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Article

Impact of Abiotic Factors on the Population Dynamics of Major Sucking Insect Pests on Bitter Gourd and Sponge Gourd

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Abstract: This study focused on the impact of different pests on bitter gourd and sponge gourd cultivation. The pest infestation of aphids, jassids, and whiteflies was investigated on bitter gourd (variety: Prachi) and Rama tori (a hybrid variety of sponge gourd). The experiment involved investigating a simple correlation between pest populations and various abiotic factors, with four repetitions. Weekly data collection involved counting the pests on 15 randomly selected plants in each sub-block using visual observation and hand lens examination. Correlation analysis revealed significant associations between pest populations and meteorological factors such as temperature, humidity, and rainfall. For sponge gourd, aphids (-0.31*) and jassids (-0.236*) were negatively correlated with maximum temperature, but whiteflies (0.22*) were positively correlated with maximum temperature. All pests, like aphids (-0.12*), jassids (-0.1327*), and whiteflies (-0.3382*), were negatively correlated with minimum temperature. Aphids (-0.2892) and jassids (-0.0891) were negatively correlated with relative humidity. However, whiteflies showed a positive correlation with relative humidity (0.1398*). In terms of rainfall, aphids (-0.1712*), jassids (-0.1574*), and whiteflies (-0.1027*) were negatively correlated with rainfall. Similarly, for bitter gourd, aphids (-0.187*), jassids (-0.264*), and whiteflies (-0.292*) were negatively correlated with maximum temperatures, while whiteflies (0.0041*) were positively correlated with relative humidity. Aphids (-0.031*) and jassids (-0.021*) were negatively correlated with minimum temperature. In terms of rainfall, aphids (-0.2125*), jassids (-0.0257*), and whiteflies (-0.0157*) were negatively correlated with rainfall.

Keywords: Sucking Insect Pests, Aphis Gossypii, Amrasca Biguttula Biguttula, Bemisia Tabaci, Abiotic Factors, Population Fluctuations, Bitter Gourd, Sponge Gourd, Correlation Analysis, Integrated Pest Management

Introduction

The agriculture sector, which contributes 22.9 percent to the GDP and generates 37.4 percent of employment, plays a crucial role in ensuring food security, providing raw materials to the industrial sector, earning foreign exchange, and promoting sustainable growth. However, in recent years, the country has experienced adverse climatic conditions that have negatively impacted the agriculture sector. The productivity of this sector is highly sensitive to the frequency of climatic shocks such as floods, droughts, heat waves, abnormal rainfall, and glacial melting. Particularly, prolonged precipitation patterns have led to increased river and inland water levels, resulting in flash floods and seasonal river and urban flooding, which have been common occurrences in the recent past. Consequently, these flood hazards significantly affect various aspects of human life, including socio-economic and politico-cultural domains. In July-August 2022, Pakistan witnessed an unprecedented episode of heavy rainfall followed by flash flooding, causing significant damage to two main sub-sectors of agriculture: crops (including important crops) and livestock [1].

The study focuses on two important crops, bitter gourd (*Momordica charantia*) and sponge gourd (*Luffa cylindrica*), due to their significance in the agriculture sector and their susceptibility to pests. These crops are widely cultivated in Pakistan and subtropical regions, making them crucial for food production and economic growth. Sponge gourd and bitter gourd are two of the most widely consumed vegetables cultivated in subtropical regions of the world. Luffa (Luffa spp.) and Bitter Gourd (*Momordica charantia*) are important cucurbitaceous crops cultivated worldwide for their nutritional value, medicinal properties, and economic significance. However, like other crops, they are susceptible to various pests that can significantly impact their productivity and quality. Among these pests, aphids, jassids, whiteflies, and mites pose significant challenges to luffa and bitter gourd production [2].

Bitter gourd, scientifically known as *Momordica charantia*, is a tropical and subtropical vine belonging to the Cucurbitaceae family. Also commonly referred to as bitter melon, bitter squash, or karela in various regions, the fruit of the bitter gourd plant is long, oblong, and typically has a rough, bumpy skin. Despite its distinctly bitter taste, bitter gourd is a popular vegetable in many cuisines, particularly in South Asia, Southeast Asia, and parts of Africa, where it is appreciated for its unique flavor and numerous health benefits. One of the key features of bitter gourd is its nutritional value, as it is low in calories and carbohydrates but rich in essential nutrients such as vitamins A, C, and various B vitamins, as well as minerals like potassium, magnesium, zinc, and iron. Additionally, bitter gourd has been utilized for its medicinal properties in traditional medicine for centuries. It is known to possess antioxidant, anti-inflammatory, and antidiabetic properties, with compounds like charantin and momordicin that may help lower blood sugar levels and manage diabetes. In culinary practices, bitter gourd is a versatile vegetable that can be cooked in various ways. It is commonly stir-fried, stuffed, added to soups, curries, or even consumed raw in salads. In some cuisines, it is also used as an ingredient in beverages and pickles. Alongside its culinary uses, bitter gourd has been an integral part of traditional medicine in many cultures, used to treat ailments such as diabetes, stomach disorders, skin infections, and respiratory conditions [3].

