RESEARCH ON THE BIOLOGICAL CONSTANTS OF APHID SPECIES IN ORDER TO LIMIT VIRUS INFECTIONS OF THE POTATO USED FOR SEEDING

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Abstract. The success of high and steady potato yields is subject to continuous production of healthy planting material with high biological value and in sufficient quantities. Achieving this goal is hampered by continuous and progressive infections of potato plants via aphids, viral disease that causes regression of production, causing degeneration. The appearance of aphids as vectors of viral diseases is influenced by climatic conditions and an inadequate vegetative home. In this context, the paper highlights the results of research on potato maintaining productive potential through effective measures to limit polluting sources and reduce viral infection transmitting. Thus, it slows, it hinders the achievable trinomial: host plant - virus - vector prerequisite condition for triggering a viral infection. The research is focused on establishing correlations between biological constants of aphid species and climatic characterization of the area of potato seed multiplication to stop the circulation of viruses from diseased plants to healthy ones, and from one year to another.

Keywords: aphid, host plant, infection, potato, viral, vector.

INTRODUCTION

Viral degeneration of the potato is universally accepted today, is a pathological phenomenon caused by specific and nonspecific potato viruses, manifested by decreased plant vigor and irreversible reduction in the production capacity of seed tubers [16]. Virus degeneration theory of the potato was first addressed in the Netherlands and America and has expanded in all countries where we find many potato cultivators. A demonstration of the viral nature of the disease [23], and detection of diseases manifested as a mosaic form and viral nature of this disease [3], founded the viral degeneration of the potato, opening the way, for the first time, for the virology in the matter of degeneration in potato.

Viral spreading in the potato culture is relatively high, now there are identified more than 30 viruses with economical importance for the potato [27], and the survival and spreading of the majority of them is dependent to the potato [26]. Of these the largest production losses were caused by potato virus Y and potato leaf roll, then followed by the virus and viruses X, A and M in mixed infections that cause serious illness.

The level and importance of production losses depend on many factors: the type and strain of virus involved, the variety of tolerance and time of infection [8]. In this sense, if favorable conditions can achieve a production of 40 t / ha, following a viral infection can drop production to about 1 to 1.7 t / ha at a rate 10% of infected plants with severe virus infection, 5 - 8 t / ha at 40 % of infected plants and the 10-22 t / ha, if the percentage is 80 % of viruses plants [9]. Viral infected cultures have a double impact on seed potato, meaning that it will affect both the production as well as from the respective following year infection as a result of migration of the vine leaves and later the tuber, leading to reduced vigor of the plant, biologically, being a major problem for their use in the creation of new cultures [7,17,21,25]. In addition to the aphids, an important role in the spread of virus infection have the weeds, as well as some host potato plant viruses and some viral vectors for infection (aphids and nematodes) [19]. The main species of aphids that transmit viruses to the potato are: *Myzus persicae* Sulzer (green peach aphid); *Aphis frangulae* Kaltenbach (calina louse); *Aphis nasturtii* Kaltenbach (verigariului louse); *Aulacorthum solani* Kaltenbach (square aphid of potato); *Macrosiphum euphorbiae* Thomas (striped louse of potato). Other aphid species are considered incidental to the potato: *Aphis fabae* Scopoli*; Phorodon humuli* Schrank*; Rhopalosiphum maydis* Fitch etc. Among these, more often encountered is the species *Aphis fabae* Scop. [29].

Identification of viral diseases is difficult due to the variety of symptoms diseased plants present. For this purpose it is used to call different diagnostic methods including, visual observation, and the use of the test plants (bioassays), electron microscopy, serological methods and other techniques. Introducing ELISA test (Enzyme Linked Immuno Sorbent Assay) highly sensitive allowed the detection and rapid identification and precision of hard viruses hardly detectable by other methods. In this context, the main objective of the farmers who grow seed potato is not to disprove aphid populations in cultures already installed, but to adopt the most efficient and environmentally friendly means of preventing dissemination to reduce the viral transmission rate [9], that population reduction [6]. It is known that obtaining seed potato starts from starting material employed in biological categories "super-elite and elite", 100 % pure, perfect plant condition "virus-free" and with high productivity characteristics [5]. The process continues by multiplying the high favorability areas and ecological for the potato, at an altitude of 600 m, where the mean temperature of the warmest month (July) is 18 – 19^0C and where aphid vectors of viruses have a small frequency and low dispersion [17], where it is taken up by farmers and placed in culture.

