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Comparison of Mineral Oil and Rapeseed Oil Used for the Protection of Seed Potatoes against PVY and PVM Infections

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Abstract The aim of this research was to compare the effectiveness of mineral oil with rapeseed oil in the protection of potato seeds against *Potato virus Y* (PVY) and *Potato virus M* (PVM) infection. The research was carried out under field conditions in the north of Poland, in the Department of Potato Protection and Seed Science of the Plant Breeding and Acclimatization Institute—National Research Institute at Bonin. The effects of oil protection on potato seed infection by viruses, yield, and its structure and phytotoxity were assessed. Two rapeseed oils and one mineral oil were used: Olejan 85 EC (85% of natural rapeseed oil), alimentary oil Marlibo (100% of natural rapeseed oil) and Sunspray 850 EC (98.8% mineral oil+1.2% emulsifier). The effectiveness of oils in protection against PVY and PVM tuber infection was tested on two cultivars (Clarissa and Rosalind), which have a different level of resistance to the two viruses. The assessment of phytotoxicity was carried out on 10 potato cultivars from different earliness groups (Augusta, Bryza, Cekin, Clarissa, Impala, Krasa, Rosalind, Satina, Velox). Two oil concentrations, 2% and 4% were applied. During the growing period, eight to nine oil treatments were applied at 7-day intervals. The effectiveness of rapeseed oils against PVY and PVM was much weaker than that of the mineral oil and for the susceptible cultivar the percentage infected tubers did not differ significantly from untreated crops. However, Olejan 85 EC deserves attention as it significantly reduced PVY infection across years in the more resistant cultivar, especially in the case of a lower concentration (2% vs. 4%). When there are no other means of protection to use on organic seed plantations, this oil can be used as an alternative, especially in the case of cultivars which are moderately resistant to PVY. A disadvantage of its application may be the fact that in some years symptoms of phytotoxicity on potato plants were recorded and a lowering of tuber yield.

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Introduction

The application of oil substances in plant protection has become increasingly important in the world, especially in the context of reducing the use of conventional plant protection. In many cases, the effectiveness of using oils is comparable to that of conventional protection. Among oil substances, the most common are mineral oils which have been used for many years in the protection of, inter alia, fruit orchards against attack from spider mites and aphids (Heng et al. 2002). Oils play a key role in integrated programs against pests and diseases in the USA (Kallianpur et al. 2002), New Zealand (Beresford et al. 1996), Australia (Nicetic et al. 2001, 2002; Northover and Timmer 2002). As early as the 1960s, consideration was given to the possibility of applying oil substances to protect against viruses, especially against *Potato virus Y* (PVY; Bradley et al. 1962, 1966; Bradley 1963). Kurppa and Hassai (1989), Milošević (1996), Turska and Wróbel (1999), Rolot et al. (2008), Boiteau et al. (2009) have since registered high efficacy (over 50%) in potato protection against PVY infection in field conditions. According to Boiteau et al. (2009) in addition to the use of mineral oil, increased protection can be achieved by creating adequate isolation surrounding the crops, e.g., planting potatoes resistant to PVY. In later research, it was shown that some oil substances, apart from providing PVY protection may also protect potatoes against *Potato virus M* (PVM; Kostiw and Iskrzycka 1976) and *Potato virus S* and to some extent against *Potato leafroll virus* (Turska 1984).

In the case of seed potato crops, mineral oils applied during the growing period provide an effective means of limiting infection by nonpersistent viruses transmitted by aphids, such as PVY and PVM (Wróbel 2006).

