APHID SURVEILLANCE IN POTATO FIELDS: IMPLICATIONS FOR VIRUS MANAGEMENT AND TUBER QUALITY

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Abstract

Aphids are the most common and effective carriers of plant viruses. The transmission of potato viruses is primarily linked to the activity of winged aphids. This study monitored migratory aphids in a seed potato field during 2020 and 2021, utilizing yellow water pan traps placed at varying distances from the field edge (20, 50, and 80 meters) to gather spatial and temporal data on the activity of winged aphids within the seed potato field. Throughout the monitoring period, 922 aphids from 65 species were identified in 2020, while 2,508 aphids from 84 species were recorded in 2021. In both years, the highest number of aphids was collected from the trap positioned at the edge of the potato crop at 20 meters. Regarding the total abundance of vector aphid populations and species, in 2021 higher values were recorded than in 2020: 1227 vector aphids from 20 species in 2021 compared with 528 vector aphids from 17 species. In comparison to 2020, the level of virus infection in the tested material was highest in 2021 across all varieties, with the most significant increases noted for the PVM and PVY viruses. Aphids play a significant role as viral vectors in potatoes, impacting tuber quality by transmitting several damaging viruses, most notably the potato virus Y (PVY) and potato leafroll virus (PLRV). These viruses, can lead to a range of quality issues in the tubers, such asstarch and dry matter content.

Key words*:*aphids, potato viruses, potato quality

INTRODUCTION

Potato (*Solanum tuberosum* L.) as a source of food and raw material for processing occupies a key place on the scale of important foods for the world's population food (Soare et Chiurciu, 2021). It propagates vegetatively and therefore seed tubers will be as healthy as their parent plant. For seed potatoes, from more than 50 different viruses infecting potato (Kolychikhina, et al., 2021), the most important are Potato Leafroll Virus (PLRV) and Potato Virus Y (PVY) (Kruger and Van der Waals, 2020). According to the research of da Silva et. al., 2020, virus populations transmitted by aphids were the least diverse while the ones transmitted vertically through tubers were the most diverse. PVY is transmitted to virus-free potato plants by aphids and passed on to the next vegetative generations through tubers (Samarskaya et al., 2023). Use of certified healthy seed tubers, plays a big role in preventing virus spread from seed tuber, which would then be transmitted by aphids from infected plants to other healthy plants (Hegde et al., 2021).

Aphids transmit viruses and this property has generated much research on aphid population dynamics and its role in viral epidemiology (Kennedy, 1962; Brault, 2010). The vector aphid dynamics and density play a crucial role that determines the PVY and PLRV incidence in the field (Jandrajupalli Sridhar et al., 2022). The two most damaging viruses in terms of economic loss, PVY and PLRV, are transmitted by aphid vectors in non-persistent and persistent modes respectively (Sigvald, 1984; Harrington et al., 1986, Basky, 2002). The vector-virus control is one of the main components for controlling the PVY (Bhoi et. al., 2022). Viral diseases contribute to a reduction in the

amount of food and income of farmers. Damage and economic losses are primarily due to reduced plant development leading to reduced production or even destruction. Yield losses depends among others, on the abundance and structure of aphid populations, potato variety andvirus infection rate (Cojocaru, 1987).The role of aphids as viral vectors in potato crops has a substantial impact on tuber quality, affecting their physical characteristics, chemical composition, and suitability for processing.

Transmission of 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 et al, 1987). There are approximately 4700-5000 aphid species in the world. The most important species of aphids are found in agricultural crops. Aphid is one of the most destructive insect pests on cultivated plants in temperate regions (Xu et Gray, 2020).

Various types of trap nets have been used, either continuously or periodically, to monitor and predict aphid flight dynamics. The yellow water traps used for aphid flight monitoring proved useful for establishing the aphid flight curves. Yellow traps provide valuable data on aphid activity within crop fields. The data on aphids catches help to determine the population density at the vegetation level of a given crop or to assess its aphid infestation, useful information for the application of the necessary measures to reduce the spread of viruses caused by vector aphids.