Because large areas favorable for ecological potato seed are relatively small, not all farmers use the

appropriate seed potato crop establishment. This has prompted the search for solutions by specialists, so now we are witnessing the development of a rebreeding system of the potato seed in favorable areas outside the closed ones. On the identification of these areas, the favorable activities conducted lie in the absence or presence of a limited number of sources of viral infection, i.e. vectors of transmission of viral infection. However the execution of technological links like destruction of vine helps to reduce viral infection by restricting passage of virus attack on vine leaves and potato tubers [24].

MATERIALS AND METHODS

Identifying the areas favourable for rebreeding the seed potato outside closed areas is a current problem receiving the interest of many specialists [13, 14, 15, 30], the organization of researches, among them the subject of this paper, organized in Sibiu area situated in the southern part of Transylvania, on the river Cibin, relatively close to the geographic center of Romania, at an altitude of 1420 m (Near the Păltiniş Resort located at 37 km from city center, with a framed mountain climate in the warm slope due to frequent thermal inversions, with fresh air, the average annual temperature of 4.3 ^{0}C and multi-annual average rainfall amount of 910.0 mm).

The researches aimed mainly the existence and evolution of populations of aphids - vectors of virus infection and was based on climate data and weather averages multiannual specific experimental years (1999-2013). These elements allow calculating the coordinates of growth and development of various species of aphid vectors of viruses. Their usefulness is great in prognosis (modelling) accurately the holo-cycle of different species in order to specify the flight time and their migration and breeding on the potato. In this manner, the methods of forecasting and warning the flight dynamics of aphid populations in the areas of seed potato can be improved, in order to determine the optimal timing for interruption of the vegetation of potato attacked by aphids in order to limit the passage of virus attack on the vine potato leaves and tubers.

To this end they sought items that are of interest in the biological cycle progression of aphids linked to hatching winter eggs on primary host plants, on the occurrence of mother stem, on the development of Aptera fundatrigenous and time of flight migration of winged aphids from the primary hosts to secondary hosts. Among these are: date of passing spring; producing date of frost of late spring and early autumn, when the minimum temperature falls below: -2^{0}C; number of days with minimum temperatures below 0^{0}C and below 5^{0}C in the spring (III-V quarter). After the emigration of aphids with flying wings to secondary hosts and therefore to seeded potato fields, of great importance are the following: number of days with precipitation; rainfall in 24 hours, exceeding the limit of 10 mm and which helps to wash aphids on potato plants; dominant wind direction and speed; frequency of days with wind speeds of 2 m/s, which favors passive flight at distances of aphids; the number of days with optimal flight temperatures (25^{0}C), minimum (17 ^{0}C) and maximum (30 ^{0}C).

RESULTS

In conditions of Mountainous Region, aphid development is determined by temperature and the availability of primary host plants, which takes place in the first part of holo-cycle of these aphids. Starting from the Botanics measurements made by Drăgulescu (2003) [10], in the Păltiniş area, located in the spruce zone, no primary hosts for most species of aphids are found. After the field researches made by Drăgulescu (2003) [10], in Sibiu, only the following species are found only up to an altitude of 650-750m (Table 1). It results, from this list of hosts of the main aphid species of virus vector on potato seed their absence in the mountain area, and that the species of aphids can reach the mountain only by long migration flights and passive flight (wind). At the altitude of 1420 m in Păltiniş are, the following hosts are common (Table 1).

Based on these findings, we have directed the research towards the possible dynamics in the sycamore, the species of aphids *Macrosiphum euphorbiae* Hott et Fris. This species of aphids attacks over 200 plant species grouped into 20 families [11]. Macrosiphum euphorbiae Hott et Fris is an active species found in potato culture in the second half of May until the second decade of August [12], it attacks a wide range of species, sends a large number of viruses and is considered to be a viral vector infection worldwide [2].

The starting point is the coordinate growth, development and multiplication of striped potato aphid (*Macrosiphum euphorbiae* Hott et Fris) set by Buiuc et al. (1989) [4], on the basis of the application of the following mathematical model (Table 2).

Table 1. Plant species - the primary hosts for aphids - found in Sibiu area and Păltiniş

Species of host plants	Species of Aphids
Plant species - the primary hosts for aphids - found in Sibiu	
Prunus piersica L and *Prunus tenella* Batsch	Hosts for *Myzus persicae* Sulz
Euonymus europaeus L. and *Eunyomus verrucosus* Scop,	Hosts for *Aphis fabae* Scop
Rhamnus catharticus L., *Rhamnus saxatilis* Jacq and *Frangula alnus* Mill	Hosts for the complex of species like *Aphis frangulae* Kalt; *Aphis nasturtii* Kalt
Plant species - the primary hosts for aphids - found in Paltinis	
Rosa canina L., *Rosa pendulina* L. and *Rubus idaeus* L.	Hosts for *Macrosiphum euphorbiae* Hott et Fris

In this manner there were obtained the biological constants of the species that are invariant thermal values that emphasize critical limits of the metabolism and that draw implicitly a change of the shifting biological motion and of the biological space and time.

