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Review paper

The effects of monitoring the abundance and species composition of aphids as virus vectors on seed potato production in Serbia

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SUMMARY

Aphids are the most important vectors of potato viruses during the crop's growing season. The most widespread and damaging viruses, the potato virus Y and potato leaf roll virus, are transmitted by aphids in non-persistent and persistent manner, respectively. The two viruses cause the greatest concern of potato producers and a great constraint to seed potato production in Serbia, the region and across the world. Potato virus Y is particularly harmful, given its distribution and spreading rate.

Seed potato production systems under well-managed conditions involve a series of virus control measures, including the monitoring of outbreaks of winged aphids, their abundance and species composition, in order to forecast virosis, i.e. potential plant and tuber infection periods. Monitoring the aphid vectors of potato viruses enables determination of optimum dates for haulm destruction when higher than normal numbers of winged aphids as vectors of economically harmful diseases have been observed. Haulm destruction in a potato crop reduces the risk of plant infection and virus translocation from the aboveground parts to tubers, thus keeping the proportion of infected tubers within tolerance limits allowed for certain categories of seed potatoes. This practice has positive effects if used in combination with other viral disease control measures; otherwise, it becomes ineffective.

This paper provides an integral analysis of the effects and role of monitoring outbreaks of aphids, their abundance and species composition in timing haulm growth termination to prevent plant infection, virus translocation and tuber infestation in potato crops in Serbia and the wider region.

Keywords: Potatoes; Plant viruses; Vectors; Aphids

INTRODUCTION

Cost-effective potato production involves the use of healthy planting material (seed potato). Seed potato tubers must be completely free of pathogens as disease-causing agents (*Synchytrium endobioticum, Clavibacter michiganensis* subsp. *sepedonicus, Ralstonia solanacearum,* nematodes, etc.), while tolerable levels are allowed for some viruses, depending on seed potato category (Elite, Original – Class A, First Reproduction, etc.) (Regulation: Criteria for the determination of the health status of crops, facilities, seeds, transplants and planting material /www.mpt.gov.rs/documents/list/63/index.php/).

Viruses are a limiting factor for producing high quality seed potato in the presence of widespread sources of infection, such as those existing in Serbia. Seed potato production that follows the prescribed health standards is not an easy task. Under high infection pressure, it is almost impossible to produce good quality seed potato due to a lack of adequately efficient control measures for prevention of virus infection. Only combined (integrated) measures, depending on virus infection pressure up to a certain level, can bring about positive effects, which are nevertheless often insufficient to reach the goal in compliance with prescribed standards (Milošević, 2009a).

Contrary to a widespread belief, seed potato production need not be restricted by altitude. Good quality seed potato crops are grown in low-altitude regions and even at altitudes below sea level (such as The Netherlands) where sources of virus infection are not so widespread as to prevent the use of other beneficial control measures. Limiting factors include the spread of infection sources (infected table potato) and the abundance of winged aphid vectors (Gabriel, 1988; de Bokx and van der Want, 1987). The only restriction for seed potato production comes from infection pressure by major viruses, i.e. the spread of infection sources such as table potatoes, more than 90% of which are infected in Serbia with at least one virus, notably the potato virus Y (PVY), which is typically accompanied by potato leaf roll virus (PLRV) that exhibits a low initial spread rate, potato virus S (PVS), and some other viruses hosted by potato. Since sources of infection are widespread in low-altitude regions of Serbia, altitude, in that respect, is a limiting factor for seed potato production (Jasnić et al., 2003; Milošević, 1992, 1992a, 1996a, 1998, 1999, 2009 and 2009a; Milošević and Bugarčić, 2005; Vučetić et al., 2013a).

The two most damaging viruses in terms of economic loss, PVY and PLRV, are transmitted by aphid vectors in non-persistent and persistent manner, respectively (Sigvald, 1984; Raman, 1985; Katis and Gibson, 1985; Bostan and Haliloglu, 2004; Bostan et al., 2006; Notle et al. 2009; Milošević et al. 2012). The two modes of transmission require corresponding control measures. Therefore, knowing the mode of transmission is essential in designing adequate control measures. PVY has been reported to cause the severest damage in seed potato production worldwide (Verbek et al., 2010), and is more harmful than PLRV in Europe and Serbia (de Bokx and Piron, 1990; Chrzanowska, 1991; Horvath and Wolf, 1999; Milošević, 1992 and 2009; Milošević and Petrović, 2000).