Luffa cylindrical, commonly known as sponge gourd, belongs to the family Cucurbitaceae [4]. *L. cylindrinca* has several applications, such as a packing medium, a shoe mat, a bath sponge, and a household cleaner. It is also used as an immobilization matrix for plants, algae, bacteria, and yeast. Luffa was grown on a total of 22342 hectares in Pakistan during the 2020-2021 growing season, resulting in a total yield of 23354 tons [5]. Pakistan's luffa yield per unit is lower than the international average for a number of reasons, including poor cultural practices, inefficient weed management, insect infestation, and so on. This is the case despite the fact that the field contains a diverse range of cultivars from different countries. These weeds, insects, and diseases are some of the key factors contributing to a lower yield [6]. During both the growing and harvesting stages of the luffa plant, it is susceptible to attack by a wide variety of insect pests, such as the squash bug, squash vine borers, cucumber beetles, red pumpkin beetles, ants, thrips, fruit flies, and aphids [7].

Materials and Methods

Study Location

The research was carried out in the vegetable-growing area of Guttwala, located in Faisalabad, Punjab, Pakistan. The specific geographical coordinates for the experimental site were 31°26'01.9" North latitude and 73°04'32.1" East longitude.

Experimental Design and Crop Cultivation

The experiment was designed with two primary blocks, each measuring one acre in size. One block was dedicated to cultivating bitter gourd, using the 'Prachi' variety, while the second block was planted with the 'Rama tori' variety of sponge gourd. The plants were arranged along ridges with a spacing of 1 foot between individual plants within a row and a distance of 3 feet separating the ridges. To facilitate replication and detailed data collection, each one-acre block was further subdivided into four smaller sub-blocks.

Pest Sampling Procedure

Data on pest infestation, targeting both adults and nymphs of aphids, jassids, whiteflies, and mites, was collected every week from sowing until the final harvest. For each sub-block, 15 plants were randomly selected every week for assessment. A systematic sampling method was employed for leaf selection, whereby the top leaf was observed from the first plant, a middle leaf from the second plant, and a lower leaf from the third plant, repeating this sequence for the remaining selected plants.

Data Collection for Individual Pests

The population of each pest type was recorded using specific techniques. Aphid and jassid infestations were quantified by directly observing and counting the number of individuals present on each sampled leaf, using a hand lens for close examination. Similarly, mite populations were assessed by meticulously examining leaves with a hand lens and recording the count. For whiteflies, the presence and number of individuals per leaf were determined through direct visual observation without the aid of a lens. This comprehensive data collection for all four pests was conducted consistently every week throughout the entire duration of the experiment.

Results

Impact of Abiotic Factors on the Population Fluctuations of A. gossypii

On bitter gourd, aphid infestation occurred between the 10th and 25th Standard Weeks (S.W.). The initial infestation began around the 10th S.W. with a mean population of 4.31 aphids per 3 leaves. The population peaked during the 12th S.W. at 5.36 aphids per 3 leaves before dropping to 4 aphids per 3 leaves the following week. By the 18th S.W., the population had declined to 3.81 aphids per 3 leaves. Correlation analysis indicated a negative correlation with both maximum temperature (-0.187*) and minimum temperature (-0.031*), as well as with relative humidity (-0.153*) and rainfall (-0.2125*). On sponge gourd, aphids appeared around the 10th S.W. with an average population of 4.16 aphids per 3 leaves and peaked during the 11th S.W. at 4.33 aphids per 3 leaves. The data revealed a negative correlation with maximum temperature (-0.31*), minimum temperature (-0.12*), relative humidity (-0.28*), and rainfall (-0.17*).

