

THE PRESSURE OF APHIDS (APHIDIDAE, HEMIPTERA), VECTORS OF POTATO VIRUSES

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Abstract - Plant viruses and aphids as their vectors, are limiting factors in the production of healthy seed potato. Potato Virus Y (PVY) and Potato Leafroll Virus (PLRV) are the two most significant potato viruses in Europe, and seed quality depends directly on the infection level. In order to determine the possibilities for healthy seed potato production in Serbia, aphid flight activities have been monitored for four years in four localities. Over 6400 specimens of aphids have been collected. The number of aphids and vector pressure index varies depending on the localities' altitude. In localities at altitudes under 1000 m, they were high. The highest index was in locality Kotražina in 2007, when the PVY index exceeded the value of 180, while for PLRV it was 60. At high altitudes, above 1100 m, the number of aphids was low, as was the vector pressure index. The lowest index values were recorded in localities on Mt. Golija at 1300 m a.s.l. where the indexes for both viruses never exceeded value 6.

Key words: Aphididae, Hemiptera, vector pressure index, PLRV, PVY, seed potato

INTRODUCTION

Aphids (Aphididae, Hemiptera) pose a significant disturbance to the successful production of healthy seed potato. The feeding of dense aphid colonies can cause direct damage and yield reduction, but their harmfulness to potato crops can primarily be seen in the efficiency in transmitting viruses. In potato crops, over 50 aphid species are vectors of a large number of persistent and non-persistent viruses (Ragsdale et al., 2001). Among 28 types of viruses infecting potato plants, Potato Leafroll Virus (PLRV) and Potato Virus Y (PVY) are the most significant potato viruses in Europe.

PLRV belongs to the group of persistent viruses and can be transmitted only by aphids whose host plant is the potato, i.e. those feeding and multiplying on potato. There are 12 such species (Robert and Baurdin, 2001). PVY belongs to the non-persistent

virus group. Aphids can adopt PVY in a couple of seconds or minutes and immediately transmit it to another plant. Aphids whose host is not potato are more efficient as vectors (Ragsdale et al., 2001). The most efficient vector of both viruses is the green peach aphid, *Myzus persicae*.

The production of healthy seed potato is conditioned by the number of aphid species – potential plant virus vectors, the number of specimens of each species, as well as the moment when aphids fly into the field and the dynamics of each species' flight. Monitoring the flight of aphids using yellow water traps is a reliable way to obtain all the required data (Sigvald, 1989; Basky, 2002; Kuroli and Lantos, 2006; Milošević and Petrović, 1997).

The aim of this research was to determine whether there are areas in Serbia where vector pressure is low.

Table 1. Vector pressure index (<http://aphmon.csl.gov.uk>)

Species	PVY index	PLRV index
<i>Myzus persicae</i>	1,00	1,00
<i>Aphis nasturtii</i>	0,40	0,25
<i>Myzus ornatus</i>	0,20	0,30
<i>Myzus ascalonicus</i>	0,20	0,30
<i>Macrosiphum euphorbiae</i>	0,20	0,15
<i>Aulacorthum solani</i>	0,20	0,30
<i>Aphis fabae</i>	0,10	0,30
<i>Rhopalosiphoninus latysiphon</i>	0,20	0,30
<i>Acyrtosiphon pisum</i>	0,70	-
<i>Rhopalosiphum padi</i>	0,40	-
<i>Metopolophium dirhodum</i>	0,30	-
<i>Brachycaudus helichrysi</i>	0,21	-
<i>Aphis gossypii</i>	-	0,50
<i>Phorodon humuli</i>	-	0,12
<i>Rhopalosiphoninus staphyleae</i>	-	0,10
<i>Brevicorynae brassicae</i>	0,01	-
<i>Sitobion avenae</i>	0,01	-
<i>Hyperomyzus lactucae</i>	0,16	-

MATERIALS AND METHODS

Research was carried out from 2007 to 2010. Yellow water traps were set on seed potato crops in four localities: Begeč, near Novi Sad at an altitude of about 50 m; Kotraž, near Čačak at an altitude of about 850 m, and two localities on Mt. Golija at altitudes of about 1100 m (Golija 1) and 1300 m (Golija 2). The dimensions of the dishes are 22x22x11 cm, with holes below the upper edge, one-third filled with water, with the addition of liquid detergent. In Begeč and in the localities on Golija, four traps were set per one hectare, while the parcels in Kotraž were ½ ha, so two traps were set. In 2007 and 2008, the traps were set in all four localities. In 2009, the traps were set in the two localities on Golija. In 2010, they were set only in Kotraž.

