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Species composition and population dynamics of aphids influencing potato virus Y (PVY) incidence in Karnataka

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Abstract
The present study was in a traditional potato growing location in Chikkamagaluru, Karnataka state, India. During the two consecutive seasons such as *Kharif* and *Rabi* of 2014-2015 observation were recorded, to understand the population dynamics and their influence on potato virus Y incidence. Population dynamics of aphids were studied using sticky trap. A total of five aphid species were observed during *Kharif* and four species during *Rabi* on sticky trap. *Myzus persicae* was found colonizing only on potato. Population was peak at the third week of August with more numbers of aphids (117) on crop per plant and 92 aphids on sticky trap. A fewer aphid population was found colonizing in *Rabi* compared to *Kharif* and also very few aphids in sticky traps. Aphid population had positive correlation with maximum temperature, minimum temperature as also on wind speed. Negative correlation was observed with rainfall, morning as well as afternoon humidity in both the seasons. Correlation between aphids and succeeding week per cent PVY incidence showed positive correlation in *Rabi* season but during *Kharif* aphids and per cent PVY incidence had negative correlation indicating possibility of infection in the seed itself. Implication of the study of the management of aphids, aphid borne viruses as well as potato seed productions are discussed.

Keywords: *Myzus persicae*, sticky trap and Potato virus-Y, PVY

Introduction
The potato (*Solanum tuberosum* L.) belongs to the family Solanaceae. In India, potato is cultivated in almost all the states under diverse agro-climatic conditions. The states of Uttar Pradesh, West Bengal, Punjab, Bihar and Gujarat accounted for more than 80 per cent share in total production. Among the peninsular states of India, Karnataka is leading in the potato production. In Karnataka, six districts are major potato cultivation *viz.*, Chikkaballapur, Belgaum, Chikkamagaluru, Dharwad, Hassan and Kolar. Crop is mainly grown as *Kharif* crop in Belgaum, Chikkamagaluru, Dharwad and Hassan districts, where as *Rabi* crop in Kolar and Chikkamagaluru districts [1]. In this area potato cultivation is seriously limited due to pests and disease. The major pests of potato are aphids, whiteflies, potato tuber moth, white grubs, leafhoppers and thrips. Among the insect pests, aphids play a major role by transmitting a number of viral diseases [2]. Aphids serve a major role in causing qualitative and quantitative losses [3]. Potato is seriously affected by different species of aphids among which green peach aphid, *Myzus persicae* Sulzer, is the most important [4]. The green peach aphid affects potato production by direct damages and indirect damage caused by the insect. The direct damage is feeding on the plants and the indirect damages caused to potato planting materials as a virus vector [5, 6]. The important species of aphids which are reported to transmit the viral diseases in potato in North India are *Myzus persicae* and *Aphis gossypii* [7]. Farmer's resort to the application of various insecticides like imidacloprid and thiomethoxam which significantly reduces the non-persistent virus transmission [8]. However, the studies on epidemiology of vector borne viruses is lacking under south Indian condition. Hence, the present study was aimed at bridging this gap to some extent.

Materials and Methods
Experimental site and Monitoring of aphids
Aphids were monitored on crop and using yellow sticky traps in a grower filed (Karkipete village; N 13022'108" E 75046'463"; MSL 1146 m) of Chikkamagaluru district, Karnataka

with the certified seeds var. Kufri Jyoti. This area is traditional potato growing region of Karnataka. Aphid monitoring was done throughout the season starting from sowing to harvesting. In *Kharif*, the date of sowing was 16th June of 2014 and harvesting date was on 3rd September. Similarly, in *Rabi*, the date of sowing was 22nd November of 2014 and harvesting date was on 14th February of 2015. In the field, 34 plants were selected at random in zigzag manner [9, 10]. In each plant, 3 compound leaves were selected from upper, middle and lower part. Observations on number of aphids on compound leaves and number of aphids were counted with the help of magnifying lens at weekly interval. Aphids sampled on crop and collected from a sticky trap (60*40 cm) were identified to species level using the key provided by Martin (1963) [11].

Monitoring of PVY incidence

Potato virus Y incidence was assessed by observing 100 plants moving in zig-zag manner and plants showing symptoms like mosaic, curling and stunted growth were recorded at weekly intervals were collected. The leaf samples were subjected to Double Antibody Sandwich- Enzyme Linked Immunosorbemt Assay (DAS-ELISA) to confirm the PVY infection. Potato virus Y antibody was obtained from Loewe, Germany. Further, per cent plants showing PVY symptoms were calculated.