The PVY virus, which belongs to the *Potyviridae* family, constitutes the greatest threat to potato crops (Chrzanowska and Zagórska 2004; Kostiw 2011). It is present in the form of several strains or pathotypes with different immunological characteristics (PVY^{0}, PVY^{N}, PVY^{N}Wi, PVY^{NTN}, PVY^{C}, PVY^{E}). Genomes of these strains can be easily recombined leading to the formation of combinations of different biological and immunological features, e.g., PVY^{NTN-NW} (Chikh Ali et al. 2010). At present, in Poland there are mainly PVY^{N-Wi} and PVY^{NTN} strains in a ratio of 80:20%. The PVY^{0} strain, which was common some time ago, has, for some years now, been very rarely registered in Poland (Kaczmarek et al. 1998; Chrzanowska 2009). The PVM virus belongs to the Carlavirus family; it is present more commonly in the eastern part of Europe than in other parts of the world (Loebenstein and Thottappilly 2003). It is not as economically significant as PVY, though it can be in case plant varieties are infected that strongly react to infection with this pathogen (Chrzanowska and Zagórska 1996). Both viruses, PVY and PVM are transmitted by aphids in a nonpersistent manner on rostrums (Kostiw 1987; Basky 2003). Many of the aphid species are capable of transmitting viruses on rostrums. However, aphids for which potatoes are host plants are most efficient in this respect (Kostiw 1987). In Poland, the most successful of these are: *Myzus persicae*, *Aphis nasturtii* Kalt., *Aphis frangulae* Kalt., *Macrosiphum euphoribiae* Thom., and *Aulacorthum solani* Kalt. *M.*

persicae is the most effective vector of PVY (Sigvald 1984; Kostiw 1987; Derron and Goy 1990; Cerato et al. 1994; Collar et al. 1997). *A. nasturtii* (Kostiw 1987), which is an effective vector of PVM because of its abundance on potato crops, also has the greatest practical importance in the case of PVY (Kostiw 2011). In addition, some aphids, which may accidentally fly over potato crops looking for a host plant but for which potato is not a host plant, are becoming more and more significant in transmitting nonpersistent viruses in the initial period of the growth season (Kostiw and Robak 2008, 2010). This is connected with their earlier (by 2 weeks or so) and more intensive flights.

In addition to mineral oils, vegetable oils are highly effective in plant protection against some pests. Their usefulness for reducing fungal diseases was reported for zucchini (Cheah and Cox 1995), cucumber (Haberle and Schlösser 1993; Nikolov 2000; Goodwin et al. 2002), tomato (Ko et al. 2003), roses (Wojdyła 2002), and in fruit orchards (Azam et al. 1998; Beattie et al. 2002). Many authors have pointed out that the effectiveness of vegetable oil's protection was similar to or higher than that of synthetic fungicides (Azam et al. 1998; Chauvel et al. 1998; Nikolov 2000; Wojdyła 2002).

Within the literature, there is no information concerned with the impact of vegetable oils on reducing virus spread in potato crops. In some minor references on other plants, authors state that vegetable oils did not have an effect on *Beet yellow virus* and *Beet mosaic virus* (Vanderveken 1968), or that their effectiveness on other plants was limited (Asjes and Blom-Barnhoorn 1994). Therefore, the frequently noted, high effectiveness of vegetable oils in plant protection against fungal diseases prompts the question whether rapeseed oil can be applied in the protection of potatoes against virus infections. This has potential for organic seed potato production where applying synthetic, chemical, plant protection products is not permitted (Council Regulation No 834/2007, www.ior.poznan.pl). The aim of this research was thus to compare the effectiveness of mineral oil with rapeseed oil in the protection of potato seeds against PVY and PVM infection.

Material and Methods

The research was carried out under field conditions during 2005–2007 in the north of Poland at the Department of Potato Protection and Seed Science of the Plant Breeding and Acclimatization Institute—National Research Institute in Bonin. Two kinds of rapeseed oil were assessed, each with different formulations: adjuvant Olejan 85 EC (85% rapeseed oil of natural growth), which is commercially available, and alimentary Marlibo (100% rapeseed oil of natural growth). Mineral oil Sunspray 850 EC (98.8% mineral oil+1.2% emulsifier) was used as a standard treatment.