In countries with well-established phytosanitary systems, monitoring programmes for the abundance, time of outbreak and species composition of winged aphids are a part of integrated virus management systems in seed potato crops (Raman, 1985; Radcliffe et al., 2008).

Monitoring the time of outbreak, abundance and species composition of aphids is aimed at timing a potential haulm destruction, i.e. the growth termination when certain species of aphids as vectors of major viruses have increased in numbers. This practice reduces the risk of subsequent plant infection of seed potato crops. Seasonal growth is terminated by haulm destruction using chemical desiccation herbicides or mechanical methods of cutting the aboveground plant parts.

A factor limiting early growth termination is the stage of plant development, i.e. the size of tubers considered as marketable seed at the moment the decision to terminate growth is made based on elevated (critical) numbers of aphid vectors. In Serbia, this factor depends entirely on the location of seed potato production for warranting good quality seed potato, i.e. on location in highland regions with low aphid population densities. In such locations, only a short period of time is available between planting and reaching adequate economic yields for timely seed potato harvests. The interval between planting (as allowed by weather conditions) at the beginning of the growing season and timely harvest is barely sufficient for an economic yield of seed potato to be achieved. Under such conditions, growth termination is generally uneconomic. In Serbia, the cultivation of seed potato in open fields is possible only in high-altitude regions where table potato as a potential source of infection is not produced, and where a short interval is available between planting and harvest preparation with the harvest itself. Weather conditions, small plot size and other parameters do not allow potato planting to start before mid-May through July. There is therefore little time left for a barely economic yield of seed tubers to form. Moreover, growers are required to desiccate their crops within a narrow interval of time, allowing seed tubers to remain in the ground for at least two weeks after desiccation and to be harvested before winter. In those regions, seed potatoes often remain unharvested due to early frosts and snow. These are the key arguments in favour of a view that monitoring the abundance of winged aphids in those regions would not be particularly effective.

Seed potato production at low altitudes is associated with the problem of high levels of annual virus (virus Y) infections that would not be possible to control by any cultural practices, including the monitoring of aphid abundance. The infection pressure in those locations is such that a large proportion of plants become infected before tuber formation. Therefore, this practice, under the conditions that exist in Serbia, cannot bring any positive effect without an integrated regulatory approach to seed potato production issues (mandatory practices, production locations, etc.).

Aphid monitoring has a single objective – to improve seed potato production in terms of reducing the proportion of virus-infected tubers. As that segment had not been working properly in Serbia, some activities were conducted not long ago to monitor aphid flight, but without a proper analysis of the problem underlying any design of a monitoring system.

APHIDS AS VECTORS OF POTATO VIRUSES

Aphids cause damage to potatoes in two ways: as pests, feeding on plants by sucking their sap and exhausting them, and as vectors of viruses that are the causal agents of diseases (Hooker, 1986). They are far more important and damaging as vectors of potato viruses (van Hoof, 1980; Harrington et al., 1986; Piron, 1986; de Bokx, 1987; de Bokx and van der Want, 1987; Weidemann, 1988; Flanders et al. 1991; Woodford, 1992; Thomas, 1997; Stevenson, 2001; Sigvald and Hulle, 2004; King et al., 2004; Saucke and Döring, 2004; Milošević et al. 2011). Potato viruses are transmitted by winged or wingless forms of both adult aphids and larvae (Robert, 1971, cit. Peters, 1987).

Myzus persicae stands out as the most efficient vector of plant viruses, potato viruses included (Sigvald, 1984 and 1989; Peters, 1987; Cloyd and Sadof, 1998, Boukhris et al., 2011). PVY is the priority problem in seed potato production due to its high spreading rate associated with a large number of aphid vectors (Valkonen, 2007).