Yellow water traps were placed in potato crops immediately after the emergence of potato. In the beginning, they were on the ground and during vegetation they were elevated in order to be visible

for the insects. Samples of the insects caught in the traps were collected once a week from the beginning of growth until desiccation. The fluid from the traps was sieved and the insects were packed into plastic boxes with 75% alcohol. In the laboratory, aphids were separated from the rest of the samples and conserved in 75% alcohol. Identification of all sampled aphids was carried out, and identification keys were used (Taylor, 1984; Jacky and Bouchery, 1988; Remaudiere and Seco Fernandez, 1990).

The risk of the infection of potato by plant viruses was calculated as cumulative vector pressure on a weekly basis, using tables of species' vector pressure index (FERA–The Food and Environmental Research agency, <http://aphmon.csl.gov.uk>) (Table 1).

A vector pressure index is obtained by multiplying the index values with the number of specimens of the same species found in one trap. The values calculated for all species in one trap are added together. The index value for one week is added to previous

weeks' values and the cumulative value of vector pressure for the locality is obtained. The lower the index value, the lower the virus transmission risk to seed potato.

The number of aphids and known PVY and PLRV vectors were analyzed, and the vector pressure was calculated for these two viruses.

RESULTS

During investigations, 6401 aphid specimens were collected and 89 different taxa of aphids were identified. The most important vector of potato viruses, *M. persicae*, was found in all localities, but in high number just in the locality Begeč in 2007. Both subspecies of this species, which were registered a couple years ago in our country (Vučetić et al., 2010), were found in the yellow water traps. The most abundant species was *Brachycaudus helichrysi*. It was found in huge numbers in all localities in 2007, especially in the locality Kotraž where over 1500 specimens were caught during the monitoring. The invasive species *Trichosiphonaphis polygonifoliae* (Shinji) that has recently been discovered on its host plant (Petrović-Obradović et al., 2010) was found in the yellow water traps.

The largest number of aphids was trapped in the locality Kotraž in 2007 when 2815 specimens were collected in two traps. In that locality a large number of aphids was recorded in the next two years, but it was not as high as in year 2007. In both localities on Mt. Golija a very low number of aphids was recorded. It was the lowest in 2008, when during the whole vegetation period only 2 aphid specimens were collected in the locality Golija 1, and 3 specimens were collected in four traps in Golija 2.

In the locality Begeč in both years of investigation, a large number of aphids was recorded (1535 in 2007, while in 2008 there were 1283 specimens). In 2007 vector pressure for both viruses reached its maximum in the fourth week of monitoring; on May 24 it amounted to an average of 60 per trap for PVY and 50 for PLRV (Fig. 1).

In the following year, in the same locality, the situation was different. The vector pressure index for PLRV was higher than that for PVY, meaning that the danger of PLRV transmittance was higher than that of PVY (Fig. 2). However, the maximum index rate for both viruses was lower than in the previous year, and it reached its peak on 9 June.

In the locality Golija 1, in all three years of investigation, the number of aphids was low, as well as the total vector pressure. In 2007, vector pressure reached its maximum in the sixth week of monitoring (June 22), when it averaged 3.2 per trap for PVY, while for PLRV it was 1.7 (Fig. 3). In 2008, there were two aphids, one on 7 July and another on 10 August. The risk of infection was negligible. In 2009, the number of aphids was higher, so the risk was also higher. The maximum was reached at the very end of monitoring, on 26 July, and it was higher for PLRV than for PVY (Fig. 4).

In the second locality on the mountain Golija (Golija 2), at the altitude of about 1300 m, the number of vectors during all three years of monitoring was low. The highest vector pressure index was recorded in 2007, a little lower in 2009. In 2008, only three aphids were recorded: the first on 29 June, the second on 6 July and the third one on 13 July. The risk of infection was negligible. The maximum index in 2007 was recorded on 22 July, while PVY infection risk was higher than that of PLRV (Fig. 5). In 2009, the maximum was recorded on 19 July. It was higher for PLRV, but still very low for both viruses (Fig. 6).

Kotraž is the locality where in 2007 the largest number of aphids was found, among which the most numerous were specimens of the species *B. helichrysi*, vectors of PVY, so the total vector index for this virus in all four years of investigation was the highest in this locality in the fourth week of monitoring and it was 180 (3 June). The index value for PLRV was considerably lower (Fig. 7).