Our research fully confirms the data presented by Meier (1958) [20], for Switzerland, which shows that the occurrence of the species *Myzus periscae* Sulzer on secondary hosts and therefore, the potato, later appears as altitude increases. Thus, at altitudes between 850 - 1000 m, species as *Myzus persicae* Sulzer on secondary hosts appears with a delay of 30 days in comparison with altitudes of 400 -600 m. For altitudes of 1000-1400 m this delay of the summer flight is by 60 days higher in comparison to the low area and at altitudes of 1250 m this flight delays until early September, so a delay of 45 days [20].

Comparing the data presented in Table 3 it is observed that the stem mother can occur at Paltinis with a delay of 38 days to Sibiu. Flight of emigration from primary hosts to secondary hosts (potato) occurs at Paltinis with a delay of 56 days to Sibiu. Delay increases as you enter autumn.

The data presented in Table 3 shows that the eco-climatic conditions specific at an altitude of 1420 m in Păltiniş area, although there are species like *Macrosiphum euphorbiae* Hott et Fris, that are necessary primary hosts, local development is impossible. Time for every generation at Păltiniş is for: fundatrigenous I 24 days as for Sibiu 18 days; fundatrigenous II 20 days as for Sibiu 15 days; fundatrigenous III 19 days as for Sibiu 13 days; virginogene I 20 days as for Sibiu 13 days; virginogene II 26 days as for Sibiu 12 days.

The specific climatic conditions of Păltiniş area, with moderate temperatures and high relative air humidity, due to frequent and abundant rainfall plus long lifetime of a generation, favor the attack of diseases that affect aphids and drastically reduce their number. In this context, we present the multiplication of species *Macrosiphum euphorbiae* bioclimogram Hott et Fris (figures 1 and 2) in terms of temperature and precipitation from Păltiniş area, under specific meteorological data of the experimental 2003 and multiannual average values, indicating that this species favorable conditions for growth and development.

Aphid *Aphis fabae* species is less demanding to temperature, having a biological threshold (to) lower than other aphids. If one accepts the hypothesis that *Aphis fabae*, would stay over winter at Păltiniş as a winter egg, the appearance of the stem mother would be signaled around the time of 26.05 (24 days later than in Sibiu) and the first generation of fundatrigene would be signaled around date of 26.06 (40 days later than in Sibiu).

Continuing with the *Aphis fabae* continuing simulation, emigration flight would occur at or around 31.07 in Păltiniş (50 days later than in Sibiu) and the first generation of viriginogene Aptera would occur at or around 17.08 (with 54 days later than in Sibiu). Under these conditions not even the *Aphis fabae* species would present a real danger to the seed potatoes grown in the area of Păltiniş.

DISCUSSIONS

Our research fully confirms the data presented by Meier (1958) [20], for Switzerland, which shows that the occurrence of the species *Myzus periscae* Sulzer on secondary hosts and therefore, the potato, later appears as altitude increases.

It appears that in this area (Păltiniş, 1420 m altitude) aphids arrive with a delay of about 45 days compared to areas located at an altitude of 400-600 m.

Table 2. Coordinates growth, development and breeding striped potato aphid (*Macrosiphum euphorbiae* Hott et Fris)

