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Impact of weather variables on seasonal dynamics of leafhopper, *Empoasca devastans* distant on potato

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Abstract
Potato losses from the leaf hopper, *Empoasca devastans* Distant, a significant sucking pest, can be extremely high. The population dynamics of *E. devastans* on potato were examined in the present investigation, carried out at the Vegetable Research Centre of GBPUA&T, Pantnagar, during the *Rabi* season of 2020-21. With a population density of 1.98 leafhoppers/3 compound leaves, leafhopper populations were first seen in the 46th standard week (SW) and peaked in the 49th SW (5.35 leafhoppers/3 compound leaves). The outcomes of the correlation analysis concluded that the leafhopper population was correlated negatively with relative humidity both morning and evening but significantly positively with maximum temperature, evaporation, and sun-shine hours. Our research also revealed a statistically non-significant relation between minimum temperature and rainfall and the leafhopper population. Together, the major weather factors analysed by means of developing a regression equation created 75.4% variation in the leafhopper population. Therefore, the dynamics of populations are a key consideration in the integrated pest management module when developing preventative measures to employ against leafhoppers.

Keywords: Leafhopper, potato, population dynamics, weather variables

Introduction
Over a billion people throughout the world eat potatoes (*Solanum tuberosum* L.), making it the most lucrative vegetable crop. Potato production in India is the second-highest in the world, making them the fourth-most significant food crop after rice, wheat, and maize. (FAOSTAT, 2017) [1]. It is expected that the widespread use of potatoes as a food and energy source, particularly in developing nations, will significantly increase food security. Because Asia is the most populated continent and potatoes have the potential to feed the masses, efforts must be made to increase potato output in Asia (Khurana and Govindakrishnan, 2004) [2]. In comparison to the usual potato cultivated locations with temperate climate, over 85% of potato crop are cultivated in the wide Indo Gangetic plains (subtropics) of North-India during the brief winter period from October-March (Khurana and Naik, 2003) [3]. Pest activity has been a major factor in determining the outcome of the potato crop for many years on a global scale. The production of potatoes is badly impacted by numerous insect pests; some of these pests are so severe that they can completely destroy a crop in a matter of time if not treated promptly (Govindakrishnan *et al*., 2005) [4]. In India, the issue of insect pests has gotten much worse, resulting in significant crop losses and significant yield reductions upto 33 per cent (Lakra, 2005) [5]. Furthermore, sucking pests that seriously harm the plants, such as aphids, whiteflies, thrips, and leafhoppers, drastically lower potato output (Bhatnagar, 2007) [6]. Among these, the leaf hopper (*Empoasca devastans* Distant) has received criticism as a pest (Singh *et al*., 2002[7]; Sharma and Singh, 2011) [8] in various regions of the globe. Hopper burn, bronzing, yellowing, and coiling of leaves result from the pest's feeding on the plant's sap in both adult and nymphal stages (Sandhi and Sidhu, 2018) [9]. Sap loss and the possible injection of toxins found in leafhopper saliva cause most of the damage to plants (Bairwa and Kumawat, 2005) [10]. In addition to direct feeding on plants, leafhoppers can spread harmful plant infections like phytoplasma on potatoes, which can cause secondary damage to the host plant (Crosslin *et al*., 2005; Munyaneza *et al*., 2008) [11, 12]. Weather conditions have a severe impact on the emergence and buil-up of the leafhopper population. Since insect pest survivability, growth, and population build-up are regulated by prevailing climatic circumstances, a thorough examination of the incidence pattern of this pest and the effect of existing climatic conditions on population fluctuation is urgently needed (Shera *et al*., 2013) [13].

The main motivation for the current investigation was to obtain insight into this field in order to develop efficient management strategies for combating harmful potato pests.