Data analysis

Correlation and regression analysis were performed to know the relationship between weekly mean weather parameters of the current week and preceding week with corresponding succeeding weekly aphid population. Similarly, correlation and regression analysis were performed to analyse the relationship between the aphid vectors both on crop (C) and sticky trap (S) and PVY incidence by using SPSS software version 16.0.

Results and Discussion

Species composition of aphid trapped on yellow sticky trap

In yellow sticky traps, a total of 190 aphids was trapped in *Kharif* 2014 and 111 aphids in *Rabi* 2014-15 respectively and were subsequently identified. A total of five and four species were recorded during *Kharif* 2014 and *Rabi* 2014-15, respectively. However, *M. persicae* was the only species found colonizing on potato. The species composition of alate aphids caught in yellow sticky trap is summarized in Table 1.

Table 1: Total number and Per cent composition of aphid species in sticky traps# collected from Chikkamagaluru during 2014-15

Aphid Species	Aphids			
	Kharif		*Rabi*	
	N*	%	N*	%
Myzus persicae (Sulzer)	95	50.00	63	56.75
Aphis gossypii Glover	63	33.15	27	24.32
Aphis craccivora Koch	23	12.10	13	11.71
Aphis spiraecola Patch	7	3.60	8	7020
Tetraneura nigriabdominalis (Sasaki)	2	1.05	00	0.00
Total	190		111	

Number of aphids collected onsticky trap;
N* Aphid count

Among the aphids trapped during *Kharif*, the green peach aphid, *Myszus persicae* (Sulzer) was the predominant and formed 50 per cent of the total aphids trapped. The other aphid species trapped were, cotton aphid, *Aphis gossypii* Glover (33.15%), cowpea aphid, *Aphis craccivora* Koch (12.10%), spireay aphid, *Aphis spiraecola* Patch (3.60%) and ragi root aphid. *Tetraneura nigriabdominalis* (Sasaki) (1.05%). Among the aphids trapped during *Rabi*, the green peach aphid, *Myzus persicae* (Sulzer) was the predominant and formed 55.75% of the total aphids trapped. The other aphid species trapped were, cotton aphid, *Aphis gossypii* Glover (24.32%), cowpea aphid *Aphis craccivora* Koch (11.71%), spireay aphid, *Aphis spiraecola* Patch (7.20%).

A large number of aphid species are vectors of potato viruses PVY in particular. *Myzus persicae* stands out as the most efficient vectors of potato viruses [12]. A much larger number of aphid species were trapped in yellow traps which act as vectors of PVY than PLRV. The potato crop was surrounded by many vegetables like cabbage, cauliflower, brinjal and french beans and other leguminous crops at Chikkamagaluru. The *Aphis gossypii* is a common pest of brinjal, okra, chilli and other vegetables [13]. Some of the leguminous crops and weeds around the main field are regular host plants of *Aphis craccivora* [14]. Hence, the species composition in trap catches is a product of multitude of factors comprising cropping systems and weather parameters.

***Kharif* season**

Aphid population on crop

The aphid population was peak during the first week of July and third week of August *i.e.*, 81 and 117 aphids per 102 compound leaves respectively. A aphid population was low during second, third and fourth week of July *i.e.*, seven, five and two aphids per 102 compounds leaves, respectively. During fourth week of August the aphid population was nil (Table 2 and Figure 1). A aphids on crop had positive non-significant correlation with maximum temperature (MT), minimum temperature (mt) and wind speed (WS) [(r = 0.31), (r = 0.15) and (r = 0.05) respectively]. Non-significant negative correlation was observed with rainfall (RF), morning humidity (RH 1) and afternoon humidity (RH2) [(r = 0.54), (r = -0.19) and (r = -0.22) respectively]. Whereas, correlation between present week weather parameters with succeeding week aphid population indicated positive correlation with minimum temperature (mt) and wind speed (WS) [(r = 0.18) and (r = 0.27), respectively]. However, negative correlation was observed with MT, RF, RH1 and RH2 [(r = -0.003), (r = -0.24), (r = -0.16) and (r = -0.12) respectively] but were non-significant (Table 3).

The multiple linear regression equation fitted with six independent variables (weather parameters) to predict aphid population on potato (y) was y = 179.34 -9.85 RF + 30.96 MT – 63.09 mt + 9.16 RH1 – 3.09 RH2 – 25.89 WS. The value of coefficient of determination (R^2) was 0.84 which implied that 84% total variation in aphid population could be explained by above six parameters. However, in succeeding week aphid population, the equation was y = - 5181.365 – 14.458 RF – 54.808 MT – 317.236 mt + 5.941 RH1 + 1.879 RH2 – 2.859 WS with R^2 of 0.762.

