

Potential Use of Insecticides and Mineral Oils for the Control of Transmission of Major Aphid-Transmitted Potato Viruses

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SUMMARY

Viruses occurring in Serbia and other countries in the region are a huge problem constraining seed potato production. At lower altitudes, in lowland and hilly regions, where table potato production is widely distributed, more than 50% of healthy plants become infected with potato virus Y during one growing season. Under these conditions, seed potato production is hindered due to a high infection pressure of potato virus Y which spreads far more rapidly compared to leaf roll virus, virus S and other viruses hosted by this plant species.

This study tended to clarify a frequent dilemma regarding the use of insecticides in preventing the infection of healthy plants with potato virus Y and leaf roll virus, given the oral and written recommendations from pesticide manufacturers, agronomists and scientists in the field of crop protection arising from a logical conclusion that aphid vector control results in virus transmission control.

The present findings, which are in agreement with reports of authors from other countries, show that the use of insecticides is ineffective in preventing potato virus Y which is nonpersistently transmitted by aphids from an external source of infection.

However, insecticides can exhibit efficacy in preventing potato virus Y transmission from infected plants to healthy plants within a crop, which can have an overall positive effect only if seed potato is grown in areas that have no external source of infection.

The present results and those of other authors show that insecticides are effective in preventing the infection of healthy plants with persistently transmitted leaf roll virus.

Mineral oils provide effective control of potato virus Y by preventing the infection of potato plants with the virus. They can be combined with other management practices to protect seed potato crops against the virus.

Given the fact that the initial first-year infection of healthy potato plants with virus Y in relation to leaf roll virus is approximately 10-20:1 under conditions in Serbia, and that the use of insecticides fails to ensure protection against PVY, this practice cannot have any positive effect on virus control under high infection pressure conditions.

Keywords: Potatoes; Viruses; Vectors; Insecticides; Control methods

INTRODUCTION

Major qualitative traits of seed potatoes which differentiate them from table potatoes include primarily the health status of tubers in terms of fungi, fungus-like organisms, bacteria, viruses, etc. During seed potato production, it is relatively easy to obtain healthy seed tubers or tubers showing a permissible degree of infection with fungi, fungus-like organisms and bacteria. One of the main and probably the most difficult tasks in seed potato production is virus management, particularly regarding the expansion of sources of infection i.e. a high infection pressure of potato viruses found in Serbia and other countries in the region.

Economically harmful potato viruses are transmitted through infected tubers from one growing season to another, while during the season, they are transmitted from infected plants within the crop and from plants in the surroundings (source of infection) mostly by aphids (fam: Aphididae). A positive correlation was registered between the number of winged aphid vectors and the degree of potato infection with PVY and PLRV (Nanafi et al., 1989; Basky, 2002).

A considerably higher number of aphid species act as vectors of PVY compared to PLRV, which is positively correlated with the ratio of the degree of first-year infection of potato plants both in Serbia and worldwide (de Box and van der Want, 1987; Milošević, 1992a).

Once the aphid picks up the virus from an infected potato plant, depending on the mode of transmission (non-persistent and persistent transmission), it transmits the virus and infects healthy potato plants immediately or after a certain period of time (Raman, 1985; Bostan et al., 2006). The virus multiplies in above-ground parts of the plant (systemic disease) and, after a while, infects potato tubers (Beemster, 1987).

PVY is the major problem in seed potato production in Serbia and other countries in the region (Milošević, 1992c; Milošević and Petrović, 2000) as well as in many other countries world wide (Stevenson, 2001; Singh, 2004; Soucke and Döring, 2004; Basky, 2006; Kirchner et al., 2009).

Virus control during seed potato production involves the use of a number of practices (Milošević et al., 2007; Milošević, 2009a), which often include insecticide treatments as their integral part, since aphid transmission is the most important mode of virus transmission in a field during a growing season (Sigvald and Hulle, 2004; Mowry, 2005; Van Toor and Teulon, 2006; Kozzampigikis et al., 2008; Nolte et al., 2009 etc.). However, regarding insecticide use, conditions under which insecticide treatments show efficacy or lack of efficacy against virus transmission are rarely specified.