The impact of oils on virus infections was assessed on two potato cultivars which differed in terms of earliness and level of resistance to viruses: Rosalind, an early cultivar (resistance to PVY 5.5 and to PVM 3.5 on scale 1–9, in which 1 means lack of resistance, and 9 extreme resistance) and Clarissa, a medium-early cultivar (resistance to PVY 4.5 and to PVM 3). The assessment of potential phytotoxic activity of the oils was carried out on 10 potato cultivars from different earliness groups (Augusta, Bryza, Cekin, Clarissa, Impala, Krasa, Nora, Rosalind, Satina, Velox). Each year, new seed potato material in elite state (B/I or B/II) came from breeding companies.

The experiments were split-plot experiments. Each block was divided into seven randomly placed main plots out of which six were protected with one of the three oils in two concentrations (2% and 4%), whereas one main plot was the control—without oil protection. Within each main plot, 10 potato cultivars were arranged randomly, 50 plants in a row (row spacing, 0.75 m; plant spacing within a row, 0.3 m). Additionally, around each main plot, 100 potato plants which were secondarily infected with PVY and PVM were planted as infection source to increase virus pressure. The experiments were carried out using three replicated blocks

Spraying of plants with oils was carried out using a small tractor sprayer and centrifugal sprayer (size, 1.0) at a pressure of approximately 10 bar. Two concentrations of oils, 2% and 4%, in water were used. The Marlibo oil did not dissolve in water due to the lack of emulsifier. Therefore, both prior to and during the treatment, the liquids in the container were intensely mixed. In this way, a homogenously distributed suspension of oil in water was obtained. Olejan 85 EC and Sunspray 850 EC contained emulsifier and after mixing with water formed an emulsion, i.e., a seemingly homogenous mixture.

During the growing period eight to nine treatments were carried out at 7-day intervals. The first treatment was conducted when 75–90% of plants had emerged. The last treatment was carried out 1 week before the haulm destruction. Haulms were destructed by means of a mechanical–chemical method. First, the above ground part of the plant was damaged using tractor haulm-cutting, leaving about 15 cm of haulm; then, the remaining part was sprayed with Reglone 200 SL in a 50% lowered dose, i.e., 2.5 l ha^{-1}.

During the growing period, observations on the dynamics of plant colonization by aphids were made every 10 days. Observations were made by taking randomly 100 individual leaves per main plot from the middle part of the plants, and counting all aphids and subdividing them into species and developmental forms.

About 2 weeks after haulm destruction, the tuber samples were collected. In order to assess the PVY and PVM infection level, a single potato tuber was collected from every plant at random; the diameter of the tuber was 40–50 mm, and in total thus three times 50 tubers were picked for a single combination. In order to assess the structure of the yield, the yield of 10 consecutive plants was collected from the centre of the ridge. The total yield was recorded on the collected material from the entire plot.

The assessment of PVY and PVM infection of the collected tubers was carried out in the spring (April–May) of the following year, after 8–9 months of storage, in postharvest virus tests in greenhouse conditions, using a double antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA) test. The procedure was as follows: fragments of the tubers with an eye were removed and planted in pots with a soil substrate in a glasshouse. Approximately 4 weeks after emergence of the plants, two to three leaves were taken from the nodes of each plant and sap was squeezed out of them. In this plant sap (diluted with buffer in ratio 1:10), the share of viruses PVY and PVM was assessed using a standard procedure of the DAS-ELISA test described by Clark and Adams (1977). Polyclonal antibodies by Bioreba and microtiter F-type plates Kartell (cat nr. 02620-00) were used.

Prior to statistical analysis, the numbers of aphids were transformed logarithmically according to a formula log $(n+1)$, in which n denotes the number of aphids per area. To determine the extent of tuber virus infection, we used a transformation for constant inoculums (number of plants secondarily infected with PVY and PVM around an area) according to the formula (Wójcik et al. 1976).

$$y = \log\left[100\ \ln\left(1 - \frac{value\ in\ \%}{100}\right)^{-1}\right] + 1$$

in which y = value after transformation and *value in* % = values of virus infection in percentage.