Aphid population on yellow sticky trap

The number of aphids trapped was during the first week of July *i.e.*, 92 aphids per trap. Very few aphids were trapped during the fourth week of July, third and fourth week of August *i.e.*, only one aphid in each week. No aphids were trapped during first and second week of August (Table 2 and Figure 1). The aphids on trap had positive significant correlation with MT and mt [(r = 0.84*) and (r = 0.89*)

respectively]. Significant negative correlation was recorded with RH1 and RH2 [(r = -0.87*) and (r = -0.91*) respectively]. Whereas, non-significant negative correlation was observed with RF (r = 0.64), non-significant positive correlation with WS (r = 00.60). Whereas, correlation between present week weather parameters with succeeding week aphid population indicated a significant negative correlation with RH1 and RH2 [(r = -0.84*) and (r = -0.78*) respectively]. Non-significant positive correlation with MT, mt and WS [(r = 0.63), (r = 0.63) and (r = 00.35) respectively]. Negative non-significant correlation was observed with RF (r = -0.62) (Table 3).

Table 2: Aphid population on potato and sticky trap during *Kharif* and *Rabi* season in Chikkamagaluru during 2014-15

Kharif			***Rabi***		
Date	**Crop***	**Sticky trap****	**Date**	**Crop***	**Sticky trap****
29.06.2014	50	69	06.12.2014	4	8
07.07.2014	81	92	14.12.2014	0	0
13.07.2014	8	15	20.12.2014	1	13
20.07.2014	9	11	28.12.2014	6	39
27.07.2014	4	1	04.01.2015	12	7
03.08.2014	20	0	12.01.2015	8	8
10.08.2014	2	0	18.01.2015	6	11
17.08.2014	137	1	25.01.2015	5	7
24.08.2014	6	1	01.02.2015	16	13
			08.02.2015	20	5
Total	317	190	Total	78	111

* On Potato – 102 compound leaves taken for aphid count (only *Myzus persicae* was recorded on crop)
** Number of aphids on sticky trap per week

The multiple linear regression equation fitted with six weather parameters to predict aphid population was y = -646.52 – 2.27 RF + 6.97 MT + 30.46 mt -0.04RH1 – 0.63 RH2 – 5.09 WS having R^2 value of 0.94, In succeeding week, the equation obtained was y = 306.06 -2.13 RF – 15.65 MT + 34.03 mt – 1.50 RH1 – 4.18 RH2 – 13.00 WS with R^2 value of 0.849.

***Rabi* season**

Aphid population on crop

The aphid population was peak during first and second week of February, *i.e.*, 20 and 16 aphids per 102 compound leaves respectively. Aphid population were low during the third week of December *i.e.*, one aphid per 102 compound leaves. During second week of December the aphid population was nil (Table 2 and Figure 2). To understand the relationship between aphid population on potato crop and the prevailing weather, the data of aphids and weekly mean weather parameters were subjected to correlation analysis. Aphids on crop had positive significant correlation with Maximum Temperature (MT) (r = 0.69*), whereas, in minimum temperature (mt) had non-significant positive correlation (r = 0.08). Negative non-significant correlation was observed with rainfall RF, RH1, RH2 and WS [(r = -0.58), (r = -0.39), (r = -0.80) and (r = -0.71) respectively]. Whereas, the correlation between present week weather parameters with succeeding week aphid population indicated non-significant positive correlation with MT, mt and RH1 [(r = 0.59), (r = 0.32) and (r = 0.02), respectively]. However, non-significant negative correlation was observed with RF, RH2 and WS [(r = -0.32), (r = -0.65) and (r = -0.67), respectively] (Table 4).

Table 3: Correlation and regression between weekly weather parameters and aphid population# during *Kharif* season

Aphid Population	**Correlation coefficient ('r' value)**						**Coefficient of determination (R^2)**
	Rainfall	**Temperature**		**Relative humidity**		**Wind speed**	
		Max.	Min.	RH1	RH2		
Aphid population on crop							
Current week weather	-0.54	0.31	0.16	-0.19	-0.22	0.05	0.84
one preceding week weather	- 0.24	-0.03	0.18	-0.16	-0.12	0.27	0.76
Sticky trap							
Current week weather	-0.64	0.84*	0.89*	-0.87*	-0.91*	0.60	0.94
one preceding week weather	-0.62	0.63	0.65	-0.84*	-0.78*	0.35	0.85

N =9; Table r value @ p = 0.05 is 0.66, * significant @ p = 0.05

A multiple linear regression equation was fitted with six independent variables (weather parameters) to predict aphid population. The equation was y = 0.41 – 1.35 RF + 2.39 MT – 1.08 mt – 0.05 RH1 – 0.08 RH2 – 3.13 WS. The value of the coefficient of determination (R^2) was 0.82. However in succeeding weeks, equation obtained was y = - 95.09 – 4.593 RF + 0.525 MT + 0.135 mt + 2.174 RH1 – 1.838 RH2 + 3.938 WS with R^2 of 0.909.