In the following two years of monitoring, the number of aphids was significantly lower, the number of viruses as well, while *B. helichrysi* has not been re-

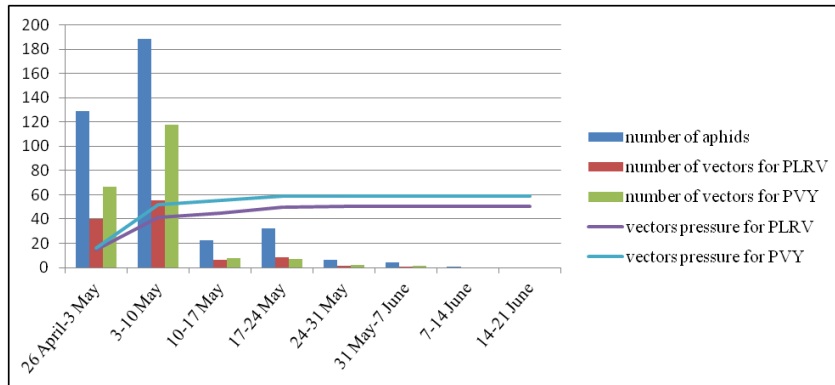


Fig. 1. Average number of aphids, vectors and vector pressure for PLRV and PVY per trap in locality Begeč in year 2007.

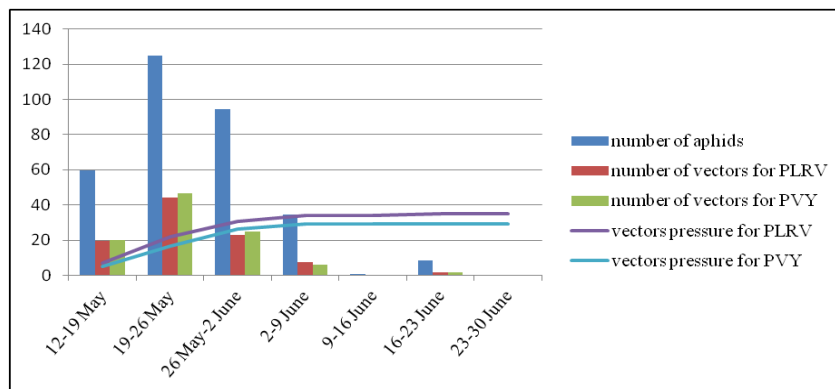


Fig. 2. Average number of aphids, vectors and vector pressure for PLRV and PVY per trap in locality Begeč in year 2008.

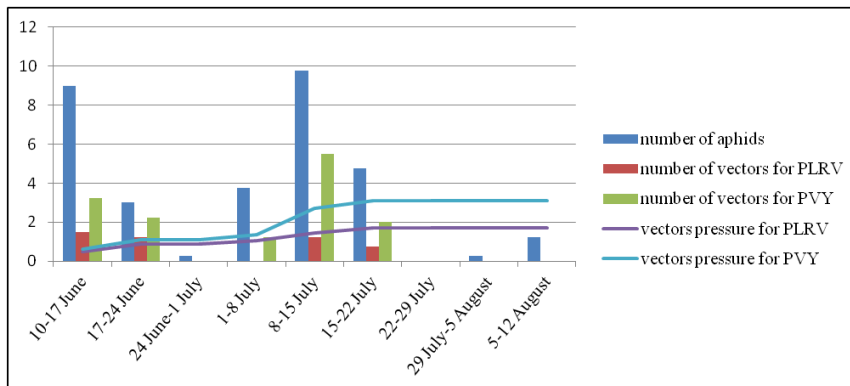


Fig. 3. Average number of aphids, vectors and vector pressure for PLRV and PVY per trap in locality Golija 1 in year 2007.

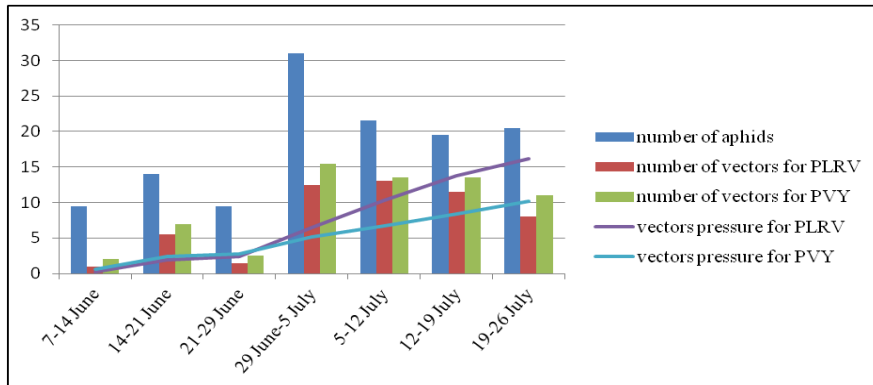


Fig. 4. Average number of aphids, vectors and vector pressure for PLRV and PVY per trap in locality Golija 1 in year 2009.