Using different literature sources (van Hoof, 1980; Bell, 1982; Bell, 1983; Sigvald, 1984; de Bokx and Piron, 1985) de Bokx (1987) reported that among 31 species of aphids colonising or just visiting potato, 28 are involved in PVY transmission and 11 in PLRV transmission, which explains the more rapid spread of PVY than of PLRV.

Transmission efficiency varies among aphid species. Winged and wingless aphids are vectors of PVY and other potato viruses. In transmitting PVY, aphids (both winged and wingless forms) lose their infectivity after a certain period of time, but the winged forms of some species, such as *A. nasturti,* retain infectivity longer, thus contributing to the transmission of the virus over longer distances (Kostiw, 1975, 1975a).

Different aphid species exhibit diverse levels of efficiency in transmitting PVY (Harrington and Gibson, 1989). In contrast to *M. persicae*, *R. padi* is a PVY vector with low transmission efficiency, and is reported to occur early and in high numbers (Kostiw, 1979).

Sigvald and Hulle (2004) reported 40 PVY-transmitting aphid species known today. PLRV is transmitted by potato-colonising aphids, while PVY can also be transmitted by other aphids, such as *Rhopalosiphum padi, Brachycaudus helichrysi* or *Acyrthosiphon pisum,* not hosted by potato plants (van Hoff, 1980; Edwards, 1963, cit. Sigvald, 1984; Kostiw, 1980, cit. Sigvald, 1984).

There are differences in transmission between persistent and non-persistent viruses. To acquire and transmit PLRV, it takes aphids longer to feed on infected plants, compared to PVY, whose acquisition takes a very short time (Kostiw, 1991).

Some aphid vectors of viruses inhabit the potato (*Myzus persicae*), unlike some others (*Aphis fabae*) (Nemecek et al. 1993), whereas *Brachycaudus helichrysi* does not colonise the potato but at the same time transmits PVA, PVY^{o}, PVY^{c} and PVY^{n} (de Bokx, 1987). Vučetić et al. (2013b) reported the presence of *A. fabae* on potato in Serbia.

Being vectors of the most harmful viruses in terms of economic loss, i.e. PVY and PRLV, aphids are a priority problem in seed potato production in Serbia (Milošević and Petrović, 1996; Milošević, 2008, 2009; Milošević et al., 2011; Vučetić et al., 2013a). A large number of aphid species are vectors of potato viruses, PVY in particular (de Bokx, 1987), which explains why it is the most widespread virus in Serbia and the neighbouring countries. *Myzus persicae* is also the most efficient vector of PLRV, which is widespread worldwide, causing great economic damage to potato crops (Khouadja et al., 2004).

A much larger number of aphid species act as vectors of PVY than of PLRV (de Bokx, 1987), which correlates with the spreading rates of the two viruses during the growing season (Milošević, 1992). Also, more species are vectors of PVY^N (PVY^{NTN}) than PVY^O and therefore PVY^N also dominates (Milošević, 1992a; Dolničar, 2004). As a result, the annual infection level is positively correlated with the mentioned fact (de Box and van der Want, 1987). In addition, the transmission of PVY^N is more efficient than that of PVY^O (King et al., 2004).

The fact to consider when analysing the importance of monitoring aphid abundance and species composition is that *Myzus persicae* is the most efficient vector of PVY (1.0), followed by *Acyrthosiphum pisum* (0.7), *Rhopalosiphum padi* (0.4), *Metopolodium dirhodum* (0.3), *Brachycaudus helichrysi* (0.21), *Aulocorthum solani* (0.2), *M. euphorbiae* (0.2) and *Hyperomyzus lactucae* (0.16) (King et al., 2004).

De Bokx and Piron (1990) reported that *Aphis nasturtii, A. sambuci, Brachycaudus* spp., *Cryptomyzus ribis, Myzus certus* and *M. persicae* were more efficient in transmitting PVY^N than other species.