Aphid population on yellow sticky trap

More aphids were trapped on yellow sticky trap during fourth week of December *i.e.*, 39 aphids per trap and less on yellow sticky trap during second week of February, first week of January and third week of January *i.e.*, five, seven and seven respectively, no aphids were trapped during first and second week of December in this location (Table 1 and Figure 2). The aphids on trap had positive non-significant correlation with RH1, RH2 and WS [(r = 0.41), (r = 0.32) and (r = 0.09) respectively]. Non-significant negative correlation was observed with RF, MT and mt [(r = -0.19), (r = -0.29) and (r = -0.21) respectively]. Whereas correlation between present week weather parameters with succeeding week aphid population indicated significant positive correlation with RF(r = 0.82*). Whereas, non-significant positive correlation with mt, RH1, RH2 and WS [(r = 0.56), (r = 0.14), (r = 0.39) and (r = 0.04) respectively]. Non-significant negative correlation with MT (r = -0.09) (Table 4).

Table 4: Correlation and regression between weekly weather parameters and aphid population# during *Rabi* season

Aphid Population	Correlation coefficient ('r' value)						Coefficient of determination (R^2)
	Rainfall	Temperature		Relative humidity		Wind speed	
		Max.	Min.	RH1	RH2		
Aphid population on crop							
Current week weather	-0.58	0.69*	0.08	-0.39	-0.80*	-0.71*	0.82
one preceding week weather	-0.32	0.59	0.32	0.02	-0.65*	-0.67*	0.90
Sticky trap							
Current week weather	-0.19	-0.29	-0.22	0.41	0.32	0.09	0.44
one preceding week weather	0.82*	-0.09	0.56	0.14	0.39	0.04	0.84

#N = 10 Table r value @ p = 0.05 is 0.63; * significant @ p = 0.05

A multiple linear regression equation was fitted with six weather parameters to predict aphid population. The equation was y = 109.16 – 12.22RF – 2.44 MT – 0.65 mt + 2.71 RH1 – 1.30 RH2 + 6.69 WS having R^2 value of 0.44. In succeeding week, obtained equation was y = -69.272 + 12.96 RF – 0.293 MT + 4.85 mt – 1.19 RH1 – 0.72 RH2 + 5.916 WS with R^2 value of 0.848.

It has been reported that the aphid population build up was a combined function of temperature, lower relative humidity and lower rainfall in Pakistan [15]. Here aphid trap catches mainly based on several weather parameters, among which wind speed was important. Wind speed has least positive correlation because winged aphid forms do not fly under windy conditions [16]. The temperature and relative humidity displayed positive association with aphid population, but the rainfall showed a considerable negative direct effect [17]. Studies have also indicated combining leaf count with sticky and water traps found positive coefficients of correlation with minimum temperature [18]. the temperature above 70^0 F, relative humidity below 80% and wind speed below 5 m.p.h. were optimum for aphids flight activity in general [19]. So the observed variation of an aphid population across two seasons is the product of various weather parameters and crops grown in the region. With two season experiment on aphid population dynamics indicated that, maximum temperature, minimum temperature and wind speed had positive correlation with aphids on the crop. It was also found that, regression equation provided better picture when aphid population of succeeding were regressed with current week weather parameters.

Potato virus Y incidence during *Kharif* and Rabi season in relation to aphid population

The ELISA values with >0.500 was considered as PVY positive. PVY incidence at harvest was 31% in *Kharif* (Figure 1). Aphids on sticky trap (S) had significant negative correlation (r = -0.786*), non-significant negative correlation found in crop (C) (R = - 0.075). The regression equation obtained was y = 17.68 + 0.16C -0.4248S with R^2 value 0.735. This implied that 73.5% virus incidence could be explained by aphid population. Whereas, the correlation between present week aphid population on sticky trap with succeeding week PVY incidence indicated that, significant negative correlation (r = -0.854*), non-significant negative correlation found in crop (r = - 0.008). The regression equation obtained was y = 19.026 + 0.086C – 0.4828S with R^2 value 0.957.