Materials and Methods

The research was done at the Vegetable Research Centre of the Govind Ballabh Pant University of Agriculture and Technology in Pantnagar-263145, Udham Singh Nagar, Uttarakhand during the *Rabi* season of 2020-2021. All suggested agronomical procedures as directed by GBPUA&T, Pantnagar, were periodically followed in order to properly raise the crop. The potato variety "kufri Surya" was planted in a field with a total of six replications, each with a plot of size 4.0m X 5.0m, to research the seasonal prevalence of leafhoppers also the effect of the current meteorological variables on its population trends. No pesticides were applied during the trial. The potato crop was monitored weekly beginning with crop emergence and continuing through harvest to record the seasonal dynamics of leafhoppers on potato. On ten randomly chosen plants, the leafhopper population was counted by looking at 3 compound leaves from the upper, middle, and lower section of each plant in each replication. Early in the morning, observations were made, and the population mean of leafhoppers was estimated. The agro-meteorological observatory of the Department of Agrometerology, G.B.P.U.A&T, Pantnagar, provided the weekly data on weather variables, including temperature both maximum and minimum, relative humidity (morning and evening), wind speed, evaporation, sun-shine hour, and rainfall. Employing SPSS, Version 20, from SPSS, Inc. Chicago, II, USA, a Pearson Correlation analysis was used to determine the connection between the leafhopper incidence and weather conditions. The leafhopper population was used as the dependent variable in a regression analysis, and meteorological factors were used as the independent ones.

Results and Discussion

Table 1 displayed information on the dynamics of the *E. devastans* population and its relationship to weather variables. The findings showed that the first leafhopper infestation in the crop field started on the 46th standard week in November with a mean population of 1.98 leafhoppers/3 compound leaves and prevalent along the cropping period with a variable population density in the potato crop. The mean maximum and minimum temperatures at the time of the initial infestation were 28.5°C and 11.3°C, respectively, with average morning and evening relative humidity readings of 92.0% and 36.0%, respectively. In the range of 0.40 to 5.35/3 compound leaves, the leafhopper population was observed. Leafhopper activity was noted from the 46th to the 05th SW, with three distinct peaks occurring in the 47th, 48th, and 49th SW, with a mean population of 3.78, 4.73, and 5.35 leafhoppers/3 compound leaves, respectively. Due to the favourable weather, the population grew steadily during this time. The peak activity of leafhoppers was noticed at 49th SW (5.35 adults/3 compound leaves). The mean maximum and minimum temperatures during this period were 25.7°C and 10.1°C, respectively, while the relative humidity in the morning and evening was 94 and 50%, respectively. The 4th week of November to the 2nd week of December 2020 (47th-49th SW) crop phenology and meteorological conditions, such as rainfall, temperature, and relative humidity, were favourable for the development of leafhoppers. Following that, the population of leafhoppers in the potato crop was substantially reduced. In comparison, the incidence of leafhoppers was higher in the early stages of crop development. This outcome is quite comparable to Sharma and Singh (2012) [14] findings, which claimed that leafhoppers first appeared in the 2nd week of November and that their numbers peaked in the first and second weeks of December. The results are consistent with those of Dahatonde *et al*. (2014) [15], who noted that the leafhopper population began to increase in November and reached a high in December. On the other hand, according to Mathur *et al*. (2012) [16], the last week of December was when leafhopper populations were at their peak.

Table 1: Seasonal Incidence of *Empoasca devastans* on potato crop during the *Rabi* season of year 2020-21

Standard Weeks	Mean leafhopper counts/3 compound leaves	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Sunshine (hrs.)	Wind velocity (km/hr.)	Evap. (mm)
		Max.	Min.	Morning	Evening				
46	1.98	28.5	11.3	92	36	0.0	8.1	1.9	3.0
47	3.78	25.1	8.7	93	43	0.0	7.5	2.2	2.9
48	4.73	25.0	8.6	94	42	0.0	6.1	1.0	2.2
49	5.35	25.7	10.1	94	50	0.0	6.4	1.3	2.7
50	2.77	20.8	9.7	93	67	2.5	3.3	3.4	1.7
51	1.35	16.0	4.1	95	65	0.0	3.1	2.5	1.0
52	0.71	20.8	4.1	96	55	0.0	5.4	1.9	1.5
01	0.99	20.3	9.2	94	62	18.6	3.1	2.8	2.1
02	0.40	18.7	8.7	97	72	0.0	3.9	5.6	2.0
03	0.62	18.2	7.5	96	69	0.0	3.7	2.7	1.7
04	0.73	16.6	8.8	96	75	0.0	1.6	2.8	1.5
05	0.51	18.8	6.1	96	61	0.0	4.5	1.1	1.8