The objective of this study was to analyze a potential use of insecticides in preventing the transmission and spread (i.e. control) of viruses during seed potato production, by controlling the aphid vectors. Seed potato producers are convinced that the use of insecticides is effective in preventing the spread of viruses due to the fact that insecticides control vectors, thereby preventing viral infection of seed potato crop. The same opinion is held by pesticide manufacturers and even agronomists.

The fact that aphids are responsible for virus transmission and infection of healthy seed potato plants logically suggests that the use of insecticides for aphid control will solve the problem. However, the suggestion is wrong and gives false hope to seed potato producers who consider insecticides their primary defense against viral infection i.e. the dominant virus Y (Radcliffe, 2006). Pesticide manufacturers, who lack the required knowledge about the problem, but aim to increase pesticide use and, hence, gain greater economic benefit, keep recommending the use of insecticides to seed potato producers for solving the problem under high infection pressure of viruses. This results in increased pesticide use, mostly without any effects in solving the problem, as well as in increased costs of unsuccessful production, destruction of beneficial fauna and environmental pollution.

When analyzing the problem regarding the control and prevention of potato viruses spread, aimed towards the production of high-quality virus-free seed potatoes or those exhibiting an allowable (tolerant) level of virus infection depending on the class, it is necessary to concentrate on understanding the viro-epidemiological situation in the region where seed potatoes will be produced. In order to ensure an effective potato virus management during the seed potato production and potential insecticide use, it is necessary to obtain information on the type of virus, rate of infestation, rate of spread during one growing season, and mode of transmission (non-persistent or persistent).

MAJOR POTATO VIRUSES AND EPIDEMIOLOGY

Economically important potato viruses in Serbia and other countries in the region

To understand the subject of this paper it is important to know that the most common potato viruses in Serbia and other countries in the region include potato virus Y (PVY) i.e. its necrotic strain (PVY^N/PVY^{NTN}),

potato leaf roll virus (PLRV) and potato virus S (PVS). The severity of the virus problem in this region is reflected in the fact that first-year infection of potato plants and newly produced tubers with PVY is above 50%, reaching up to 90% in a single growing season (Milošević, 1989, 1992a, 1996a). This is an important piece of information that should be considered when analyzing the problem of seed potato health management in regions experiencing the abovementioned virus infection pressure in Serbia and surrounding countries (Milošević, 1992b, 1992c, 1995; Jasnić et al., 2003; Milošević et al., 2000; Milošević and Đalović, 2004).

The situation in terms of virus spread is similar in Europe and worldwide. Kotzampigikis et al. (2008) report that PVY and PLRV are the most widely spread viruses in Bulgaria. In Europe, PVY^N(PVY^{NTN}) has predominated since 1980 (Weidemann, 1988; Chrzanowska, 1991; Wolf et al., 1998; Basky, 2002; Dolničar, 2004; Sigvald and Hulle, 2004; Rolland et al., 2008). This virus has caused epidemics in Hungary (Horvath and Wolf, 1999). PVY i.e. its necrotic strain PVY^N is the biggest problem in seed potato production not only in Serbia, but also in other countries of the world (Stivenson, 2001; Singh, 2004; Soucke and Döring, 2004; Kirchner et al., 2009).

The research conducted under conditions in Serbia (Milošević, 1992a) showed that the initial (first-year) infection of healthy plants with PVY was more than tenfold higher than with PLRV. This is another important information that should be considered when analyzing the use of insecticides for potential protection of seed potato plants against viral infection.

Aphids as pests or vectors of potato viruses?

Aphids are incomparably the most important and the most harmful as vectors of potato viruses (Van Hoof, 1980; Piron, 1986; de Bokx and van der Want, 1987; de Bokx, 1987; Weidemann, 1988; Nanafi et al., 1989; Flanders et al., 1991; Woodford, 1992; Thomas, 1997; Stevenson, 2001; Sigvald and Hulle, 2004; King et al., 2004; Soucke and Döring, 2004; Milošević, 2009a). *Myzus persicae* alone is a vector of more than 150 types of viruses as well as the most effective vector of plant viruses (Cloyd and Sadof, 1998). It is the most effective aphid vector of PVY, according to many researchers (Van Hoff, 1980; Van Harten, 1983; Sigvald, 1984; King et al., 2004), but not necessarily the most responsible for the transmission of the virus. More than 40 species of PVY transmitting aphids are known today (Sigvald and Hulle, 2004).