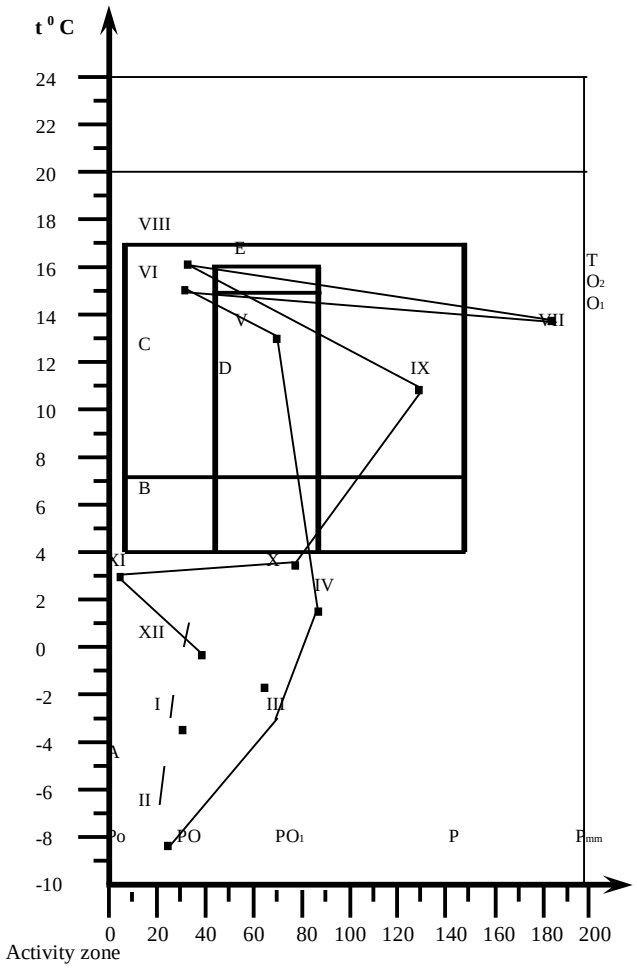
Name of coordonate	Invariable thermical values
Development ecuation	$16,8\ (14,1 - t_0) = 9,7\ (21,8 - t_0)$
Biological verge	t =3,6 ° C
Thermal constant	K=176,4 ° C
Prolific verge	O = 7,2° C X_n = 48,4 zile
Thermical optimum verge	O_1 =15,2 C X_n =15,2 zile
Superior verge of the thermical optimum	O_2 =16.0 C
Superior thermical verge	T= 16,9° C X_n=13,3 zile
Breeding constant	C { t_n=15,2° C x_n=15,16 zile}
Breeding ecuation	γ =1,3038 (t_n - 3,6° C)
Breeding time	X=230
Time areal of winter	egg = 135 zile

Table 3. Annual dynamics of the potato's striped louse, in the multi annual averages in Păltiniş area (1420m) and in Sibiu (420m)

Area	Primary hosts				Secondary hosts								Primary hosts	
	F	Fg I	Fg II	Fg III	V I	V II	V III	V IV	V V	V VI	V VII	VS VIII	S	Winter egg dep.
Păltiniş	4.06	28.06	18.07	6.08	26.08	21.09	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sibiu	26.04	14.05	29.05	11.06	24.06	6.07	17.07	28.07	8.08	20.08	1.09	15.09	3.10	13.10

Date of emigration flight — Date of retromigration flight

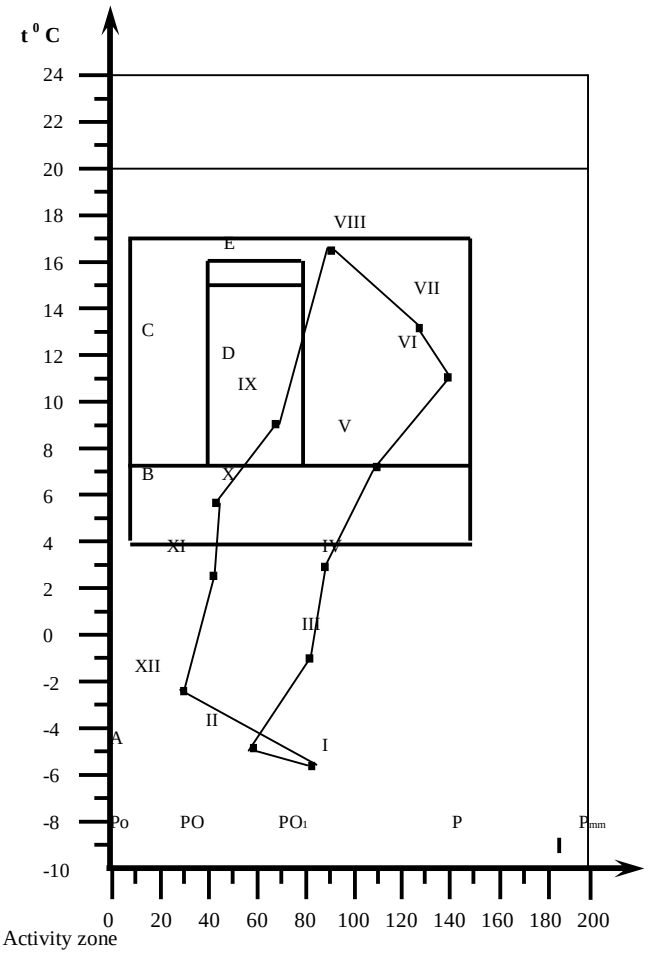
Legend: F = Stem mother; Fg = Fundatrigenous; V = Virginogene apter; Vs = Virginogene sexupare; S = Sexual ♂ winged, ♀ apter; N/A = non existent