MATERIALS AND METHODS

This study was carried out with the aim of determining the abundance and flight dynamics of populations and species of winged aphids in the seed potato crop at different distances from the field edge, establishing the percentage of vector aphids from the total aphids captured and the percentage of virus infection identified in six Romanian potato varieties tested in 2020 and 2021.

To determine the population density at the vegetation level of given seed potato field and to assess its aphid infestation, to understand the relationships between aphid population structure, dynamics and virus spread in seed potato field, from May to September (in 2020 and 2021) has been used yellow water pan traps (Möericke traps) placed in the seed potato field to monitor winged aphid populations from the vegetation level. The GPS coordinates for the field where the traps were placed were for 2020: 45.67171o, 25.53596o; 45.67319o, 25.53837o; 45.67436o, 25.5368o; 45.67356o, 25.53346o and for 2021: 45.671713o, 25.535992o; 45.673173o, 25.53838o; 45.671927o, 25.539938o; 45.67040o, 25.533713o. Yellow pan traps are used for aphid flight monitoring (Moericke, 1951) to investigate the diversity of aphidofauna and the incidence of vector aphids responsible for virus transmission in potato crop. This technique has been used to capture the migrating aphids. Aphids are strongly attracted to reflected light in the range between 500 and 700 nm (Moericke, 1969, cited by Zimmerman-Gries, 1979).

Major PVY vectors are atracted by yellow color: *M. persicae, Acyrtosiphum pisum, Aphis nasturtii, Phorodon humuli and Brachycaudus helichrysi* (Milošević et al., 2014). This type of trap consists in a round or rectangular yellow pot (with water and added detergent) and are effective for catching aphids in flight.

Three yellow water traps were placed in the seed potato field at the vegetation level at different distances from the field edge. The field where the yellow pan traps were placed was 250 meters long and 240 meters wide in 2020 and 250 m long and 160 meters wide in 2021. The traps were placed at half-width, at 20 m, 50 m and 80 m from the edge of the field. Each yellow water trap was numbered: V1 (20 m); V2 (50 m) and V3 (80 m) depending on the distance from the edge of the field. In this way, the influence of the distance from the edge of the field on the structure, abundance and dynamics of aphid populations can be determined.

The traps filled with water and liquid detergent were placed at ground level in the field immediately after potato sprouting and during the vegetation period they were

gradually raised and maintained at the level of the tops of the potato plants to be visible to the aphids.

Daily captured aphids were collected, sorted, counted and aphid species were identified using winged aphid identification keys, following the aphids morphological characters (Blackman et al., 2000; Jacky and Bou-chery, 1982; Nieta-Nafria et al., 1999; Autrique and Ntahimpera, 1994; Basky, 1993).

Of the total varieties grown no randomised in the two years (2020, 2021) in the field where the aphids were monitored, a number of six Romanian varieties, positioned in the central area of the field, were tested for viral infection (Asinaria, Cosiana, Castrum, Sarmis, Christian, Brașovia). Potato varieties were grown in the same proportion, four rows of 250 meters long, no randomised, with all samples taken from the edge of the experimental field.

The Clark and Adams protocol (1977) was used to do the analysis, using polyclonal antibodies and conjugates from Bioreba (Switzerland) specific for each virus (antisera used: PLRV art no 110611 lot no 260575, PVA art no 112111 lot no 220533, PVY art no 112511 lot no 200684, PVM art no 110211 lot no 270548 and conjugate used: PLRV art no 110621, PVA art no 112121 lot no 230533, PVY art no 112521 lot no 210684, PVM art no 110221 lot no 280548. Positive controls from Bioreba (Switzerland) were used to identify each virus type (PLRV art no 110653 lot no 241660, PVA art nr 112153 lot no161939, PVY Art no 112553 lot no 151840, PVM art nr 110253 lot no 081491). Potato leaf samples were used for determine the percentage of virus infection. The absorbance values were estimated at 405 nm (A405) using a Tecan SunRise reader (software Magellan). The material was tested for four viruses (Potato Virus Y - PVY, Potato Leaf Roll Virus - PLRV, Potato Virus M - PVM and Potato Virus A - PVA) that are transmissible by aphids.

