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MONITORING THE DYNAMICS AND ABUNDANCE OF APHID SPECIES - VECTORS OF POTATO VIRUSES

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Abstract

The very early emergence of the vectors of potato virus poses a very serious risk to the phytosanitary quality of potatoes and for that their monitoring is very important in anticipating their maximum flight. To monitor the flight dynamics of aphid species with vector capacity in seed potato crops, in 2020-2022 at Brasov, 3 yellow water traps placed at different distances from the potato field edge and a 12.2 m high suction trap were used to capture flying aphids. 22 vector aphid species were selected from the catches of the two types of traps; their flight was analyzed in relation to the climatic data from the years of monitoring. Some of the dominant and eudominant virotic vectors (Aphis fabae, Brachycaudus helichrysi, Rhopalosiphum padi, Myzus persicae, Hyalopterus pruni, Aphis sambuci, Phorodon humuli, Aphis craccivora) started their activity, from the first decade of May and their maximum flight was different from one species to another and from one climatic year to another. The suction trap was an efficient tool in capturing vector aphids, in order to monitor their flight.

***Key words**: aphids, monitoring, potato, virus vectors.*

INTRODUCTION

There are a number of significant threats to the successful growing of the seed potato crop and one of the most important is the potential for the transmission of viruses by aphids (Northing, 2009; Sridhar et al., 2022; Slimani and Fekkoun, 2021). Aphids constitute a very important group of pests whose presence limits the productivity of potato crops and causes serious damage to plants both directly by feeding (Xu and Gray, 2020) and indirectly as vectors of viruses. The most significant damage is caused indirectly by plant pathogenic viruses transmitted by aphids (Ait Amar and Benoufella-Kitous, 2020). For example, potato virus Y (PVY) is transmitted in a non-persistent manner by 65 species of aphids (Pitt et al., 2022). One of the most widespread and damaging species is *Myzus persicae* (Sulzer) (Hemming et al., 2022). With enough efficient vectors, significant PVY spred could occur even when initial virus inoculum was low (Galimberti et al., 2020)

A healthy seed potato production depends on the number of aphid species - potential plant virus vectors, the abundance of each species, as well as the moment when aphids fly into the field and the dynamics of each species' flight (Vučetic et al., 2013).

Seed potato crops require effective aphid control to minimise the risk of virus infection. As integrated crop protection system aimed at producing virus-free seed potatoes place strong emphasis on control of the aphid vectors at all the stages of seed growing (Sukhoruchenko et al., 2019). Regular aphid monitoring data enable growers strategically to target location and timing of control measures, to optimise the timing of planting, haulm destruction and harvest (Krijgeret and van der Waals, 2020).

Over time, different techniques have been used to monitor aphid populations, with the aim of understanding the relationships between the structure, dynamics of aphid populations and the spread of viruses in agricultural crops. There are two main methods for monitoring aphid flights: the suction trap for indication of aphid flights on a regional scale and yellow water traps as field traps for indication of aphid flights on a local scale. Suction traps give a stable, long-term, area wide sample of the population of aphids in an area and yellow water traps provide localised and more recent information on which aphids are flying close to seed potato crops.

Data from a suction-trap network, combined with the equivalent run of weather data available, makes it possible to establish the timing of the start of aphid flights and aphid abundance in spring and early summer. (Rothamsted Insect Survey) https://insectsurvey.com/aphid-forecast. There are approximately 4400 species of aphids in the world, distributed mainly in the northern hemisphere (Heie, 1994) and the key factor underlying this distribution is temperature. Aphids are adapted to regions with cold winters, surviving the winter as eggs (Strathdee et. al., 1995). The number of winged individuals and their ability to fly depends on the temperatures. The optimum temperature for aphid development is between 20 and 25ºC (Harrington et al., 1995), the flight of aphids taking place at temperatures between 13 and 31ºC (Irwin et al., 2007).

The aim of these studies was to determine the biodiversity of aphids, the similarity in aphid composition and differences in vectors flight dinamics between two methods of capturing. Also, the aim of these studies was to establish the relationship between climate conditions and the vectors aphids flight dynamic.