REASONS FOR MONITORING APHID FLIGHT ACTIVITY (ABUNDANCE)

Given the fact that aphids are responsible for virus transmission during the growing season, it is logical to suggest that monitoring outbreaks in the abundance and variety of species of aphid vectors of major viruses for the purpose of terminating plant growth has an effect on the health status of tubers. When aphid vectors of economically harmful potato viruses are highly abundant, termination of seasonal growth is undertaken in order to prevent plant infestation, i.e. translocation of viruses from the infected plants into tubers. Once an aphid has acquired a virus on an infected potato plant in a surrounding crop or within the crop, depending on the mode of transmission, the aphid is able to transmit the virus and infect healthy potato plants immediately or after a certain period of time (e.g. PVY in a few seconds, or PLRV in a few hours). The virus then multiplies in the above-ground parts of the potato plant (systemic disease) and, after a while, infects its tubers (Table 1). Therefore, there is an interval between plant infestation and tuber infection. The duration of that interval varies, depending on cultivar, plant age and time of infection (Table 1). The total count of aphids and the number of aphids as vectors contribute to potato infection with PVY and PLRV (Basky, 2002).

An increase in aphid numbers increases also the risk of subsequent infection, particularly regarding aphids that are vectors of PVY and PLRV. There is a need then to terminate haulm growth, either chemically or mechanically, but only if a marketable yield of the crop has been achieved and in locations that have a very low infection pressure. As the above practice is part of an integrated virus management system in countries with well-developed seed potato production systems, an important question is what would be the effect of aphid flight monitoring on seed potato quality under high infection pressure, such as the pressure occurring in Serbia and its neighbouring region?

Monitoring the time of outbreak, abundance and species composition of aphids in seed potato crops is an efficient practice in well-managed seed potato production systems, such as the one in The Netherlands, which involve the use of adequate practices of an integrated system to prevent the spread of viruses.

Even in cases of virus transmission from the source of infection to healthy plants, there is still time, depending on plant age at the time of infection (Beemster, 1987) (Table 1), to prevent virus transmission from their vines to tubers and a consequent increase in the proportion of infected tubers. Otherwise, the increased proportion of infected tubers will not allow the crop to be certified as seed potato or will be classified as lower quality. This helps reduce financial costs, while increasing returns.

FACTORS LEADING TO A DECISION ON EARLY TERMINATION OF HAULM GROWTH

Decision on the destruction of aboveground parts of potato, i.e. early haulm growth termination, depends on several factors:

1. An increase in the abundance of winged aphids as vectors of economically deleterious viruses,
2. The time of increased abundance of aphid vectors in relation to the stage of plant development,
3. An increase in the abundance of aphid species that are vectors of the most widespread virus (PVY),
4. The stage of formation of an economic yield of potato tubers,
5. The time of virus translocation from the aboveground parts to tubers, as relating to the time of infection and plant growth stage,
6. The time interval between haulm growth termination and potato harvest, so that highland weather conditions should not prevent harvest. Quite frequently, potatoes remain unharvested in high-altitude locations in Serbia due to early frosts and snow.

Posing the main problem in seed potato production, PVY requires careful forecasting activities. The PVY forecasting method is based on several parameters:

- Monitoring of the winged forms of aphids
- PVY transmission efficiency of aphid species
- Age-related plant resistance
- The number of PVY-infected plants as sources of further infection in their environment
- Haulm destruction date, infection source elimination date, the number of oil treatments, the cultivar (Sigvald, 1990a)

A positive correlation has been observed between the abundance of winged aphid vectors and the degree of infestation of potato plants with PVY and PLRV (Basky, 2002), i.e. the abundance of *Myzus persicae* and the percent infection of plants with PLRV (Hanafi et al., 1989), and confirmed by many researchers. Furthermore, Gabriel et al. (1975) found a strong correlation between the numbers of winged forms of some aphid vectors of PVY trapped by yellow pan traps and potato infestation with the virus, while no effect of wingless aphids was detected by the 100 leaf count method on PVY tuber infection. The time of outbreak, abundance and species composition of aphids are monitored considering these findings. Therefore, early haulm destruction ensures healthy seed potato tubers (Minari et al., 1999).

The goal of aphid flight monitoring is to forecast viruses, i.e. to assess the risk of plant and tuber infection in a seed crop. Forecasting and assessment seek the following information: the number of vectors, virus transmission efficiency of vectors, source of infection – abundance, distance, aphid flight activity as related to plant development stage, age-related resistance, cultivar, use of mineral oils and haulm destruction.