The tubers starch contentofthe potato varietiestested for virotic infections was determined using the Polikait balance and the dry matter content using the oven drying method.

RESULTS AND DISCUSSIONS

During monitoring period (May – September) were collected and identified from potato field a total of 922 aphids from 65 species in 2020 and 2058 aphids from 84 species in 2021 (Figure 1).

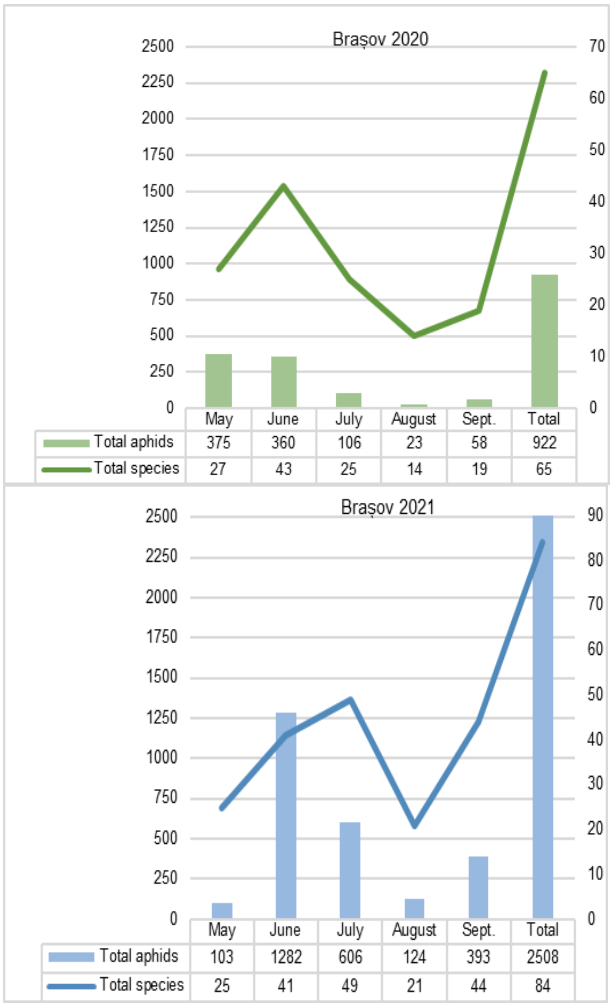

Figure 1.Monthly abundance of aphid populations and species - Brasov 2020 and 2021

In 2020, the number of aphids collected in May and June was approximately equal, representing a percentage of 79.72% of the total catches; in June of the total aphids collected in 2020, the largest number of species was identified – 43 (66.15% from total species). Aphids number decreased in August and September at 23 and 58 aphids respectively.

In 2021, compared to 2020, a larger number of aphids (2508) from a larger number of species (84) were captured. Unlike 2020, in this year the largest aphid catches were

recorded in June and July representing a percentage of 75.28% of the total catches. The largest number of identified species was established in July – 49 (58.33% from total species).

Analysis of the effect of the distance of yellow water pan traps from the potato field edge on the aphids abundance (Figure 2) revealed that in 2020, in May, the most abundant were the catches of V1 trap (20 m - 145 specimens) and V2 (50 m - 131 specimens); June V2-128 specimens; V3-122 specimens.