MATERIALS AND METHODS

Transmission of many potato viruses (field to field) is mainly attributed to the activity of winged aphids. They are also largely responsible for virus transmission within a crop from plant to plant (de Bokx, 1972). For many years, the aphid populations monitoring in potato crops in our country has been done through a network of yellow water traps (Moericke traps) placed directly in the potato crops to capture winged aphids and in recent years also with the help of a high-performance suction trap. This monitoring provides data on the structure, abundance and flight activity of aphid populations. The suction trap is an ideal tool for assessing changes in insect communities at a large geographical scale and, by implication, the effects of climate on aphid population activity, distribution and diversity.

To assess the flight dynamics and aphid species diversity and their abundance on the potato field in 2020, 2021 and 2022 at Brasov 3 Möericke yellow water traps placed at different distances from the potato field edge: 20 m, 50 m, 80 m installed directly in the field when the potato plants emerging and a 12.2 m high suction trap were used to capture flying aphids. Daily captured aphids were collected starting from May until September; then, the catches were sorted, counted and aphid species were identified using a stereoscopic microscope and winged aphid identification keys (Blackman and Eastop., 2000; Basky, 1993).

For identification were used morphological characteristics such as length, colour and shape of the body, antennae, scelerites on abdominal tergites, siphunculi, cauda, size and shape of the brush or setae, shape of the wing veins.

Aphid species with potential to transmit potato viruses were selected from the catches obtained using the suction trap (ST) and 3 yellow water traps (YWT). The abundance of these species, flight dynamics and relative dominance during the three years of monitoring were analyzed.

Their flight was analyzed in relation to the climatic data from the years of monitoring.

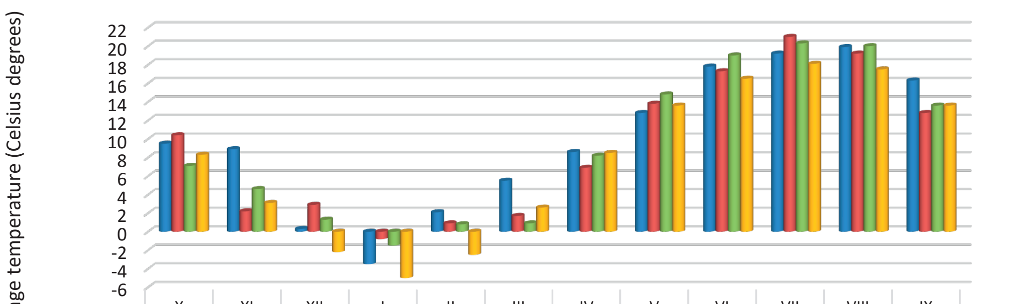
According to Bodenhaimer (1955) and Balog (1958) cited by Varvara et al. in 1989, abundance represents the number of individuals of a species captured in a time interval and relative dominance represents the ratio of a species to the number of individuals of all captured species. Species dominance is divided into 5 classes:

- >10% are eudominant species;
- 5.1-10% are dominant species;
- 2.1-5% are subdominant species;
- 1.1-2% are receding species;
- 0-1% are subreceding species.

The dynamics of eudominant and dominant species were analyzed by comparing the two types of traps and the three years of monitoring.

Climatic data regarding average temperatures recorded in the monitoring years for the Brasov area were compared with the multi-year average recorded for this area (Figure 1).

The total abundance and dynamics of vector aphid species captured with the suction trap and yellow water traps were analized in relationship with average decadal temperatures during the vegetation period (may-september) (Figures 2, 3, 4).



	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX
2019-2020	9,5	8,9	0,3	-3,5	2,1	5,5	8,6	12,8	17,8	19,2	19,9	16,3
2020-2021	10,4	2,2	2,9	-0,8	0,9	1,7	6,9	13,8	17,3	21	19,2	12,8
2021-2022	7,1	4,6	1,3	-1,5	0,8	0,9	8,2	14,8	19	20,3	20	13,6
MYA	8,3	3,1	-2,2	-5	-2,5	2,6	8,5	13,6	16,5	18,1	17,5	13,6

Figure 1. Evolution of average monthly temperatures 2019-2022 compared to multiannual average (MAA) - Brasov

RESULTS AND DISCUSSIONS

Since temperature plays a decisive role in the initiation of winged aphids flight, the thermal flight threshold for most aphid species being 15°C, the flight of aphids during the three years of monitoring was analyzed according to the recorded climatic conditions.