Impact of Abiotic Factors on the Population Fluctuations of A. biguttula biguttula

On bitter gourd, jassids were observed from the 10th to the 25th S.W., starting with a mean population of 3.18 per three leaves. The peak incidence occurred in the 16th S.W. with a mean population of 4.25 per three leaves, after which the population gradually decreased. A significant negative correlation was found between jassid population and maximum temperature (r = -0.264*), minimum temperature (r = -0.021**), relative humidity (r = -0.0496*), and rainfall (r = -0.0257*). On sponge gourd, the incidence commenced around the 10th S.W. with a mean population of 1.98 per three leaves and peaked during the 19th S.W. at 3.2 per three leaves. The results revealed a positive correlation with maximum temperature (r = 0.225*), a negative correlation with minimum temperature (r = -0.1327*) and relative humidity (r = -0.0891), and a significant negative correlation with rainfall (r = -0.1574*).

Impact of Abiotic Factors on the Population Fluctuations of B. tabaci

On bitter gourd, the whitefly population ranged from 1.65 to 3.51 whiteflies per three leaves between the 10th and 25th weeks, with the highest population in April and the lowest in June. The correlation with weather parameters revealed non-significant negative correlations with maximum temperature (0.092*), minimum temperature (-0.05*), relative humidity (-0.004**), and rainfall (-0.01*). On sponge gourd, whitefly observations began during the 36th week with an average population of 3.41 per three leaves and peaked during the 21st week with an average population of 3.56 per three leaves. Correlation analysis indicated a positive but non-significant correlation with maximum temperature (0.22*) and relative humidity (0.13*), a negative but non-significant correlation with minimum temperature (-0.33*), and a non-significant negative correlation with rainfall (-0.10*).

Table 1. Impact of abiotic factors on the seasonal incidence of sucking insect population on bitter gourd during *Kharif* 2022-23.

Std. Week	Month and Date	Temperature (⁰C)		R.H %	Rainfall	Average* number of sucking pests per 3 leaves		
		Min temp.	Max temp.			Aphid	Jassids	Whitefly
10	3/13/2022	34	16	71	0	4.31	3.18	2.78
11	3/20/2022	36	23	64	0	3.76	3.66	2.73
12	3/27/2022	37	18	51	0	5.36	3.83	3.51
13	4/3/2022	39	21	43	0	4	4.23	3.48
14	4/10/2022	41	22	45	0	3.93	3.38	3.1
15	4/17/2022	42	20	41	0	4.86	4.25	3.28
16	4/24/2022	39	21	46	0	4.86	4.25	3.28
17	5/1/2022	39	25	53	0	4.1	3.9	3.13
18	5/8/2022	42	28	41	0	3.81	3.71	3.6
19	5/15/2022	47	30	49	0	4.43	3.63	2.8
20	5/22/2022	43	25	34	0	4.58	3.38	2.98
21	5/29/2022	42	28	43	0	4.68	3.8	3.2
22	6/5/2022	47	29	34	0	4.36	3.03	1.65
23	6/12/2022	46	26	42	2.4	4.56	3.81	3.25
24	6/19/2022	41	22	53	0	4.46	2.53	2.5
25	6/26/2022	45	29	49	0	4.55	3.66	2.91
Correlation with abiotic factors		Maximum Temperature (⁰C)				-0.18**	-0.26*	-0.29*
		Minimum Temperature (⁰C)				-0.03*	-0.02**	-0.05*
		Relative Humidity (%)				-0.15*	-0.04*	-0.004**
		Rainfall (mm)				-0.21*	-0.02*	-0.01*

Average* of three replications SW= Standard Week *Significant at p≤0.05 **Significant at p≤0.01