Monitoring and forecasting may play an important role in preventing the transmission of potato viruses. Aphids go through their development cycles on a number of plants, rather than on a single plant. Aphids acquire viruses from infected potato plants and transmit them across fields or from one plant to another within a crop.

The spread of a virus depends on cultivar susceptibility, the abundance of infection sources, and the number of aphid vectors (de Bokx and Piron, 1990). Mature plants are less susceptible to virus infection (age-related resistance), hence their lower rates of virus translocation from foliage to tubers (Sigvald, 1985; Beemster, 1987).

VIRUS TRANSLOCATION FROM ABOVEGROUND PARTS TO TUBERS

This is important information for the monitoring activity of outbreaks, abundance and species composition of aphids to be meaningful and effective in terms of haulm destruction, health status and high-quality seed potato production.

An aphid abundance and species monitoring system and, accordingly, haulm growth termination require the knowledge of additional important factors that affect the rate of virus translocation from leaves to tubers. Naturally, after plant infestation, it takes some time for virus translocation to occur from the aboveground parts to tubers. Translocation time depends on plant age at the time of inoculation, the length of time between inoculation and destruction of the haulm and inoculated parts of the plant (apex, middle, base), potato cultivar, etc. Regardless of plant age at the time of infection, there is an interval between infection and virus translocation to the tuber (Table 1). When managing the health status of seed potato, information on the critical time of virus translocation to tubers after infection is of key importance. The risk of infection is assessed based on the abundance of winged aphids and numbers of aphid species as vectors of certain viruses, and on the time of outbreak of a critical number of aphids as relating to the development stage of potato.

Research has shown that arid conditions – compared to optimum moisture under identical other conditions – lead to a significant increase in the percentage of PVY-infected tubers in relation to infected plants (Wislocka, 1982).

Table 1. Percentages of PVY-infected tubers depending on the time of infection (Gibson, 1991)

Time of inoculation	Average 1987/1988 data for cultivars King Edward, Record, Maris Piper and Desiree	
	with PVY^O	with PVY^N
1 week after emergence	52	25
2 weeks after emergence	45	42
3 weeks after emergence	44	30
4 weeks after emergence	35	17
5 weeks after emergence	20	12
6 weeks after emergence	7	3
7 weeks after emergence	2	0
Noninoculated	0	0

METHODS OF MONITORING OUTBREAKS, ABUNDANCE AND SPECIES COMPOSITION OF APHIDS

Aphids are strongly attracted to the colour that reflects light within the spectrum range of 500-700 nm (Moeriche, 1969, cit. Zimmerman-Gries, 1979). Accordingly, yellow pan traps are used for aphid flight monitoring (Moeriche, 1955). Aphid abundance and species monitoring is conducted using the suction trap (SP) system and yellow pan traps (YPT) (Turl, 1984; Kostiw, 1999; Stufenks et al., 2000; Basky, 2003; King et al., 2004; Kirchner et al. 2009; Vučetić et al., 2011, 2013a and 2013b). Maximum aphid flight activities and dominant species are determined. The identification of their critical number and the virus transmission efficiency of aphid species help to decide when to terminate haulm growth (Kirchner et al. 2009).

Yellow pan traps are more attractive to some aphids than others (Moeriche, 1955). The most efficient vector, the green peach aphid, *M. persicae*, is attracted to yellow. Catches of PVY vectors are higher in yellow pan traps than in suction traps due to the yellow color attraction of major PVY vectors: *Acyrtosiphum pisum, Aphis nasturtii, Phorodon humuli* and *Brachycaudus helichrysi*. A strong positive correlation has been observed among aphid numbers, PVY vector numbers in yellow pan traps and tuber infestation (Basky, 2003). Aphid numbers and potato infection with PVY are positively correlated (van Harten, 1983; Sigvald, 1990; Basky, 2006).

MONITORING APHID FLIGHT ACTIVITY IN SEED POTATO CROPS IN SERBIA – EFFECTS AND PROSPECTS

As already mentioned, seed potato production in Serbia and neighbouring countries is possible only in areas with low infection pressure, i.e. in high-altitude regions where table potato as a source of infection is not produced (Milošević, 1992a, 1996a; Zindović, 2011).