In the three experimental agricultural years 2019-2020, 2020-2021, 2021-2022 the thermal regime indicates three years with average annual temperatures higher than the multiannual average (MAA) of 7.7°C. The highest temperatures during the vegetation period (April-September) were recorded in the 2021-2022 agricultural year when the average temperature during the vegetation period (16°C) exceeded the MAA value for this period by 1.4°C. And in the winter period (October-March) the same increase in average temperatures is observed compared to MAA, the agricultural year with the highest temperatures in this period being 2019-2020, exceeding the multiannual value by 3.8°C.

The evolution of average monthly temperatures 2019-2022 compared to MAA - Brasov (Figure 1) shows an increase in the average temperatures of the winter months December, January and February with a maximum difference from MYA in December 2020 of 5.1°C, in January 2021 of 4.2°C and in February 2020 of 4.6°C.

Using the suction trap information researchers at Rothamsted have shown strong relationships between winter temperature and the time that *Myzus persicae* (Sulzer) are first caught in traps and their abundance. Relationships for other species are less strong. Compared to 50 years ago, many aphids are flying a month or more earlier.

In the three years of monitoring, the flight of aphids started in the first decade of May, with a much lower intensity in 2021 compared to 2020 and 2022.

Although the temperatures in the winter months in 2021 were higher compared to MAA and compared to the other monitoring years, the maximum flight of vector aphid species (Figures 3, 4) captured in ST was recorded in the second decade of July and in YWT in the third decade of June as a probable consequence of rising temperatures in June and July. High temperature was identified as environmental factors that were positively associated with aphid abundance (Cocu et al., 2005). In May 2020, the average air temperature had large fluctuations from one decade to another, which led to an interruption in the flight of aphids in the third decade of the month, highlighted by the captures in ST. With the increase in temperatures in the first decade of June, they intensified their flight reaching the maximum.

In 2022, the air temperature had an evolution without large fluctuations; compared to 2020 and 2021 in the third decade of May the highest average temperature was recorded, 16.3°C, which led to a maximum flight of vector aphids uring this period recorded in both ST and YWT.

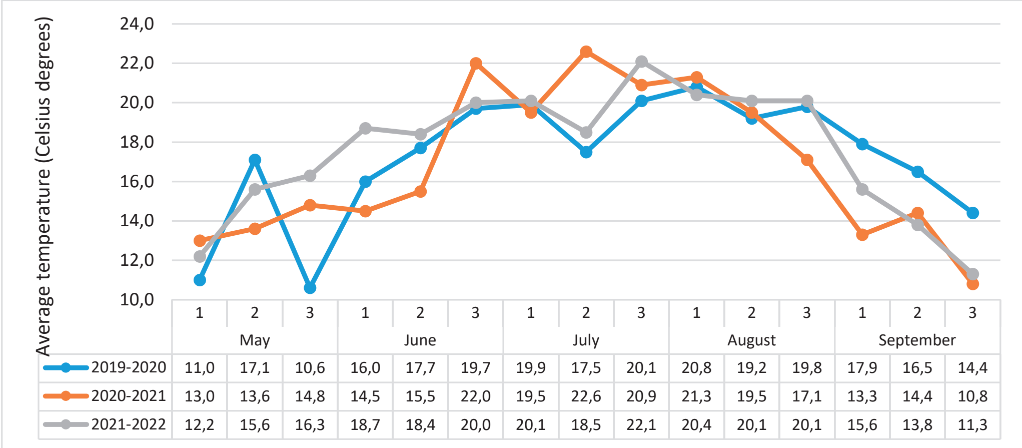


Figure 2. Average decadal temperatures during the vegetation period (may-september)