The obtained values were subjected to an analysis of variance. In order to determine the significance of differences between the studied combinations, mean values were tested with Tukey's test at a significance level of α=0.05. Statistical calculations were made using the program Statistica 9.0. Following the analyses, the obtained values were retransformed into numbers or percentages as presented in the following section.

Results and Discussion

Phytotoxicity

Vegetable oils may at times produce stronger phytotoxic reaction symptoms than mineral oils (McKenna 1999; Nikolov 2000; Wojdyła 2002). This depends on numerous factors, such as the species of a protected plant, the type of oil applied, its physical–chemical properties, applied concentration, as well as the frequency and conditions of the application. A reaction of potato plants under field conditions (practically on all cultivars) was observed only after the application of Olejan 85 EC oil; the reaction was slight and depended on the research year. Possibly because of severe weather conditions in 2006 (drought) and 2007 (excessive rainfall), there were no visible symptoms of phytotoxicity in these years. Clear symptoms were only observed in 2005, with the diminution and wrinkling of the youngest leaves which, to an inexperienced observer, could seem to be the result of PVM infection and which, as a result, would hamper roguing. These observations confirm earlier results of research conducted in glasshouse conditions (Urbanowicz and Wróbel 2005; Wróbel and Urbanowicz 2007). Similar symptoms on celery plants following the application of mineral oil were observed by Traicevski et al. (2002).

Another symptom which was recorded frequently was the deformation of leaves of the lower level, which took a shape of a little boat turned inside out (sides of leaf blade rolled downwards with their longer ridges) or had an unnatural shape—notches on leaf ridges. Effects on the plants were clearest in the third decade of June, i.e., after three treatments. Later (end of third decade of July), a complete disappearance of phytotoxicity symptoms was recorded. At the higher concentration, we also recorded occasionally dark brown stains (reminiscent of necrosis) along nerves on the bottom side of the leaf blade which looked to some extent like the effects of first degree of PVY infection. Unlike the symptoms of PVY infection, however, the necrosis had a clearly greasy (shiny) look. Beattie et al. (2002) also point to a diverse phytotoxicity reaction of various products based on rapeseed oil applied for citrus trees protection.

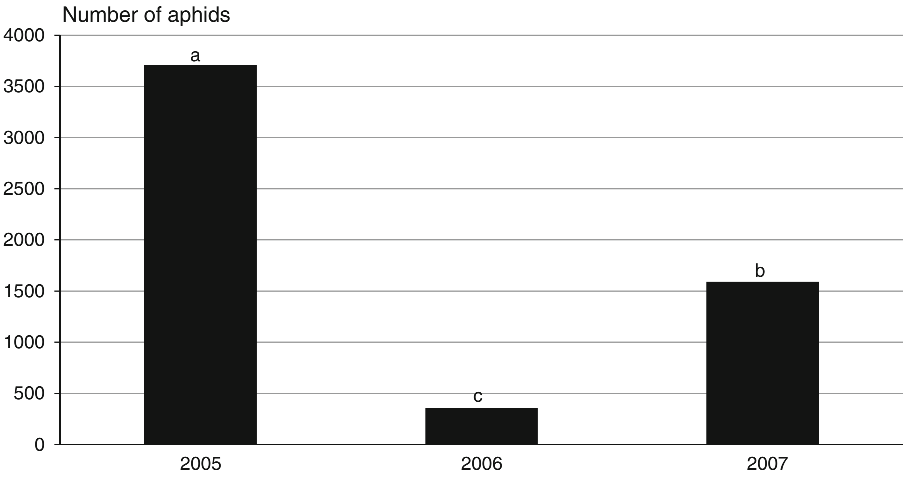

Fig. 1 Number of *M. persicae* and *A. nasturtii* aphids on potatoes in 2005–2007 (total number of aphids on 100 leaves from I. decade of June until III. decade of July). Means with the same *letters* do not differ significantly according to the Tukey test (α=0.05)