What effect does aphid flight monitoring have on seed potato production in Serbia? The fact to bear in mind is that relating legal regulations do not specify the requirement for seed potato production to be located solely in areas with low infection pressure. Unfortunately, the regulations lack this foremost requirement that would also involve the use and the effects of other measures. Given that seed potato production is allowed in some locations under high infection pressure in the municipalities of Lučani, Požega, Gornji Milanovac, Čačak, Arilje and Ivanjica, this paper will further analyse the effects of aphid monitoring under those local conditions on potato virus management. Massive infections of seed potato crops there occur at the beginning of the growing season, inevitably leading to massive plant and, hence, tuber infestation. At that stage of PVY^N infection, the virus is translocated to tubers faster, and tubers become infested already at the setting stage. This is the key reason of ineffective desiccation when seed potato is grown under high infection pressure, regardless of potential aphid monitoring activities. Seed potato production should virtually not be allowed in such locations. In plants infected with PVY and PLRV later in the growing season, the percentage of infected tubers is lower than in plants infected earlier in the season (Beemster, 1976; Sigvald, 1985; Beemster, 1987; Gibson, 1991).

On the other hand, concerning seed potato production in locations under low infection pressure, the entire production process should be analysed. In Sjenica, potatoes are planted from 10^{th} May through the end of June. Under favourable weather conditions, an optimal planting termination date is 10^{th} June. Desiccation for tuber lifting starts in early September and ends in early October. It takes 50 days from the emergence to desiccation for early maturing cultivars and 80 days for late maturing cultivars to form an optimal number and size of tubers. Even under such conditions, tens of hectares of seed potato crops sometimes remain unharvested and rot due to bad weather. Therefore, there is no room for any intervention in terms of early haulm growth termination, even if aphid flight monitoring is conducted (Milošević, 2006). The situation is similar to that of potato planting and lifting operations in Vlasina, Kopaonik and other regions (personal communication with seed potato growers in Serbia).

Under the conditions that exist in Serbia, good quality seed potato can be produced only in locations that have low virus infection pressure. Those are areas with low population density, mostly located in highlands, and characterised by a harsh climate. Depending on weather conditions, potato planting sometimes ends in the second half of June. To conduct a timely harvest, without the usual risk of large amounts of potatoes remaining unharvested due to bad weather, desiccation of a seed potato crop must be performed in a timely manner. Considering the short growing season and the need to harvest tubers with mature skin, haulm destruction should necessarily be undertaken not earlier than 15 days before the beginning of tuber harvest.

With the present lack of legal provisions prescribing an avoidance of infection sources in seed potato production in Serbia (which presently allow seed potato production to be located in areas with high infection pressure), what are the effects of monitoring the time of outbreak, abundance and species composition of aphids? Under such conditions, seed crop infection occurs very early in the growing season. Research results (Table 1) show that the virus is translocated to tubers faster when infection is early, which means that tubers become infected with PVY before a marketable yield of potatoes has been achieved. Early plant infection leads to an increased percentage of PVY-infected tubers (Mnari et al., 1999).

The monitoring of aphid abundance and species in regions with high infection pressure, where some of the seed potato production is located, has no beneficial effect whatsoever. It was not long ago that aphid flight monitoring was imposed by organisers of seed potato production and control authorities to enable timely growth termination in regions such as Guča and Čačak (Petrović-Obradović et al., 2006; Vučetić et al., 2011 and 2013b). However, it is beyond any rational thinking to suppose that seed potato can be produced in those locations, since none of the virus management practices can yield any positive effect on the quality of seed potato there. In such locations in Serbia, i.e. at low altitudes where the production of table potatoes massively infected with PVY is widespread, it is not possible to prevent virus transmission and infection by using insecticides. It is a well-known fact that insecticides cannot prevent the transmission of non-persistent viruses, such as the aphid-vectored PVY, from infected plants outside the crop that is being protected against virus infection, which has been confirmed in many studies (Milošević, 1996; Raman, 1985; Radcliffe, 2006; Milošević et al.. 2012)

STEPS TOWARDS MEANINGFUL APHID FLIGHT MONITORING ACTIVITIES

Firstly, an important fact to consider is that PVY is the most dominant potato virus in Europe (Chrzanowska, 1991; Horvath and Wolf, 1999; Chrzanowska and Doroszewska, 2004; Chatzivassiliou et al, 2008; Kotzampigikis et al., 2008), as well as in Serbia (Buturović and Kus, 1989; Milošević, 1992a).