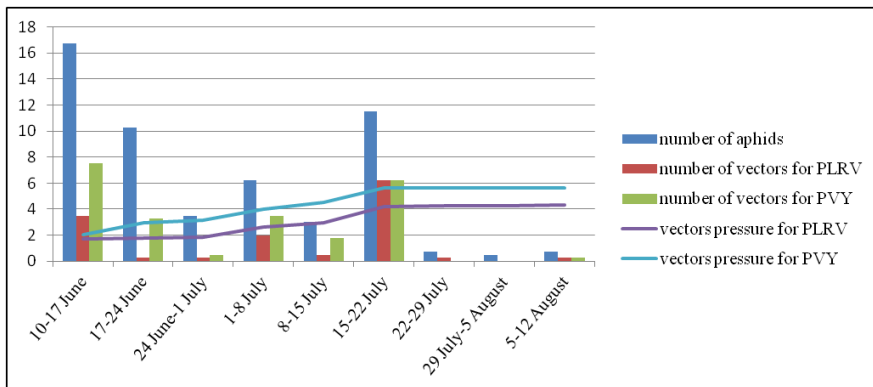


Fig. 5. Average number of aphids, vectors and vector pressure for PLRV and PVY per trap in locality Golija 2 in year 2007.

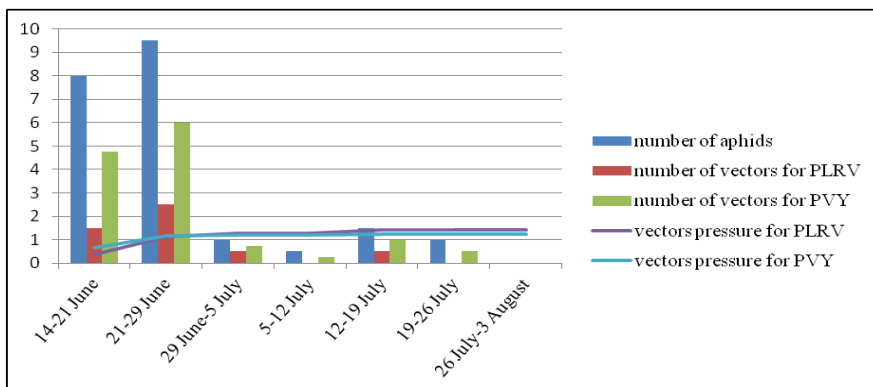


Fig. 6. Average number of aphids, vectors and vector pressure for PLRV and PVY per trap in locality Golija 2 in year 2009.

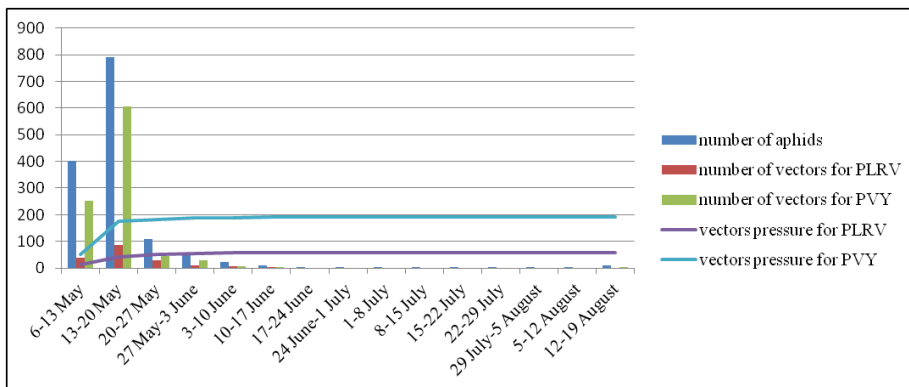


Fig. 7. Average number of aphids, vectors and vector pressure for PLRV and PVY per trap in locality Kotraža in year 2007.