A considerably higher number of aphids are vectors of PVY rather than of PLRV (De Bokx, 1987). Therefore, the ratio of the first-year infection degree of potato plants is correlated with the above statement (de Bokx and van der Want, 1987).

There are two modes of potato virus transmission by aphids. PVY is transmitted in a non-persistent manner, meaning that a short period of time, measured in seconds and minutes, is required for the virus to be picked up from the infected plant, by aphid whose stylet becomes contaminated with the virus, and is capable of immediately transmitting the virus and infecting the healthy plant. The second most important virus in Serbia is the leaf roll virus transmitted persistently by aphids. It takes longer for aphid to feed on the infected plant in order to acquire the virus. After virus acquisition, the aphid is not able to transmit and infect the healthy plant immediately, but a latent incubation period of several hours is required. These facts are very important in explaining the use of insecticides in preventing the spread of these viruses.

Most potato viruses, including PVY, are transmitted by aphids in a non-persistent manner with the aphid taking a short time to feed on the epidermal tissue in order to be contaminated with the virus. Persistently transmitted viruses (PCLV) are located in a plant phloem and require a longer period of feeding (20-30 minutes) and a subsequent incubation period of several hours in order to be transmitted (Raman, 1985).

Potato virus epidemiology

In order to effectively manage the health status of seed potatoes during the production process, considering the fact that aphids are responsible for virus transmission during the growing season, it is of great importance to be reminded of some basic information about the potato virus epidemiology.

The fact to have in mind is that seed potato class is not determined by a degree of multiplication but rather by tuber infection with the causal agent of a disease (Milošević, 2009a). This important fact is not specifically emphasized in organized systems as it is obvious and generally accepted (Holland, etc.). However, particular importance must be given to this factor in Serbia and similar countries as it is a basic constraint for seed potato production. Therefore, a question arises: what factors affect the degree of infection of potato tubers – the answer will help in providing the effective management of the tuber health status.

The degree of tuber infection with viruses is affected by the infection pressure of viruses in a particular

region. Major factors affecting the infection pressure include the amount of inoculum in the surrounding environment, the amount of inoculum within the higher-class potato crop that will be used for the production of low-class seed potatoes and the numbers and types of virus vectors (Gabriel, 1988).

Which of these factors can be managed? The amount of inoculum within the crop is the first manageable factor, followed by the amount of inoculum in the surrounding environment. The inoculum referred to in this work stands for virus-infected potato plants i.e. table potatoes displaying 90% PVY infection in Serbia. Another manageable factor is the number of vectors. We cannot individually reduce i.e. cause a reduction in inoculum amount in the surrounding environment i.e. at the locality. We can avoid pollution sources in the surroundings by moving seed potato production to locations where no production of table potatoes, as a source of infection, is registered (Milošević, 1998, 2000, 2008, 2009a).

An internal source of infection includes the multiplication of sick plants within the crop. The internal inoculum can be managed as follows: in order to multiply, for instance, higher class seed potatoes for the production of low-class seed potatoes, higher-quality higher-class planting material with a lower percentage of virus infected tubers should be used (e.g. if 2-6% infected tubers are allowable for class A, class A planting material having 2% of infected tubers should be used). The internal source of infection can also be reduced by cleaning the crop i.e. destroying the infected plants at the beginning of growing season (Gabriel, 1988).

POSSIBILITIES OF CHEMICAL CONTROL OF MAJOR POTATO VIRUSES IN SERBIA

Does the use of insecticides for aphid control ensure seed potato protection?