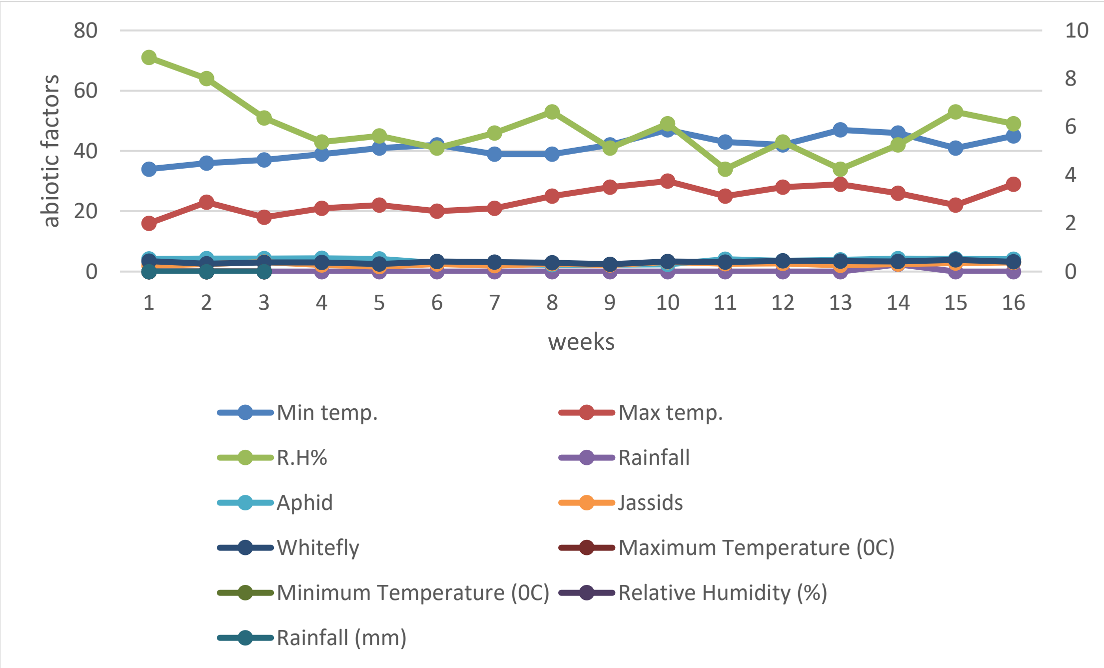

Figure 1. Impact of abiotic factors on the seasonal incidence of sucking insects per 3 leaves on bitter gourd.

Table 2. Impact of abiotic factors on the seasonal incidence of sucking insect population on sponge gourd during *Kharif* 2022-23.

Std. Week	Month and Date	Temperature (⁰C)		R.H %	Rainfall	Average* number of sucking pests per 3 leaves		
		Min temp.	Max temp.			Aphid	Jassids	Whitefly
10	3/13/2022	34	16	71	0	4.16	1.98	3.41
11	3/20/2022	36	23	64	0	4.33	2.51	2.61
12	3/27/2022	37	18	51	0	4.28	3.11	3
13	4/3/2022	39	21	43	0	4.4	2.18	3.03
14	4/10/2022	41	22	45	0	4.16	1.65	2.53
15	4/17/2022	42	20	41	0	2.81	2.46	3.3
16	4/24/2022	39	21	46	0	2.53	1.95	3.13
17	5/1/2022	39	25	53	0	2.26	2.58	2.96
18	5/8/2022	42	28	41	0	2.33	2.18	2.43
19	5/15/2022	47	30	49	0	2.36	3.2	3.38
20	5/22/2022	43	25	34	0	4.1	2.66	3.13
21	5/29/2022	42	28	43	0	3.56	2.68	3.56
22	6/5/2022	47	29	34	0	3.86	2.08	3.41
23	6/12/2022	46	26	42	2.4	4.26	2.51	3.38
24	6/19/2022	41	22	53	0	4.2	2.78	3.88
25	6/26/2022	45	29	49	0	4.05	3.01	3.28
				Maximum Temperature (⁰C)		-0.31*	-0.23*	0.22*
				Minimum Temperature (⁰C)		-0.12*	-0.13**	-0.33*
				Relative Humidity (%)		-0.28*	-0.08*	0.13*
				Rainfall (mm)		-0.17*	-0.15*	-0.10*