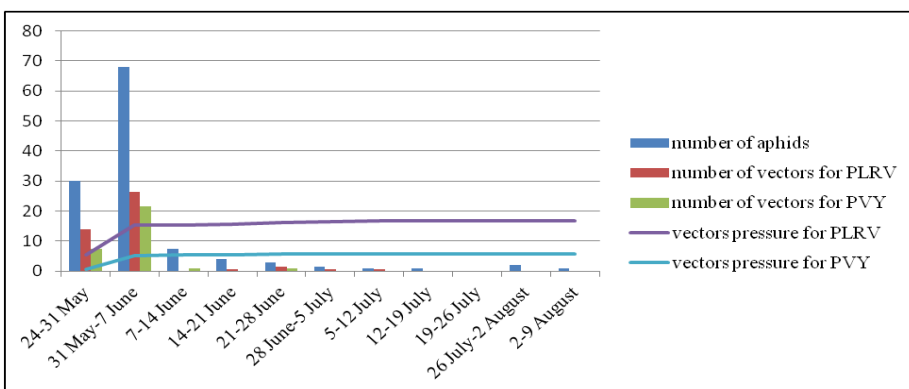


Fig. 8. Average number of aphids, vectors and vector pressure for PLRV and PVY per trap in locality Kotraža in year 2008.

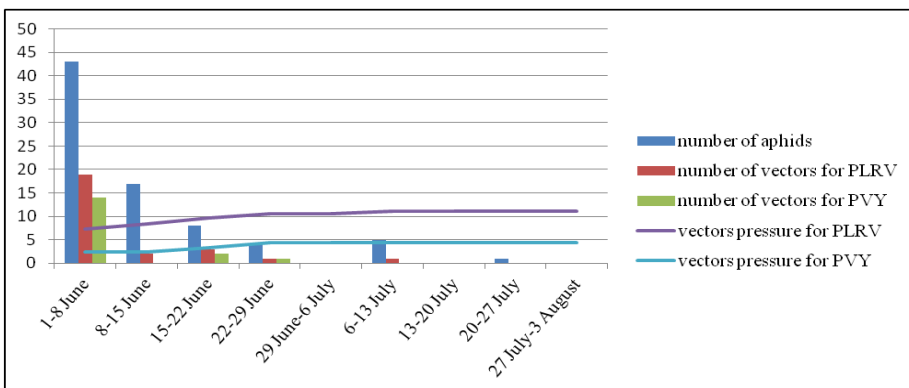


Fig. 9. Average number of aphids, vectors and vector pressure for PLRV and PVY per trap in locality Kotraža in year 2010.

corded in large amounts. Therefore the total vector indexes in both years were a lot lower, i.e. the virus transmittance risk was lower than in 2007. In 2008, the vector pressure suddenly rose in the second week of monitoring (7 June) and remained at the same level until the end of monitoring (Fig. 8). In 2010, it rose slowly until 29 June, remaining at nearly the same level until the end of monitoring (Fig. 9).

Comparing the total vector pressure indexes in all the analyzed localities, it can be concluded that the highest index was in Kotražica in 2007, when the PVY index exceeded the value of 180, while for PLRV it was 60. In the same year in Begeč, the PVY index reached 60 and for PLRV it was a little lower. That number of vectors and such high indexes was not repeated in the following years. High index values were recorded in Begeč in 2008. The lowest index values were recorded in Golija 2.

DISCUSSION

In the localities Begeč and Kotražica, potato sowing is usually undertaken in April, while there is an intensive growth of potato in May when aphid flight is at its maximum and the risk of virus infection is the highest. Potato is the most sensitive during the first development phases, until flowering (DiFonso et al., 1994). In some countries, earlier sowing and the removal of the aboveground mass are carried out at critical phases of virus development inside a plant (Van Harten, 1983). The results of these investigations indicate that early desiccation is not possible in our country because it would completely interrupt the plant's vegetation and the yield would be lost. According to Sigvald (1987), a virus needs three weeks to go down from the leaves to the tubers, while according to Basky (2002), it needs 12 days. Following the recommendation of Basky (2002), desiccation of the aboveground mass should be done 12 days after the cumulative vector index has reached 10 and it is possible to produce healthy seed material if the vector index does not exceed 10-15 until the end of June, beginning of July. The only region satisfying these criteria in our research is Mt. Golija, where index values never exceeded the critical limit for the critical period.