There is a necessity to discuss a question regarding the use of insecticides to control potato virus transmission and hence, ensure seed potato protection against virus infection, since it brings large misconceptions. Studies show that all researchers give priority to insecticide use for the control of seed potato crops against viruses, without considering the modes of virus transmission, distribution, internal and external sources of infection, etc. Unfortunately, this leads to pesticide manufacturers recommending to seed potato producers the use of one insecticide or another, guaranteeing

efficient protection of seed potato crop against viral diseases even in cases when potato production is established at locations with a high infection pressure of potato viruses. Unfortunately, practical results are quite the opposite – the use of insecticides has no effect in most cases, particularly under conditions in Serbia where the production of “seed” potato is allowed at locations with an ample source of inoculum.

In order to understand the potential use of insecticides for the control of major potato viruses, primarily PVY and PLRV, the following facts for Serbian and regional conditions should be considered:

1. Degree of first-year infection of healthy plants with potato viruses,
2. Ratio of the degree of first-year transmission (spread) for individual potato viruses,
3. Mode of transmission (persistent and non-persistent transmission) of the most widespread potato viruses, since effectiveness of chemical insecticide control is dependent on the mode of virus transmission by vectors – aphids (Purcell and Almeida, 2005),
4. The abundance (spread) of infection sources at locations where seed potato will be produced.

The current situation and the results of Serbian seed potato production show a high degree of first-year infection with the most widespread potato virus (PVY) despite the multiple treatments with insecticides (Milošević, 1996b; Milošević, personal communication with seed potato producers), if seed potatoes are produced, as in Serbia, at locations experiencing a high infection pressure of viruses (PVY).

The results from Serbia show that potato virus Y is the fastest spreading virus in Serbia and other countries in the region (Milošević, 1996a; Horvath and Wolf, 1999). The degree of first-year infection of potato tubers with this virus is above 50% in most regions in Serbia, except the highlands.

PLRV is another economically harmful virus in Serbia. However, its initial spread (first-year infection of healthy plants) lags quite behind the spread of PVY, resulting in the spreading ratio of these two viruses of 20:1-2 (Milošević, 1992a). An identical ratio of PVY to PLRV has been reported by researchers from Hungary (Basky, 2002), Turkey (Bostan and Haliloglu, 2004; Bostan et al., 2006), and Greece (Chatzivassiliou et al., 2008). This practically means that the initial first-year PVY infection is 50-90%, while the infection with PLRV is about 2-5%. These results refer to the degree of first-year infection with the two viruses when healthy starting material is used (from virus-free to elite having

less than 1% infected tubers). An important element to consider is that this initial infection has been “brought” by aphids from infected plants in the surrounding environment i.e. by the external source of infection.

In most regions except in high mountains in Serbia and countries created from the former Yugoslavia, during the second year, the planting material infected with PVY and PLRV at the abovementioned level in the first year becomes infected 100% with PVY and also in a much higher degree compared to the first year with PLRV. Therefore, apart from the external source of infection, the internal source of infection is also present in the second year. These are very important elements which will be useful in further analysis of the subject matter of this study.

Effect of insecticides used to control the spread of potato virus Y

The research conducted at locations under conditions in Serbia showing a high degree of degeneration or first-year infection with PVY suggests that insecticide use was ineffective against the spread of the virus, and that it even promoted the infection (Figure 1). Naturally, this refers to the control of virus transmission from the external source of infection – infected potato plants at the location (Milošević, 1996b).

The abovementioned refers to potential cases of seed potato production under high infection pressure conditions i.e. in regions widely dominated by the production of table potatoes infected with PVY, e.g. in Serbia and other countries in the region.

Chemical control is dependent on the mode of virus transmission by vectors (Purcell and Almeida, 2005). This is attributable to the fact that PVY is transmitted in a non-persistent manner, with a short time required for aphid to become contaminated with the virus from an infected plant, transmit the virus and infect a healthy

plant (Groves et al., 2009; Nottle et al., 2009). The rate of infection is even higher in insecticide-treated crops, which is also possible, as confirmed by other researchers as well. Gabriel et al. (1982) reported that insecticide applications reduced aphid population density on potato plants, without reducing, but even increasing the rate of PVY infection. Birecki et al. (1967) (cit. Gabriel et al., 1982) also observed a significant increase in PVY infection after an insecticide treatment. Quemener and Guillery (1982) found that insecticide treatments were effective against leaf roll virus transmission but had no effect on other viruses. Peters (1987) also reported the ineffectiveness of insecticides for the control of PVY. Gabriel (1988) found no effect of metamidofos and pyrimicarb on potato crop protection against PVY, while Broadbent (1957) reported no success in insecticide use to control the transmission of potato viruses.