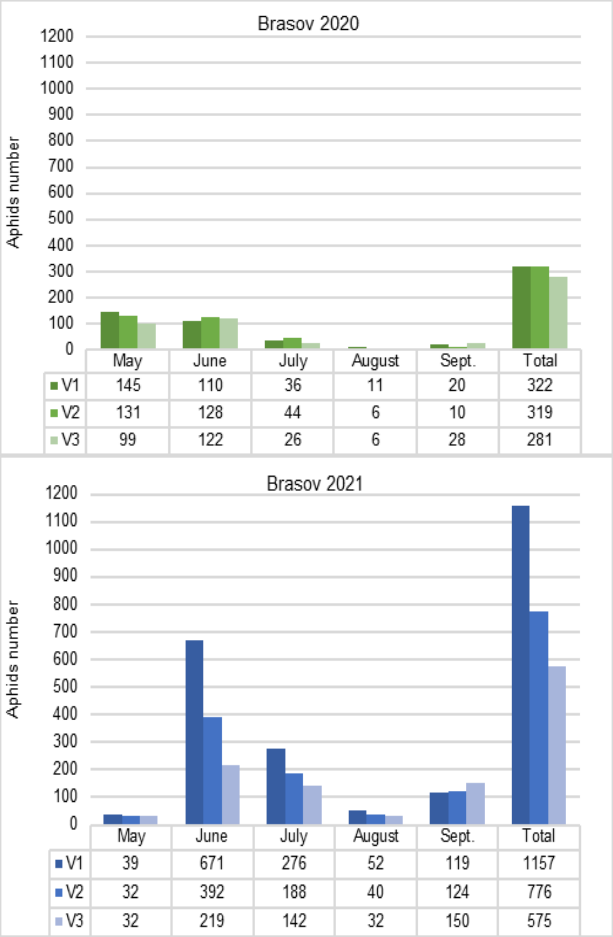

Figure 2. Monthly abundance of aphid populations in the three yellow water pan traps - Brasov 2020 and 2021

In July, August and September catches from all traps were greatly reduced in 2020. In 2021, at the beginning of the potato growing season (May), the presence of aphids in the seed potato field was low, this month (May) recording the lowest number of winged aphids in all three yellow water pan traps.

The highest number of aphids was captured in June, followed by July. In June and July the largest catches (671 and 276 specimens) were recorded 20 meters from the edge of the field (V1).

Analyzing the total aphids collected, in both years, it was observed that in the trap located at the edge of the potato crop at 20 m (V1) the largest number of aphids were collected and the lowest number of aphids was collected at 80 meters from the edge (V3) of the seed potato field, a trend found every month in 2021 except September. We specify that the months of May, June, July, August were vegetation months, and the aphids monitoring in the field in September was done after dehulming. It is observed that in September, in the absence of vegetation, the trend of the vegetation months is no longer maintained, namely with the decrease of aphid catches from the edge of the potato field to its center, from V1 to V3. The number of aphids collected in September in 2021 was higher compared to 2020.

From the analysis of monthly dynamics of the vector species collected using the yellow water pan traps (Figure 3), it is evident that in 2020 vector species appears with a high abundance (275 aphids from 12 species) in May, which could indicate that their activity started much earlier, probably from the first or second decade of April. These species had an intense, abundant and very early flight. Considering that the potato planting was done in the first decade of April, it is found that these species were present in potato field before potato sprouting and throughout the sprouting of potato plants.

It is known that in the early stages of growth, potato is very susceptible to aphid-borne virus infections.

The spread of PVY virus usually occurs in the first half of the growing season (mid-July) but the presence and intense activity of the vector species such as M. persicae (the most efficient known vector (Bahrami, 2021), Aphis fabae and Aphis. sp. certainly

contributed to the increase of PVY virus infection starting as early as June.