Aphids

Aphids such as *M. persicae* and *A. nasturtii*, to which potatoes are a host plant, were most numerous in 2005 (Fig. 1), whereas *A. nasturtii* was the dominating species (Kostiw and Robak 2007). Regardless of the year, all oils caused an increase in the number of aphids in comparison with those objects with no oil protection (Fig. 2), but differences were only significant for Marlibo. The greater number of aphids on plants protected with rape oil may be connected with a better turgor pressure of the plants during drought. The oil layer on the plants effectively limited transpiration which was evident during hot days.

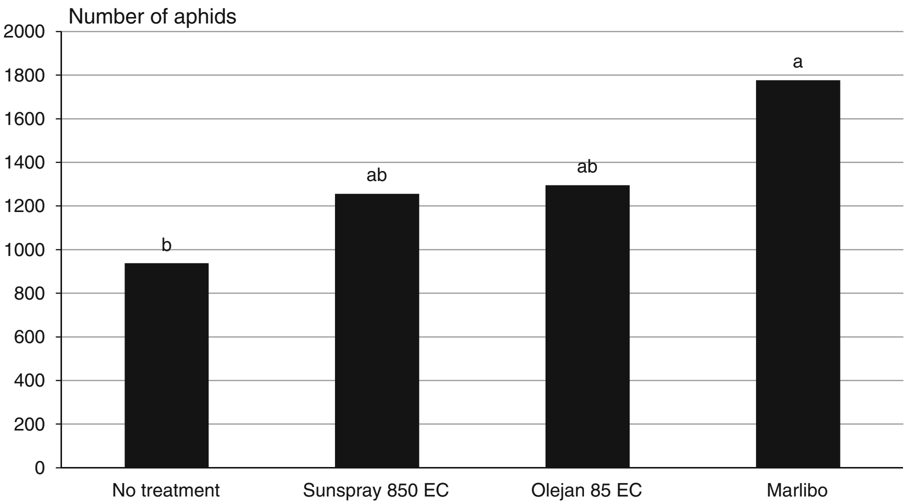

Fig. 2 Total number of aphids observed on potatoes during the growing season (means across years 2005–2007 in time period from I decade of June until III decade of July). Means with the same *letters* do not differ significantly according to the Tukey test (α=0.05)

Table 1 PVY infection of potato tubers (% infected tubers) in cv. Clarissa under different oil treatments

Oil	Years			Mean
	2005	2006	2007	
No treatment	72.6 a	72.2 a	74.8 a	73.2 a
Sunspray 850 EC	34.5 b	37.1 b	26.3 b	32.4 b
Olejan 85 EC	72.3 a	67.2 a	61.7 a	67.1 a
Marlibo	50.7 a	92.1 a	57.6 a	68.5 a

Means within a column with the same letters do not differ significantly according to Tukey's test (α=0.05)

There is no literature on the impact of rapeseed oil on aphids. Some observations are provided in a paper by Martín-López et al. (2006) in which the authors observed in laboratory conditions a higher mortality rate of *M. persicae* on tobacco leaves of imidacloprid in combination with rapeseed oil then following application with the insecticide only. In the case of mineral oils, there is no agreement. Some authors observed a reducing effect of mineral oils on aphid numbers (Heng et al. 2002; Martín-López et al. 2006; Wróbel 2006). Others, however, observed no effect at all (Turska and Wróbel 1999). This is probably associated with the weather conditions during the growth season, diverse aphid pressure, and the kind and dose of the applied oil.