Many other researchers also confirm the ineffectiveness of insecticides used to prevent PVY transmission (Raman, 1985; Radcliffe, 2006; Van Toor and Teulon, 2006; Kotzampigikis et al., 2008; Nottle et al., 2009; Gray et al., 2010; Olubayo et al., 2010). Therefore, insecticides are ineffective in non-persistent virus management (Racah, 1986; Perring et al., 1999; Hooks and Fereres, 2006; Croves et al., 2009).

Are there any cases where the use of insecticides is effective for the control of PVY transmission? In order to answer this question it is necessary to consider a tolerance of tubers of some classes of seed potatoes (1%, 6% and 10% for elite, class A and class C potatoes, respectively, in Serbia, according to current regulations) to virus infection.

For example, class C potatoes can be produced from class A (max. 6% of infected tubers) only at low infection pressure of viruses, as it is done in Serbia, in high altitude regions with a considerably lower infection pressure. There is greater possibility that class C potatoes with

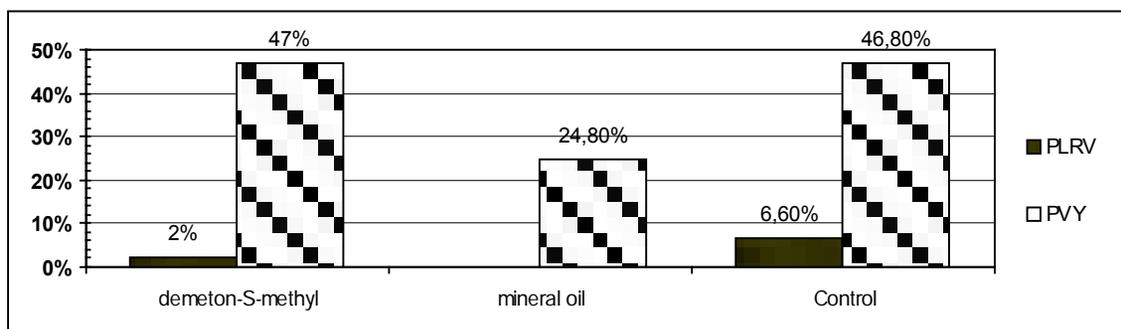


Figure 1. Average percentage of first-year infection of healthy potato plants with PVY and PLRV in untreated control, and insecticide and mineral oil treatments (Milošević, 1996b) in the Village of Kaona, Lučani, at about 600 m a.s.l.

maximum 10% infected tubers will be produced if class A potatoes have a lower percentage of virus-infected tubers. However, aphid vectors of PVY are also found in these regions (Milošević and Petrović, 1996). Accordingly, despite a lower risk of importing viruses by aphids from the adjacent environment (from an infection source outside the crop), there is a risk of virus transmission from infected plants to healthy plants within the crop. In this case, the use of insecticides can produce the desired effect.

Under the overall conditions in Serbia and other countries in the region where PVY spreads incomparably faster than PLRV, regardless of insecticide effect for the control of PLRV transmission, insecticide applications are useless in preventing the spread of potato viruses in seed potato production. However, if this production is translocated to upland regions that have a low infection pressure and no source of infection in the surroundings (table potatoes), the use of insecticides can have a positive effect in terms of preventing PVY transmission from infected to healthy plants within the crop, i.e. from the internal source of infection to other healthy plants.

The results show the efficacy of mineral oils for the control of PVY transmission (Figure 1). Studies conducted under the conditions of high infection pressure (Milošević, 1996b) reveal that the 7-day use of 3% oil emulsion is effective but insufficient to provide protection of seed potato crop at a defined tolerance level for the desired class. Therefore, the use of mineral oils can have effects only if seed potato production is located under low infection pressure conditions. The effectiveness of mineral oil applications in preventing PVY transmission during seed potato production was also reported by other authors (Boiteau and Singh, 1981; Dedić, 1986; Powell, 1992; Boiteau et al., 2009).