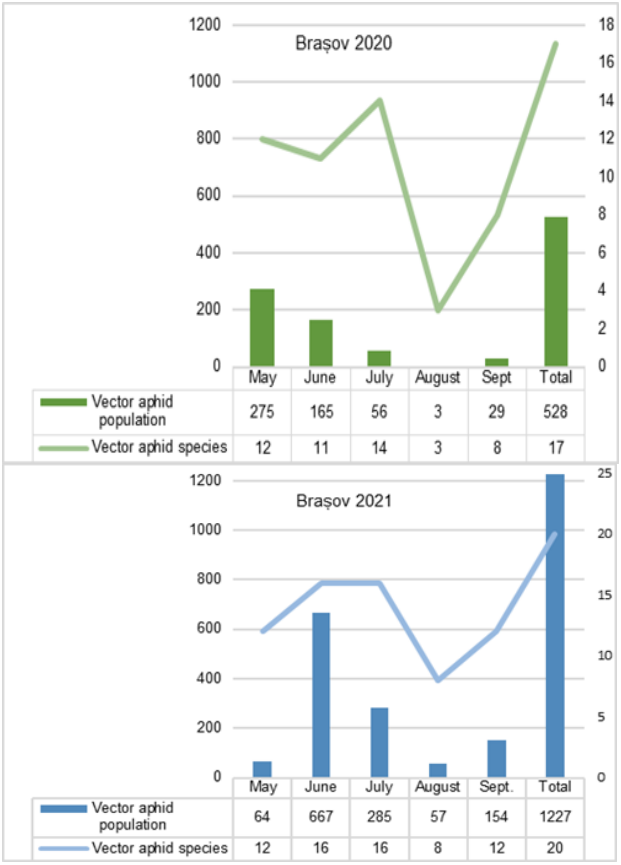

Figure 3. Monthly abundance of vector aphid populations and species – Braşov 2020 and 2021

In 2021 the highest abundance of vector aphid population and species was registered in June (667 aphids from 16 species) followed by July (285 aphids from 16 species).

Comparing the total abundance of vector aphid populations and species it can be seen that in 2021 higher values were recorded than in 2020: 1227 vector aphids from 20 species in 2021 compared with 528 vector aphids from 17 species.

After the identification of the aphid species, it was observed that in 2021, although the number of aphids and species captured was much higher than those captured in 2020, the annual percentage of vector species and populations from the total aphids was lower than in 2020 (Figures 4, 5).

Figure 6 presents the level of virus infection of the material collected in 2020 and 2021 from the field trials in Braşov.

The viruses PVM and PVA are not so harmful like PLRV or PVY, but in case of mix infections the effects on the quality of the crops are very important. This is the reason because we tested these two viruses besides PVY and PLRV.

In 2020 the lowest value (0%) of the virus infection level was observed at varieties Asinaria and Sarmis for all viruses tested. As seeing in figure 6, in 2020, the level of virus infection was 2.5% for variety Brașovia (PVM), Castrum (PVA), Cosiana (PVY) and Cristian (PLRV). Compared to year 2020, in 2021 there was a strong increase in the percentage of infection for all viruses tested and for all the varieties (Figure 7). The highest increase in infection rate of the material was observed in the case of PVM (16.52%) and PVY (8.26%).

The high level of viral infection in 2021 compared to 2020 is also due to the high abundance of aphids in the months (June and July) when the potato plants are more vulnerable to aphid attack and virus inoculation. As can be seen in Figures 1, 2 and 3 the abundance of species and populations of aphids in these months in 2021 was higher than those in 2020.

Experiments conducted suggest that in the studied varieties, the expression of PLRV, PVY, PVA, and PVM in field conditions is often latent, supporting the effectiveness of roguing infected plants; this finding aligns with results from other research (Bădărău et al, 2018).

Certification programs have long relied on low disease tolerance as a strategy to maintain low virus levels in the field. (Knutson, 1998). The challenge with this approach is that the most susceptible cultivars often dominate certification programs. As a result, the supply of seed available for replanting is limited, placing strain on the system and pressuring growers to use lower-quality seed lots for planting. (Bădărău et al, 2018).The knowledge regarding the factors that could influence the virus transmission like the rate of aphides abundance, several environmental factors (climatic conditions, virus sources, host-plants) are very important for all the potato growers.