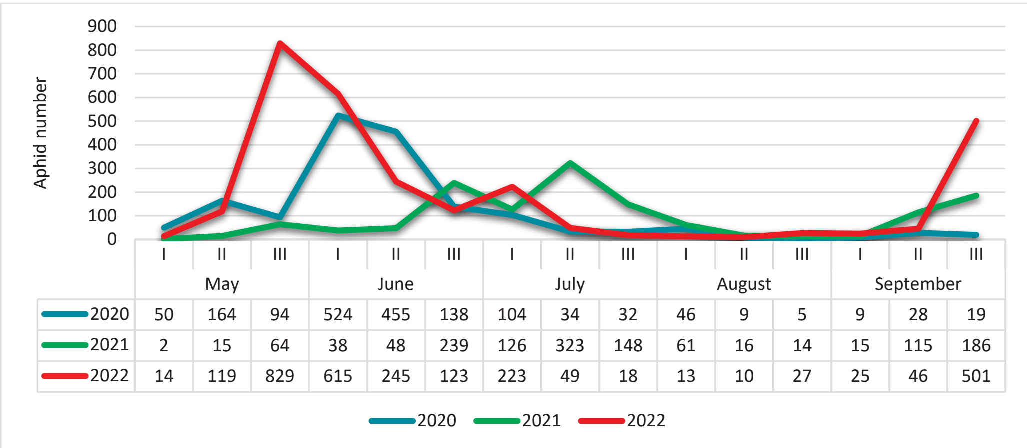


Figure 3. Total abundance and dynamics of vector aphid species captured with suction trap

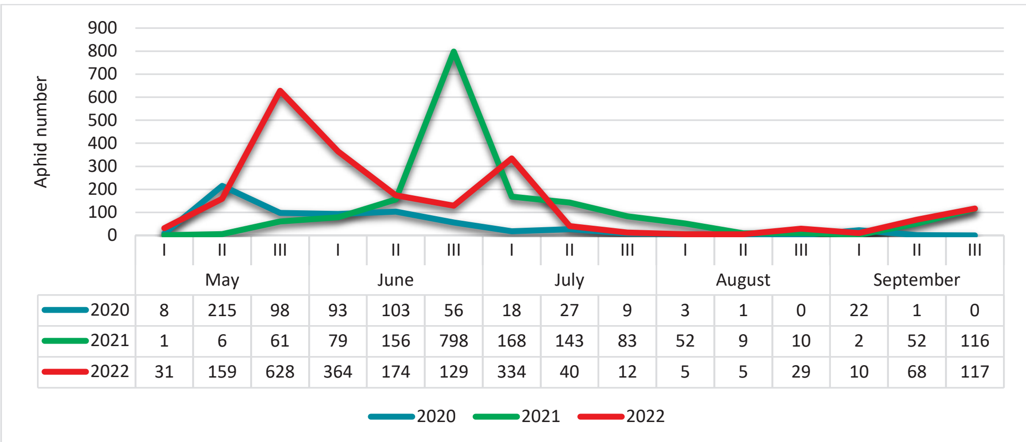


Figure 4. Total abundance and dynamics of vector aphid species captured with yellow water traps