Effect of insecticides in preventing the transmission of potato leaf roll virus

PLRV is transmitted by aphids in a manner quite different from PVY transmission. The virus multiplies in aphids. Upon its acquisition by the aphid, it takes a certain period of time for the aphid to transmit the virus.

The results of the present research conducted under high infection pressure of potato viruses show that insecticide applications are effective in protecting healthy plants against viruses transmitted from external sources of infection (Milošević, 1996b). Furthermore, the effect of insecticides used to control PLRV transmission has also been reported in the literature (Woodford, 1992; Sigvald and Hulle, 2004; Van Toor and Teulon,

2006). If a seed potato crop is subjected to insecticide treatment, the aphid “carrying” the virus acquired at the source of infection in the surroundings during incubation i.e. during the period from virus acquisition to its transmission, will feed on a healthy insecticide-treated plant, pick up the insecticide and die before being able to transmit the virus.

Insecticides cause specific effects in preventing the transmission of PLRV from infected to healthy plants within the seed potato crop. A similar effect is observed in controlling the transmission of PVY.

If a one-sided unsystematized approach is adopted, the wrong conclusion might be drawn that the use of insecticides in preventing PLRV transmission will ensure crop protection against all viruses and hence, result in the production of a certain seed potato class. In order to reach a realistic conclusion, the spreading ratio of two economically most harmful viruses should be considered. In view of the fact that PVY spreads faster, with no positive effect of insecticides in preventing the transmission of the virus from the external source of infection, the use of insecticides in preventing the transmission of PLRV is, accordingly, useless since it will not result in the desired class of seed potatoes. The level of PVY infection will exceed the legally prescribed level for the particular class of seed potatoes.

Mowry (2005) reports differences in the efficacy of insecticides in controlling PLRV, emphasizing that the most effective are imidacloprid and thiamethoxam. The trial involving experimental transmission of PLRV by the *Myzus persicae* aphid showed high efficacy of imidacloprid, pymetrozin and thiametoxam.

Kotzampigikis et al. (2008) determined higher efficacy of insecticides in preventing the transmission of viruses from the internal source of infection than from the external source.

The efficacy of systemic insecticides in preventing the spread of PLRV has been confirmed by many researchers who studied this matter and recommended their use in seed potato production (Fernow and Kerr, 1953; Broadbent et al., 1956; Quemener, 1978; Quemener and Guillery, 1982; Turska and Szulc, 1988). Broadbent et al. (1956) determined a regularity according to which the use of different insecticides in the potato crop caused complete or partial declines in populations of potato-colonizing aphid vectors of PLRV, depending on the insecticide used, i.e. led to the reduction or elimination of PLRV infection in potato plants. The same regularity was established by Fernow and Kerr (1953) who determined the efficacy of Systox in controlling the spread of PLRV. Peters (1987) reported that insecticides

can be effective in preventing the expansion of PLRV from one plant to another within the crop and less effective in preventing the spread to another crop. Additionally, Gabriel (1988) found that treatments with methamidophos and pyrimicarb significantly prevented PLRV infection of healthy plants. Considering the fact that the use of insecticides for leaf aphid control leads to potato plant protection against PLRV infection, other researchers who obtained similar results are worth mentioning (Rasocha and Trnkova, 1988; Beukema and van der Zaag, 1990). Insecticidal control of potato aphids helps prevent the spread of the potato leaf roll virus, as confirmed by other authors (Rieckmann, 1985, 1989; Castle et al., 2009). Hooker (1986) recommends the use of systemic insecticides in PLRV control.

CONCLUSION

Producing both healthy seed potatoes and potatoes showing viral infection within tolerance levels is not an easy task, particularly under conditions characterized by wide distribution of infection sources at the levels occurring in Serbia and other countries in the region.