Activity zone
a. lowest
b. unfavorable
c. slightly favorable
d. favorable
e. optimum

Po – Biological limit
PO – Prolificity limit
PO_1 – Optimum limit
P – Superior limit

Figure 1. Bioclimograma striped potato aphid multiplication, depending on temperature and precipitation, in accordance with the eco-climatic conditions of 2003 year Paltinis



Activity zone
a. lowest
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PO_1 – Optimum limit
P – Superior limit

Figure 2. Bioclimograma striped potato aphid multiplication, depending on temperature and precipitation, in the multiannual average values in the Paltinis area

They consist of a small number of species whose incidence of transmission of the viral infection is lower, as it is concluded from the research conducted by Vučetić et al., 2013 [31], which is in favor of holding this activity micro zone potato production and seed multiplication.

Starting from the existence in the area of the studied area of host plants unique only to the striped potato aphid (*Macrosiphum euphorbiae*), the research has been directed to studying its annual growth. The results show the existence of eco-climatic conditions unfavorable for the development of this species and its vivacity manifested both in the abundance, variability and persistence compared to other species of aphids (*Myzus persicae* and *Aphis nasturtii*) as results from research conducted over a period of 6 decades conducted by Lamb et al. of 2011 show [18]. Another feature of this viral vector of transmission is its mobility, which found in his research by Alyokhin and Sewell, 2003 [1], after a study on potato crop colonization by *Macrosiphum euphorbiae*, *Myzus persicae* and *Aphis nasturtii*. This calls for careful monitoring of the summer flight of this species and others arrived in potato fields at 1400 m of altitude as a result of long migration flights and flight mode.

The Summer flight study leads to the optimal timing of interruption of vegetation to stop the migration of viral infection in tubers and leaves an important criteria in obtaining a potato planting material with high biological effect. These results and the importance of this criteria is also emphasized by the research conducted by Pietricele et al ., in 2007 [24].

Choosing a favorite area for potato seed multiplication outside the closed areas, in conjunction

with the identification of the optimal timing of interruption of the growing season , taking into account the emigration of aphids flight (*Macrosiphum euphorbiae* and others), is the basic criteria of obtaining a material of potato plant healthy and free of viruses. The results presented highlight the suitability of the area for the organization of a system of breeding and seed potatoes, which is in conformity with studies made by many experts in similar growing conditions, among which the research conducted by Morar et al, in 2003 [22], on the micro-area of Huedin and by Vučetić et al . , in 2013 [31], on the micro-area of Golija, at altitudes above 1100 m.

The results shown above plead for considering favorable the Păltiniş micro-region for potato seed multiplication especially as the vector of transmission of viral infection characterized by the presence of host plants in the micro-area, high mobility, abundance and persistence in comparison to other vectors (*Myzus persicae* and *Aphis nasturtii*) show a relative inability to transmit the virus Z to the potato, according to research conducted by Singh and Boiteau, in 1986 [28].

The results argue for organizing the multiplication seed of potatoes in the high area of Păltiniş because it ensures a virus-free material based on finding the following:

In the area of Păltiniş, aphid emergence occurs due to flight and passive flight-range (transport by wind aphids) with a delay of 40-45 days than in the Sibiu Depression.

Maximum Flight aphid vectors of viruses in the Păltiniş area occurs in the first and the second decade of August, so with 10 to 20 days before the destruction of potato haulm, which prevents migration of viruses from the vine on to the tubers.

Knowing the biology of specific species of aphids in Sibiu, species with low virulence but high biological pressure and rising, contributes to more a efficient combat and leads to establishing proper interruption vegetation time of the potato for seeding.

Knowing the retro migration flight that occurs in autumn is very important because the intensity of this flight is tied with the amount of potato aphids that attack the next year.

Setting the coordinates for growth, development and multiplication of different aphid species vectors of the virus contributed to modeling, with accuracy, the holo-cycle of different species and leads to a more accurate flight time determination of their migration and breeding on the potato.

Knowing the retro migration flight, combined with tracking the aphid colonies on primary hosts, allows establishing a forecasting and warning system to combat aphids.

All of these highlight the potetial of the Păltiniş micro-area for the production and breeding of seeding material of potato, free of viruses and so on to other mountain areas of Romania, which leeds to a higher procentage of renewal of seeding material, to a increase in the medium production obtained and an increase in revenues for farmers.

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