Correlation analysis with weather variables

In order to determine the relationship between the population of *E. devastans* and the primary weather variables during 2020-2021, a correlation research was conducted (Table 2). According to the *E. devastans* population's correlation coefficient with various weather variables, the leafhopper population significantly correlated favourably with Tmax. (r= 0.71**), sun-shine hours (r= 0.58*), and evaporation (r= 0.59*), similar to the outcomes of Varma *et al*. (2011) [17] and Mahmood *et al*. (2002) [18]. According to the conclusion of Ratanpara *et al*. (1994) [19] and Varma *et al*. (2011) [17]., there is a positive association between the population of leafhoppers and sunshine hours. Consistent with results of Mahmood *et al*. (2002) [18] and Singh *et al*. (2013) [20], our results concluded a negative and significant association between morning (r= -0.63*) and evening (r= -0.64*) relative humidity and potato leafhopper population, respectively. In line with the results of Meena *et al*. (2010) [21], Saroj *et al*.

(2017) [22], and Natikar and Balikai (2018) [23], our research likewise revealed that the population of leafhoppers exhibits a statistical non-significant relation with Tmin. and rainfall. Factors such as humidity (Jindal and Brar, 2005) [24], temperature and sunshine (Singh and Sekhon, 1998) [25] have a crucial impact on the development and decline of the leaf hopper density.

Table 2: Pearson's correlation matrix between weather observations and *Empoasca devastans* population on potato during *Rabi* 2020-2021

Variables	PHp	Tmax	Tmin	RHmor	RHeve	Rf	SS	WV
Tmax	0.71**							
Tmin	NS	0.60*						
RHmax	-0.63*	-0.76**	-0.58*					
RHmin	-0.64*	-0.92**	NS	0.71*				
Rf	NS	NS	NS	NS	NS			
SS	0.58*	0.91**	NS	-0.58*	-0.94**	NS		
WV	NS	NS	NS	NS	0.62*	NS	NS	
Evap.	0.59*	0.90**	0.74**	-0.64*	-0.75**	NS	0.82**	NS

PHp: leafhoppers population per three compound leaves; Tmax. and Tmin.: Maximum and minimum temperature (°C); Tmin.; RHmin. and RHmax.: Relative minimum and maximum humidity (%); Rf: Rainfall [mm]; SS: Sun-shine hrs.; WV: Wind velocity [Km/h] and Evap.: Evaporation [mm]. Highlighted numerals depicts the correlation statistics; data preceded by a '*' indicate a statistically significant association at the $p<0.05$ level; data preceded by a '**' indicate a statistically significant association at $P < 0.01$; NS: non-significant

The following regression equation shows that temperature (Maximum and Minimum), relative humidity (Morning and Evening), rainfall, evaporation, wind velocity, and sun-shine hours all contribute roughly 75.4 per cent to the population of *E. devastans* in potato, which is a rather high level of accuracy (R2 = 0.754).

Potato leafhopper = 38.165 + 1.543 Tmax – 1.779 Tmin – 0.532 RHmor + 0.001 RHeve – 0.295 Rf – 3.880 SS + 0.170 WV + 7.068 Evap

Reviewing the aforementioned equation revealed that there would be an increase of 1.543 and 7.068 leafhoppers and 7.068 for each 1°C rise in temperature maximum and 1mm increase in evaporation, while there would be a decrease of 1.779, 0.532, 0.001 and 0.295 leafhoppers, for every 1°C increase in minimum temperature, 1 per cent increase in relative humidity morning and evening, and 1mm increment in rainfall respectively.

Conclusion

The most renowned sucking pest of potatoes is the leafhopper, which is active at different population densities throughout the growing season with a peak period in early December. Weather conditions have a significant impact on the development of the leafhopper population. Knowing when a certain species of leafhopper is most active gives us the green light to develop management techniques that will hopefully keep potato yields from dropping. Lack of scientific understanding of the dynamics of pest populations is the primary impediment to pinpointing the source of the problem in pest management. Consequently, population dynamics play a pivotal part in the IPM module when determining how to best manage this pest in advance.

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