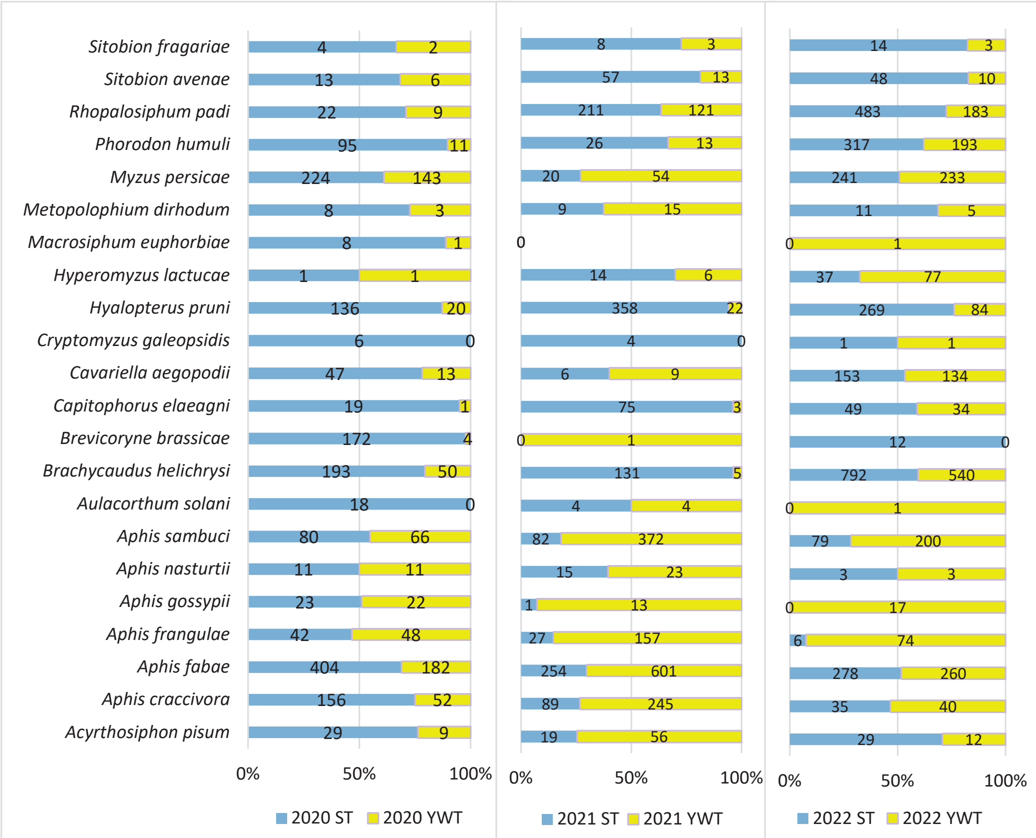


Figure 5. The abundance of vector aphid species collected in 2020, 2021, 2022 with suction trap (ST) and yellow water traps (YWT)

The abundance of vector species captured in 2020, 2021 and 2022 with two types of traps, suction traps and 3 yellow water traps, is shown in Figure 5.

Using ST in 2020, 1711 individuals from 22 species of vector aphids were captured, and with the help of YWT a smaller number of individuals, 654, from 20 vector species were captured. In 2021, YWT vessels proved to be more effective in capturing vector aphids, totaling a number of 1736 individuals from 20 species, and in ST 1410 individuals from 20 species were collected.

The ST catches totaled a higher number of individuals (2857) compared to YWT (2105), but belonging to a reduced number of species (19) compared to 21 in YWT.

The relative dominance of aphid vector species for the three years of monitoring using two types of traps, ST and YWT, is shown in Figure 6. The colonizing species, vectors of PLRV, *Macrosiphum euphorbiae* (Thomas), *Aulacorthum solani* (Kltb.) and *Aphis nasturtii* (Kaltenbach) were slightly abundant in the two types of traps, but other non-colonizing species became very abundant and dangerous to the potato seed phytosanitary quality: *Aphis fabae* (Scopoli) (2020, 2021, 2022), *Brachycaudus helichrysi* (Kltb.) (2022), *Rhopalosiphum padi* (Linnaeus) (2021, 2022), even though they are less efficient vectors than potato-colonizing species *Myzus persicae* (Sulzer), whose activity decreased greatly in 2021.

Sometimes a less efficient vector can be more important in spreading a virus if its abundance is

greater than that of more efficient but less represented vectors.

