140	-0.139	-0.388	-0.390	0.045	0.087	-0.011	-0.058	-0.283	-0.556	-0.588
Evening Relative Humidity (%)	0.040	0.017	0.017	0.006	0.025	0.039	0.034	0.007	-0.018	-0.065	-0.036	0.035
Rainfall (mm)	0.31	-0.032	0.012	0.039	0.039	-0.022	-0.040	0.006	-0.009	0.005	0.034	0.024
Wind speed	0.631	0.950**	-0.036	-0.848	-0.793	0.778**	1.012**	0.362	0.293	-0.601	-1.256	-1.340
Sunshine hours	-0.536	-0.479	-0.383	-0.794	-0.810	-0.508	-0.503	-0.295	-0.400	-0.447	-1.069	-1.230
R^2	0.738	0.707	0.847	0.783	0.780	0.759	0.685	0.850	0.612	0.600	0.715	0.731

Y = Incidence of aphids; X_1 = Maximum temperature; X_2 = Minimum temperature; X_3 = Morning relative humidity (%); X_4 = Evening relative humidity (%);
X_5 = Rainfall (mm); X_6 = Wind speed (Km/hr); X_7 = Sunshine hours

$Y_1 = -27.409 + 0.911\ X_1 - 0.136\ X_2 + 0.004\ X_3 + 0.040\ X_4 + 0.31 + 0.631\ X_6 - 0.536\ X_7$
$Y_2 = -43.334 + 1.056\ X_1 - 0.196\ X_2 + 0.140\ X_3 + 0.017\ X_4 - 0.032\ X_5 + 0.950\ X_6 - 0.479\ X_7$
$Y_3 = -0.677 + 0.277\ X_1 + 0.285\ X_2 - 0.139\ X_3 + 0.017\ X_4 + 0.012\ X_5 - 0.036\ X_6 - 0.383\ X_7$
$Y_4 = 29.730 - 0.121\ X_1 + 0.795\ X_2 - 0.388\ X_3 + 0.006\ X_4 + 0.039\ X_5 - 0.848\ X_6 - 0.794\ X_7$
$Y_5 = 26.834 + 0.019\ X_1 + 0.682\ X_2 - 0.390\ X_3 + 0.025\ X_4 + 0.039\ X_5 - 0.793\ X_6 - 0.810\ X_7$
$Y_6 = -33.668 + 0.962\ X_1 - 0.120\ X_2 + 0.045\ X_3 + 0.039\ X_4 - 0.022\ X_5 + 0.778\ X_6 - 0.508\ X_7$
$Y_7 = -39.685 + 1.079\ X_1 - 0.229\ X_2 + 0.087\ X_3 + 0.034\ X_4 - 0.040\ X_5 + 1.012\ X_6 - 0.503\ X_7$
$Y_8 = -16.223 + 0.455\ X_1 + 0.133\ X_2 - 0.011\ X_3 + 0.007\ X_4 + 0.006\ X_5 + 0.362\ X_6 - 0.295\ X_7$

CONCLUSION

From the results of field experiments, it was concluded that the activity of aphids was recorded to be maximum during March and April, 2022. CABYV infection started at 15 DAS and increased in proportion to the vector population until complete damage. From the results of multiple linear regression analysis, maximum (T_{max}) and minimum (T_{min}) temperature and morning and evening relative humidity had positive relationship with aphid population, but, rainfall, winds speed and sunshine hours had significant negative relationship. Necessary management measures should be implemented during early stage of the crop for effective management of aphid vectors and CABYV incidence.

FUTURE SCOPE

Through this study sowing date can be adjusted to protect the crop from pest incidence. It can be used to predict the weather based forecasting models for the successful management of pest.

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