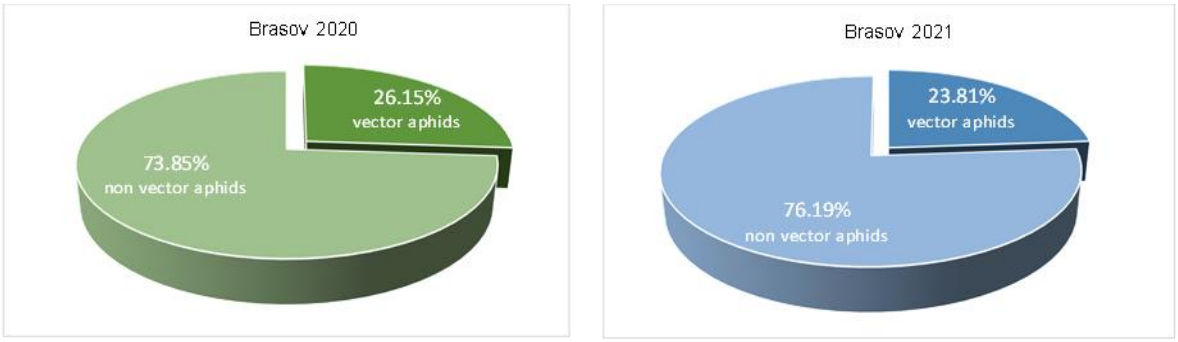

Figure 4. Annual percentage of vector and non vector aphid species – Brașov 2020 and 2021

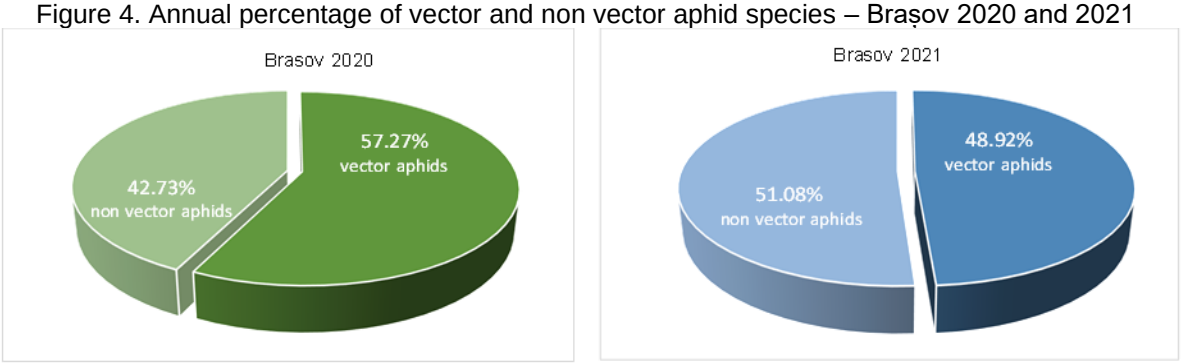

Figure 5. Annual percentage of vector and non vector aphid populations – Brașov2020 – 2021