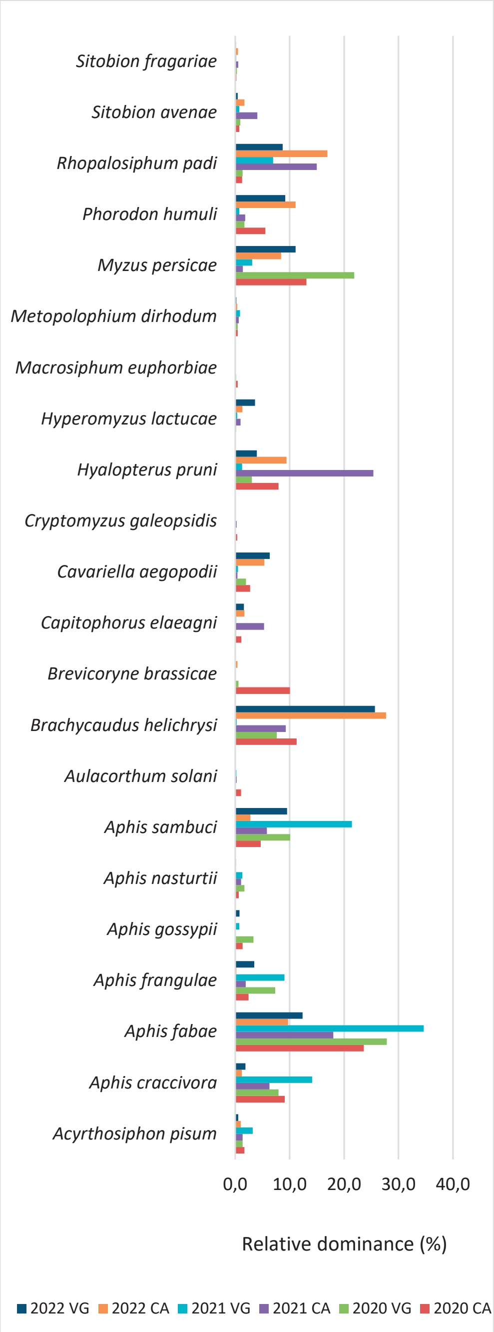


Figure 6. The relative dominance of aphid vector species in 2020, 2021, 2022 captured with ST and YWT

Analyzing the dynamics of eudominant and dominant species captured with ST and YWT, differences were observed between the data obtained in the three years of monitoring and the two types of TRAPS (Figure 7).

In 2020, among the vector species captured with ST, four were eudominant, the most abundant being *Aphis fabae* (Scopoli), important vector of potato leafroll virus (PLRV), with a maximum flight recorded in the first decade of June (124 aphids). The next species in order of their abundance were *Myzus persicae* (Sulzer), the most efficient vector of PLRV and PVY, *Brachycaudus helichrysi* (Kltb.), important PVY vector as well and *Brevicoryne brassicae* (Linnaeus). In YWT the catches recorded the highest abundance for *Aphis fabae* (Scopoli) followed by *Myzus persicae* (Sulzer) with a maximum flight recorded in the second decade of May (81 aphids). ST recorded the maximum flight of the species *Myzus persicae* (Sulzer) much later, in the second decade of June.

In 2021, in ST, the highest abundance was recorded by *Hyalopterus pruni* (Geoffroy) with a maximum flight in the second decade of July (141 aphids), followed by *Aphis fabae* (Scopoli) and *Rhopalosiphum padi* (Linnaeus). Among the species captured in the YWT the highest abundance recorded *Aphis fabae* (Scopoli), with a maximum flight in the third decade of June (287 aphids), followed by *Aphis sambuci* (Linnaeus) and *Aphis craccivora* (Koch). In 2021 YWT were more effective than ST in capturing vector aphids in terms of their abundance and virus transmission efficiency.

In 2022, in both types of TRAPS, the species with the highest abundance was *Brachycaudus helichrysi* (Kltb.) with a maximum flight recorded in the third decade of May (451 aphids in ST and 347 aphids in YWT). Flight dynamics for *Myzus persicae* (Sulzer) were recorded differently in the two traps, the maximum flight was recorded in ST in the first decade of June, and in YWT in the first decade of July.