It frequently occurs that seed potato producers use insecticides to control aphids and hence, reduce viral infection under conditions that allow seed potato production under very high infection pressure. Research conducted in Serbia, and confirmed by many authors across the world, showed that insecticide applications had no positive effect in terms of preventing the spread of non-persistent aphid-transmitted viruses such as PVY, the most widespread virus in this region, transmitted from an external source of infection – i.e. infected plants in the surroundings. The use of insecticides can be effective in preventing the transmission of PVY from infected plants within the crop if seed potato production is established at locations with very low infection pressure where there is no external source of infection i.e. table potato production.

The use of mineral oils can produce effects in terms of reducing PVY infection, provided that the production is established at locations with low infection pressure.

Moreover, the present study and findings of other authors show the efficacy of insecticides in the control of viruses transmitted by aphids in a persistent manner such as PLRV.

Given the fact that PVY is the most widely distributed virus spreading faster than any other potato virus, the use of insecticides to control its expansion from the external sources of infection, widely distributed in the surrounding environment, has no practical importance.

An important condition to be fulfilled in order to have positive effects of insecticide applications for the control of seed potato infections with economically important viruses is to locate the seed potato production in low infection pressure areas. With this requirement satisfied, the use of insecticides under conditions in Serbia can also produce positive effects in providing protection for seed potato crops against the economically most important viruses PVY and PLRV.

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Mogućnost primene insekticida i mineralnih ulja u sprečavanju transmisije važnijih virusa krompira koji se prenose biljnim vašima

REZIME

Virusi u Srbiji i državama regiona predstavljaju veliki problem i ograničavajući činilac u proizvodnji semenskog krompira. Na nižim nadmorskim visinama, u ravničarskim i brdskim područjima, gde je raširena proizvodnja konzumnog krompira, Y virusom se zarazi u toku jedne vegetacije više od 50% zdravih biljaka. U takvim uslovima nije moguća proizvodnja semenskog krompira zbog visokog infekcijskog pritiska Y virusom krompira koji se znatno brže širi u odnosu na virus uvijenosti lišća, S virus krompira i druge viruse čiji je ova biljka domaćin.

U ovom radu smo pokušali razjasniti dilemu, koja se često nameće, da li ima efekta primena insekticida u cilju sprečavanja zaraze zdravih biljaka Y i virusom uvijenosti lišća krompira s obzirom na usmene i pisane preporuke, proizvođača pesticida, agronoma i naučnih radnika iz oblasti zaštite bilja, koje nastaju kao posledica logičkog zaključivanja da suzbijanjem vektora, biljnih vaši, suzbijamo i prenošenje virusa.

Rezultati naših istraživanja, što je u saglasnosti i sa rezultatima istraživača iz drugih zemalja, pokazuju da primena insekticida nema efekta na sprečavanje prenošenja Y virusa, koji se vašima prenosi na neperzistentan način, sa spoljnog izvora zaraze.

Međutim, primena insekticida može imati efekta u sprečavanju prenošenja Y-VKr sa zaraženih na zdrave biljake unutar useva krompira, a to može imati ukupan pozitivan efekat samo ako se semenski krompir uzgaja u područjima bez spoljnog izvora zaraze.

Naši, i rezultati drugih istraživača pokazuju da primena insekticida radi sprečavanja zaraze zdravih biljaka virusom uvijenosti lišća koji se prenosi na perzistentan način ima efekta.

U zaštiti biljaka krompira od infekcije Y-VKr su efikasna mineralna ulja koja sprečavaju infekciju biljaka ovim virusom i koja se mogu koristiti sa drugim merama u sistemu zaštite semenskog useva krompira od ovog virusa.

S obzirom na činjenicu da je, u našim uslovima, početna jednogodišnja zaraza zdravih biljaka krompira Y virusom u odnosu na virus uvijenosti lišća približno 10-20:1, a primena insekticida ne osigurava zaštitu od Y-VKr, onda ova mera ne može imati nikakvog pozitivnog efekta u suzbijanju virusa u uslovima visokog infekcijskog pritiska.

Cljučne reči: Krompir; virusi; vektori; insekticidi; mere suzbijanja