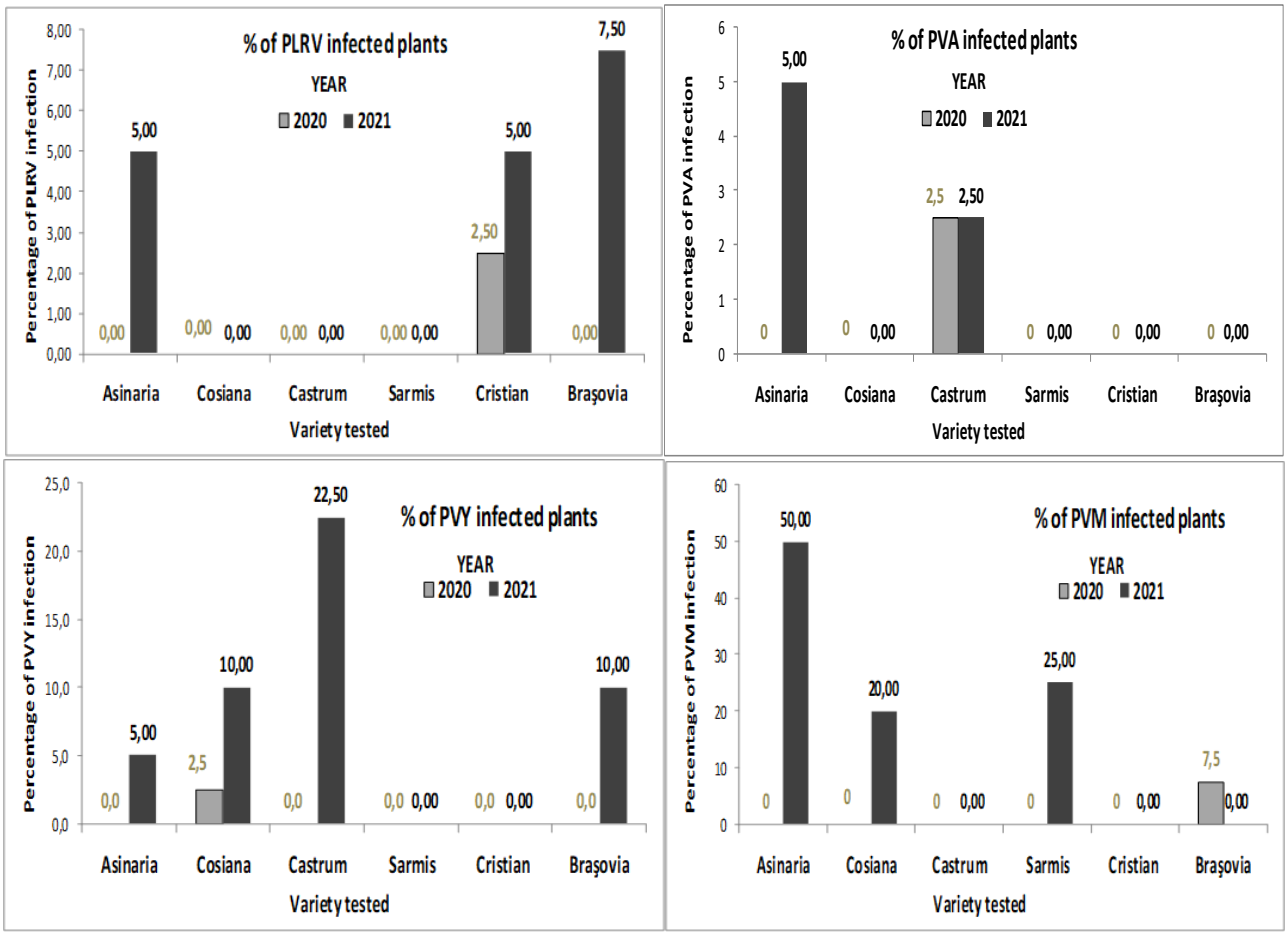

Figure 6. Percentage of virus infection identified in the samples tested in years 2020 and 2021, depending on the variety (% reported to the 40 samples for each variety)

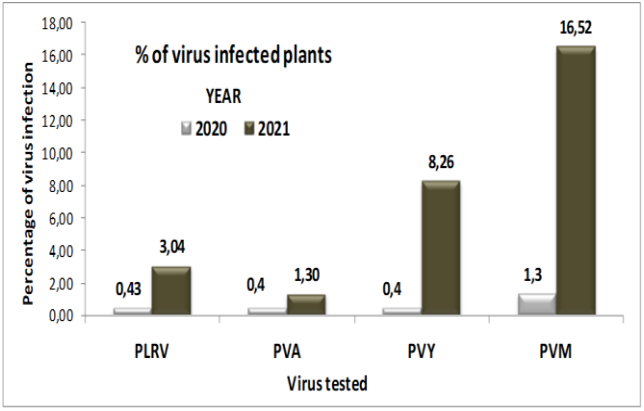

Figure 7. Percentage of virus infection (PLRV, PVA, PVY and PVM) identified in the biological material tested in years 2020 and 2021 (total % infection reported to all material tested from each variety– 240 samples / year)

Analyzing the high level of viral infection in 2021 compared to 2020 and the variation in the content of potato tubers in starch and dry matter (Figure 8), it can be seen that the high level of viral infection in 2021 also may led to a decrease in the quality of the tubers by reducing the content of starch and dry matter in 5 of the varieties tested.