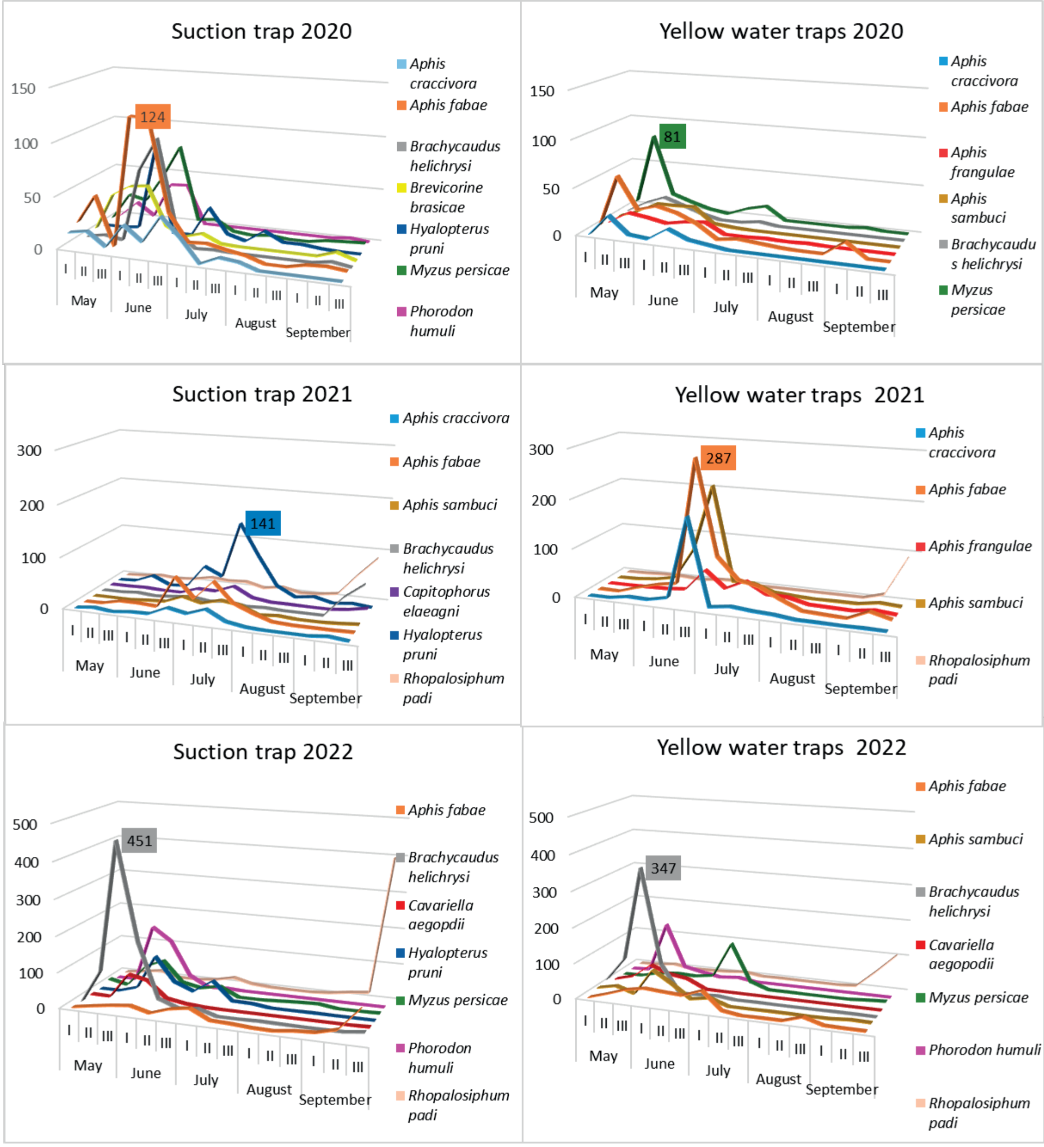


Figure 7. Dynamics of eudominant and dominant vector aphid species collected with suction trap (ST) and yellow water traps (YWT)

CONCLUSIONS

The high temperatures of the winter period allowed the survival of aphid species on plants, in closed spaces (sunrooms, greenhouses, warehouses) and their slow multiplication. The flight in May, the first month of potato vegetation, was particularly intense in 2020 and 2022. Some species (*Brachycaudus helichrysi*, *Myzus persicae*, *Aphis fabae*) were very active and abundant during the first stages of seed potato vegetation, others appeared at the end (*Rhopalosiphum padi*) but with a reduced virotic impact because the potato crops have finished their growing season. This early flight for many species had viral implications for the phytosanitary quality of the seed potato.

Aphids reaction to the climate change are of particular ecological importance, due to their role in natural and agricultural ecosystem.

The increasingly climate changes require seed potato producers to observe even more strictly the technological sequences established for this crop. The early appearance and high abundance of potential virus vector species require the earliest possible planting of potato and the lowest possible levels of viral infection of the seed potato.

Collection and interpretation of data regarding the diversity, abundance and development of potential vector species and estimates of risk periods contribute to the development and application of effective strategies in the aphids control.

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