Viruses

The percentage of PVY infection was very high during the research years (Tables 1 and 2). A clear response in plant resistance was registered. Cultivar Clarissa—which was slightly more susceptible to virus infection—was infected much more with PVY than cv. Rosalind (Tables 1 and 2).

The percentage of PVM infection was much lower than that of PVY (Tables 3 and 4). In 2005, when high numbers of aphids were recorded (Fig. 1), tuber infection was decisively higher than in the following years. Except in 2006, no significant differences in the level of PVM infection between the cultivars were registered, despite their different resistance level.

The higher infection in some years can be explained by the role of noncolonizing aphids which do not primarily feed on potato plants but do occasionally feed on them

Table 2 PVY infection of potato tubers (% infected tubers) in cv. Rosalind under different oil treatments

Oils	Years			Mean
	2005	2006	2007	
No treatment	60.9 a	40.7 a,b	44.7 a	48.5 a
Sunspray 850 EC	21.1 b	31.1 a,b	15.7 b	22.0 b
Olejan 85 EC	36.3 a	20.1 b	38.6 a	30.7 b
Marlibo	48.1 a	44.8 a	37.9 a	43.5 a

Means within a column with the same letters do not differ significantly according to Tukey's test (α=0.05)

Table 3 PVM infection of potato tubers (% infected tubers) in cv. Clarissa under different oil treatments

Oils	Years			Mean
	2005	2006	2007	
No treatment	38.2 a	12.0 a	18.8 a	21.0 a
Sunspray 850 EC	35.8 a	4.8 b	4.2 b	9.7 b
Olejan 85 EC	34.9 a	14.5 a	7.3 ab	16.0 ab
Marlibo	33.6 a	18.4 a	5.7 ab	15.9 ab

Means within a column with the same letters do not differ significantly according to Tukey's test (α=0.05)

while searching for a more suitable host. These aphids play an important role in transmitting nonpersistent viruses (Kostiw and Robak 2010). Despite the fact that in 2005–2007 one could observe only a single "non-potato" aphid specimen on potato leaves (Table 5), the early appearance of these aphids, especially in 2005 and 2006, may have contributed to higher infection of potato seeds with PVY and PVM (Kostiw and Robak 2007).

The differing resistance of the cultivars had a significant impact the effectiveness of protection by particular oil treatments. For the more susceptible cultivar Clarissa, in each year of the research, only the mineral oil Sunspray 850 EC turned out to be effective (Table 1); the level of seed potato infestation by PVY was more than 50% lower than in the control. However, the application of rapeseed oils for the protection of potatoes did not reduce the PVY infestation level of potato tubers in this cultivar. For cv. Rosalind, which is slightly more resistant to PVY infection than cv. Clarissa, following Sunspray 850EC mineral oil it was rapeseed oil Olejan 85 EC that reduced PVY infection of potato tubers across years (Table 2). The effectiveness of protection against PVY infection of tubers was not significantly different from that of the mineral oil across years and in the 2006 season, which was regarded a dry season with a small amount of rainfall and low level of aphids. In the remaining years of the research, its effectiveness was slightly weaker than that of the mineral oil. Similar results were obtained by Martín-López et al. (2006) who, in field conditions, sprayed eight times mineral oil and rapeseed oil onto seed potato plants treated with imidacloprid before sowing. Mineral oil reduced PVY-infected

Table 4 PVM infection of potato tubers (% infected tubers) in cv. Rosalind under different oil treatments

Oils	Years			Mean
	2005	2006	2007	
No treatment	25.2 a	3.8 a	9.9 a	10.3 a
Sunspray 850 EC	29.2 a	7.6 a	5.3 a	11.0 a
Olejan 85 EC	25.9 a	5.7 a	4.6 a	9.2 a
Marlibo	36.9 a	9.6 a	9.8 a	15.7 a

Means within a column with the same letters do not differ significantly according to the Tukey's test (α=0.05)

Table 5 Number of aphids noncolonizing potatoes and time of first trapping in 2005–2007 (total number of aphids on 100 leaves from I decade of June until III decade of July)