Per cent PVY incidence in *Rabi* was low compared to *Kharif*. PVY incidence at harvest was 12% (Figure 2). Aphids on crop and sticky trap had non-significant positive correlation with PVY incidence with r = 0.141 and r = 0.23, respectively. The regression equation was y = 6.275 + 0.269C + 0.0598S with R^2 value 0.315, which implied that 31.5% virus incidence could be explained by aphid population. Whereas, correlation between present week aphid populations with succeeding week PVY incidence indicated that non-significant positive correlation with aphids present on crop(C) (r = 0.548) and on sticky trap(S) (r = 0.313). The regression equation was y = 5.02 + 0.375C + 0.018S with R^2 value of 0.468. This may be due to possibility of seed material which might have been already infected with viruses. As the certified seeds were used in the experiment, possibility of infection to the seed tubers cannot be eliminated. Tuber infection and early plant infection lead to an increased percentage of PVY [20, 21]. In *Kharif*, negative correlation has been observed between the aphid vectors and the degree of infection with PVY, it may be due to migrating aphids which play an important role in transmitting non persistent viruses in potato with lower transmission efficiency [22]. Correlation between current week aphids and succeeding week % PVY incidence showed positive correlation in *Rabi* compared to present week PVY incidence. After inoculation of viruses by aphid vector, it takes time to express viral symptoms on any of the plant species, as documented in papaya ring spot virus transmitted by migrating aphids [23, 24]. This reason may also be true with PVY transmitted by aphids in non-persistent manner.

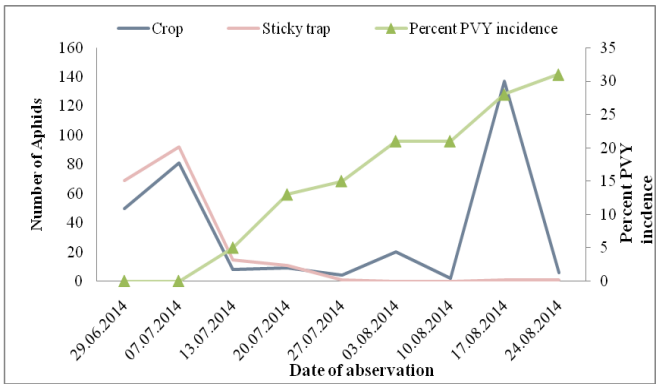

Fig 1: Aphid population dynamics and per cent PVY incidence during *Kharif* season

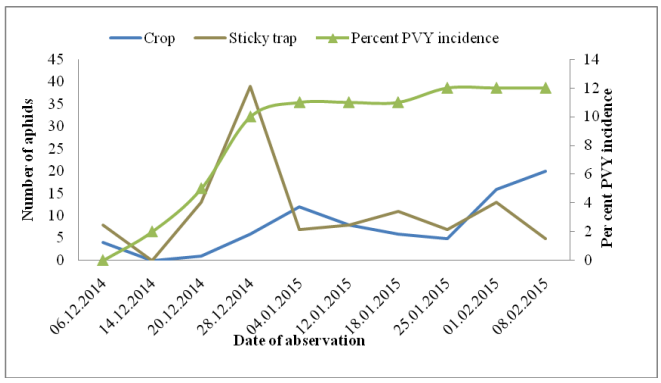

Fig 2: Aphid population dynamics and per cent PVY incidence during *Rabi* season

Table 5: Correlation and regression on aphid population# and per cent PVY incidence of current week and succeeding week at Chikkamagaluru during *Kharif* and *Rabi season of 2014-15*

Per cent virus incidence	Correlation coefficient ('r' value)		Coefficient of determination (R^2)
	Aphids on crop	On sticky trap	
Kharif	-0.075	-0.786*	0.735
	One week preceding aphid population+		
	-0.008	-0.854*	0.957
Rabi	0.141	0.23	0.315
	One week preceding aphid population@		
	0.548	0.313	0.468

#N = 9; Table r value @ p = 0.05 is 0.66; * significant @ p = 0.05
+N = 8; Table r value @ p = 0.05 is 0.70 for *Kharif*
#N = 10; Table r value @ p = 0.05 is 0.63; * significant @ p = 0.05
@N = 9: Table r value @ p = 0.05 is 0.66 for *Rabi*

Conclusion

The results of the present study lead to the following points. Aphid population had positive correlation with maximum temperature, minimum temperature and wind speed. Negative correlation was observed with rainfall, morning and afternoon humidity in both the seasons. Correlation between aphids and succeeding week % PVY incidence showed positive correlation in *Rabi* season but during *Kharif*, aphid population and % PVY incidence had negative correlation, indicating a complex interaction involving various factors.

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