Ideal areas for the production of seed potato are isolated, areas without a source of inoculum. In some countries, the solution is growing potato at high altitudes, isolated from other plant production. Based on these criteria, Golija is the most suitable for growing seed potato. Besides the number of aphids being lower at high altitudes, later sowing enables avoidance of the periods of maximum aphid flight. The result of late sowing was a very low number of aphids in this locality in 2008. In addition, at higher altitudes, agricultural production is not intensive and the possibilities for isolated production are stronger.

These investigations include the regions of Serbia where seed potato has already been grown for many years. However, results show that only on Golija, especially at high altitudes, is it possible to grow healthy, non-viral seed potato. This research indicates that the potential of the other mountainous regions of Serbia where potato is grown is good and that Serbia has the capacity for the production of quality seed potato.

Neighboring countries such as Bosnia and Herzegovina, Croatia, Bulgaria and Romania have similar relief, vegetation composition, composition of aphid fauna, and the possibility of crop production. For all these reasons, this research may have relevance and application in other countries as well.

Acknowledgments - The research was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Project No. III 46008 – Development of integrated management of harmful organisms in plant production in order to overcome resistance and to improve food quality and safety).

REFERENCES

- Basky, Z. (2002). The relationship between aphid dynamics and two prominent potato viruses (PVY and PLRV) in seed potatoes in Hungary. *Crop Protection* **21**, 823–827
- DiFonso, C.D., Ragsdale, E.B., Radcliffe, E.B. and E.E. Banttari (1994). Susceptibility to potato leafroll virus in potato: effects of cultivars, plant age at inoculation, and inoculation pressure on tuber infection. *Plant Disease* **78**, 1173–1177
- Jacky, F. and Y. Bouchery (1988). Atlas des formes ailees des especes courantes de pucerons. INRA, 48 pp.

- Kuroli, G. and Z.S. Lantos (2006). Long-term Study of Alata Aphid Flight Activity and Abundance of Potato Colonizing Aphid Species. *Acta Phytopatologica et Entomologica Hungarica* **41** (3-4), 261-273
- Milošević, D and O. Petrović (1997). A study of aphids flight activity (Homoptera, Aphididae) potential vectors of potato viruses. *Acta Hort* **462**, 999-1006
- Petrović-Obradović, O., Tomanović, Ž., Poljaković-Pajnik L., Hrnčić S., Vučetić A., and Radonjić S. (2010): New invasive species of aphids (Hemiptera, Aphididae) in Serbia and Montenegro. *Arch. Biol. Sci. Belgrade*, **62** (3), 775-780
- Ragsdale, D.W., Radcliffe, E.B. and C.D. DiFonso (2001). Virus and Virus-like Diseases of Potatoes and Production of Seed-Potatoes. The Netherlands, Kluwer Academic Publishers. Chapter 9. Epidemiology and Field Control of PVY and PLRV; 237-270
- Remaudiere, G. and M.V. Seco Fernandez (1990). Claves para ayudar al reconocimiento de alados depulgonas trapeados en la region mediterranea (Hom. Aphidoidea). Universidad De León, León, 2V, 205 pp.
- Robert, I. and D. Bourdin (2001). Virus and Virus-like Diseases of Potatoes and Production of Seed-Potatoes. The Netherlands, Kluwer Academic Publishers. Chapter 8. Transmission of Viruses. Aphid transmission of potato viruses; 195-226
- Sigvald, R. (1987). Aphid migration and the importance of some aphid species as vectors of potato virus Y⁰ (PVY⁰) in Sweden. *Potato Research* **30**, 267-283
- Sigvald, R. (1989). Relationship between aphid occurrence and spread of potato virus Y (PVY) in field experiments in southern Sweden. *J. Appl. Ent.* **108**, 35-4
- Taylor, L.R. (1984). A Handbook for Aphid Identification. (A Handbook for the Rapid Identification of the Alate Aphids of Great Britain and Europe). Roth. Exp. Stat., Harpenden, 171 pp
- Van Harten, A. (1983). The relation between aphid flights and the spread of potato virus Y^N (PVY^N) in the Netherlands. *Potato Research*. **26**, 1-15
- Vučetić, A., Petrović-Obradović, O. and Stanisavljević, Lj. (2010): Morphological variation of *Myzus persicae* (Hemiptera: Aphididae) from peach and tobacco in Serbia and Montenegro. *Arch. Biol. Sci. Belgrade*, **62** (3), 767-774
- <http://aphmon.csl.gov.uk>