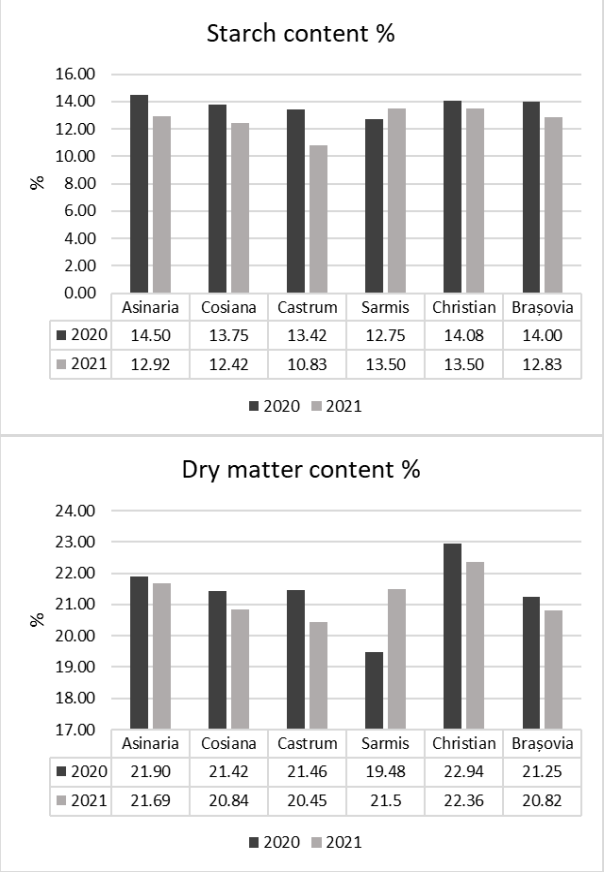

Figure 8. Percentage of starch and dry matter content determined in potato tubers from each variety in 2020 and 2021

The Sarmis variety does not fit into this trend, the percentage of viral infection in the two experimental years being equal to zero for the PLRV and PVY viruses, which studies have shown that can reduce the tuber's starch and dry matter content (Ospankulova et al., 2023; Marshall et. al, 2008). Addressing these viral infections with management practices like using certified seeds and controlling aphid populations is essential to maintaining high tuber quality.

CONCLUSIONS

The yellow water traps used for aphid flight monitoring provide important data regarding the activity of the aphids inside the crop canopys; they proved useful for establishing the abundance of aphid populations and species at the vegetation level.

In 2021, compared to 2020, a much larger number of aphids from a larger number of species were captured (1227 vector aphids from 20 species in 2021 compared to 528 vector aphids from 17 species in 2020).

In the two years of study, the month with highest abundance of vector aphid populations and species was different: in 2020 was May with 275 aphids from 12 species and in 2021 was June with 667 aphids from 16 species.

As the yellow water trap located at 20 m from the edge of the potato field collected the largest number of aphids in both monitoring years, the highest virus pressure occurring at the edges of the potato field.

The viral infection level for all tested potato varieties in 2021 was higher than 2020, especially for PVM and PVY viruses, consequence of higher species abundance and population of aphid vectors in 2021 compared to 2020.

Effective measures must be implemented to limit virus spread, particularly during the early growing season. Preventive actions and treatments targeting aphids, the viral vectors in potato crops, are essential to control the spread of potato viruses during this critical period.

Managing aphid populations and preventing viral infections through integrated pest management strategies and the use of virus-resistant potato varieties is critical to maintaining high tuber quality.

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