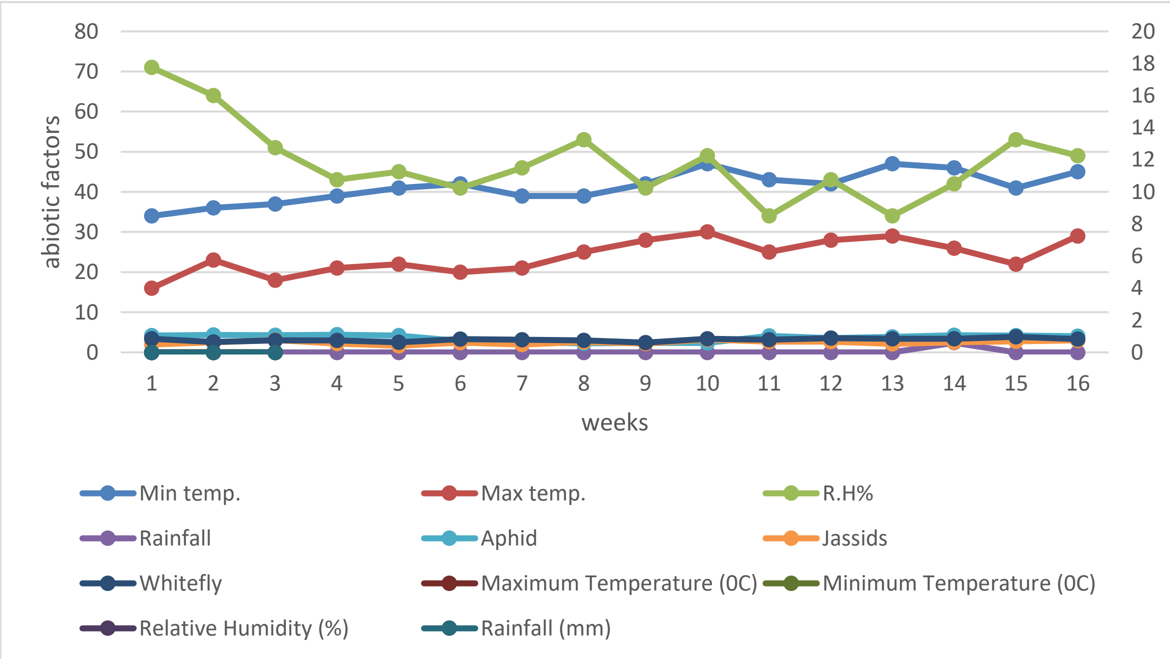

Figure 2. Impact of abiotic factors on the seasonal incidence of sucking insects per 3 leaves on the sponge gourd.

Discussion

The findings of this study elucidate the significant influence of abiotic factors on the population dynamics of key sucking pests in bitter gourd and sponge gourd, with both consistencies and variations observed when compared to the broader scientific literature.

The consistent negative correlation observed between rainfall and the populations of aphids, jassids, and whiteflies across both crops is a prominent and expected finding. This aligns with the established mechanical impact of rainfall, which can dislodge and drown small, soft-bodied insects and disrupt their feeding and egg-laying activities. The observed aphid results were found to be in strong agreement with those previously documented by Shah et al., who also reported a non-significant negative correlation with rainfall [8]. However, the significant negative correlation identified in this study was further supported by the findings of Chattopadhyay et al., who demonstrated a significant inverse relationship between aphid populations and precipitation [9]. This consistent suppressive influence of rainfall has therefore been interpreted as a general regulatory mechanism affecting these pest groups across different agroecological conditions.The impact of temperature on aphid populations was clear, with higher maximum and minimum temperatures consistently correlating with population decline on both crops. This finding was observed to diverge from some earlier studies. In contrast to the present results, a non-significantly positive correlation between aphid populations and maximum temperature was reported by Singh et al. and by Boopathi and Pathak [10], [11]. Such inconsistency could be attributed to variations in regional climatic conditions, the crop varieties examined, or the dominant aphid biotypes present during those investigations. Nevertheless, the observation that minimum temperature exerted a negative influence aligns with the findings of both Singh et al. and Boopathi and Pathak, who also noted a nonsignificant negative effect of lower temperatures on aphid populations [10], [11].The relationship between jassid populations and weather parameters revealed intriguing crop-specific responses. A negative correlation with maximum temperature on bitter gourd was found to be consistent with the observations of Iqbal and of Boopathi and Pathak, who reported no significant positive correlation (Iqbal,[11], [12]). Conversely, the positive correlation identified on sponge gourd was observed to contradict these earlier studies but to correspond with the findings of Sharma and Sharma, who documented a positive relationship with minimum temperature [13]. This pronounced discrepancy has been interpreted to indicate that the host plant species plays a decisive role in mediating the effects of abiotic stress on pest insects, likely due to variations in plant physiology, leaf surface texture, or nutrient composition that influence microhabitat suitability.The population trends of whiteflies presented the most complex and often non-significant correlations with weather parameters. The ambiguous relationship with temperature and humidity in our study mirrors the variable outcomes reported in the literature. For example, our finding of a positive (though non-significant) correlation with relative humidity on sponge gourd is consistent with [13], who identified a significant positive correlation. Similarly, the variable correlation with temperature fluctuations we observed aligns with the non-significant associations noted [14], [15]. The consistent negative correlation with rainfall across both crops in our study is supported by Sharma and Rishi, who also found no significant negative correlation between rainfall and whitefly incidence.

Conclusion

In conclusion, this study confirms that abiotic factors are key drivers of sucking pest populations in cucurbit agro-ecosystems, but the effects are not always uniform. The general suppressive role of rainfall is a consistent theme, but the influence of temperature is highly dependent on the specific pest and host plant combination. These findings highlight the critical importance of developing crop-specific Integrated Pest Management (IPM) strategies that leverage local meteorological data for more accurate pest forecasting. The discrepancies with previous research emphasize the need for region-specific and crop-variety-specific studies to build robust predictive models for sustainable pest management.

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