Regulatory activities and improvement of potato production as a whole require maximum regulation of seed potato production based on the experience of countries that have adopted well-managed seed potato production systems. In other words, plant virus control underlying a sound seed potato production should follow a strict sequence of measures (Milošević, 2000; Milošević et al., 2000). The absence of any vital measure preventing virus infestation of seed crops results in almost complete inefficiency. This is the key problem when organising seed potato production in Serbia and countries in the region. In other words, seed potato production is a very complex issue necessitating huge experience in order to be adequately addressed. Unfortunately, this is not the case in Serbia. Certain operations are being taken out of context and with no positive effect.

To improve seed potato production by monitoring the time of outbreak, abundance and species composition of winged aphids, the following measures should be taken:

1. The entire seed potato production must be located in areas with low infection pressure in order to be effective.
2. Each seed potato production location/region should be assessed in terms of the effects of aphid monitoring and growth termination.
3. Aphid collection and identification must be organised by the authorities, i.e. the competent ministry or the Plant Protection Office and its extension services.
4. The monitoring of aphid abundance and species composition should be organised at the state level by the Ministry of Agriculture, Department of Seed Production, once the primary conditions have been met, in order to make the monitoring activities meaningful and effective.
5. Locations with annual infection levels of more than 30% or even 50% should be excluded from coverage by production plans, since virus infection under such conditions cannot be controlled by any separate measure or a set of measures, thus rendering the monitoring of aphid abundance and species composition a financial burden yielding negative effects.

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Uticaj praćenja brojnosti i vrsta biljnih vaši kao vektora virusa na proizvodnju semenskog krompira u Srbiji

REZIME

Biljne vaši su najznačajniji vektori virusa krompira u toku vegetacije. Od važnijih virusa u smislu rasprostranjenosti i štetnosti, Y virus krompira biljne vaši prenose na neperzistentan, a virus uvijenosti lišća krompira na perzistentan način. Ova dva virusa predstavljaju najveći problem u proizvodnji krompira i ograničavajući su činilac proizvodnje semenskog krompira u Srbiji i regionu i mnogim državama sveta. Posebno je štetan Y virus s obzirom na njegovu rasprostranjenost i brzinu širenja.

U sistemu proizvodnje semenskog krompira, u dobro uređenom i kontrolisanom semenarstvu, jedna u nizu mera suzbijanja virusa jeste i monitoring biljnih vaši odnosno praćenje vremena pojave, brojnosti i vrsta krilatih formi biljnih vaši radi prognoze viroza. Time se prognozira vreme mogućih infekcija biljaka i zaražavanja krtola. Monitoringom biljnih vaši, vektora virusa, odredjuje se optimalno vreme za uništavanje nadzemne mase krompira kada se pojave krilate vrste vaši koje su vektori ekonomski štetnih virusa u većem broju od uobičajenog. Uništavanjem nadzemne mase krompira smanjuje se rizik od eventualne zaraze biljaka i translokacije virusa iz cime u krtolu i na taj način se sprečava da procenat zaraženih krtola pređe granicu dozvoljenu za određenu kategoriju semenskog krompira. Ova mera ima pozitivnog efekta ako se primenjuje uz druge mere koje su značajne za suzbijanje viroza. Ako se druge mere ne sprovode, onda ova mera može biti bez ikakvog efekta.

Sadržaj ovoga rada predstavlja integralno razmatranje problematike efekta i značaja praćenja vremena pojave, brojnosti i vrsta biljnih vaši na vreme prekida vegetacije krompira radi sprečavanja zaraze biljaka, translokacije virusa i zaražavanja krtola u uslovima Srbije i regiona.

Ključne reči: krompir, biljni virusi, vektori, biljne vaši