Years	No treatment	Sunspray 850 EC		Olejan 850 EC		Marlibo		Time of first aphids caught into yellow traps[a]	
		concentration		concentration		concentration		*M. persicae*+ *A. nasturtii*	aphids noncolonizing potatoes
		2%	4%	2%	4%	2%	4%		
2005	3	31	2	7	3	11	11	15.06	1.06
2006	13	7	9	3	2	0	3	12.06	31.05
2007	5	12	14	8	10	4	12	21.05	26.05

[a] Kostiw and Robak (2007)

plants by 60% and rapeseed oil by 40% compared with plots treated with imidacloprid only.

Effects of oil treatment on percentage tubers infected by PVM were only observed in the more susceptible cultivar Clarissa with only mineral oil reducing PVM infection in 2006, 2007, and across years (Tables 3 and 4). Both rapeseed oils showed an effectiveness that did not differ significantly from mineral oil and the untreated plots only in 2007. This testifies to their weak ability to protect potato crops against infection which in practice does not qualify rapeseed oils for potato protection against PVM infection.

No difference in protection against PVY and PVM infection of the tubers was registered between the applied concentrations in any of the years (Tables 6 and 7). Because of this, in practice, it is possible to limit the application of doses of oils to 2%, without losing the effectiveness of protection against PVY and PVM infection of seed potatoes.

Low effectiveness of the assessed rapeseed oils partly agrees with the opinion of Asjes and Blom-Barnhoorn (1994), who in their research on limiting the infection of lilies with *Lily symptomless virus* and *Lily virus X* found that plant oils are slightly more effective at a lower infection pressure; however, as the threat of infection grew, their effectiveness decreased. According to Wenzl (1970), vegetable

Table 6 Impact of the applied oil concentration (2% and 4%) on PVY infection (% infected tubers) of two cultivars (means across the years 2005–2007)

Oil	Cv. Clarissa		Cv. Rosalind	
	2%	4%	2%	4%
No treatment	73.2		48.5	
Sunspray 850 EC	27.6 a	37.7 a	20.3 a	23.7 a
Olejan 85 EC	58.4 a	75.5 a	25.2 a	37.1 a
Marlibo	68.3 a	68.8 a	44.2 a	42.8 a

Means within a cultivar and oil treatment with the same letter do not differ significantly according to the Tukey's test ($\alpha=0.05$)

Table 7 Impact of the applied oil concentration (2% and 4%) on PVM infection (% infected tubers) of two cultivars (means across the years 2005–2007)

Oil	Cv. Clarissa		Cv. Rosalind	
	2%	4%	2%	4%
No treatment	21.0		10.3	
Sunspray 850 EC	15.4 a	5.9 a	11.5 a	10.6 a
Olejan 85 EC	12.7 a	20.0 a	12.7 a	6.6 a
Marlibo	16.8 a	15.1 a	16.3 a	15.2 a

Means within a cultivar and oil treatment with the same letter do not differ significantly according to Tukey's test (α=0.05)

oils are not as effective as mineral oils. The results of the present research confirm this assumption.

Yield and its Structure

The numerous treatments with the mineral oil Sunspray 850 EC and the rapeseed oil Maribo during the growing period did not affect tuber yield in cvs Clarissa and Rosalind (Fig. 3). However, after Olejan 85 EC application, the tuber yield was 10–25% lower in comparison with the control (no treatment) although the difference was not significant in cv. Rosalind. This resulted from, among others, the reproduction coefficient, i.e., the number of tubers which were produced by a single plant, which was significantly lower for plants protected by Olejan 85 EC in cv. Clarissa, with the same trend showing in the other cultivar without being significant (Fig. 4). A significantly lower yield for this oil was also observed in earlier glasshouse experiments (Urbanowicz and Wróbel 2005; Wróbel and Urbanowicz 2007). Partial

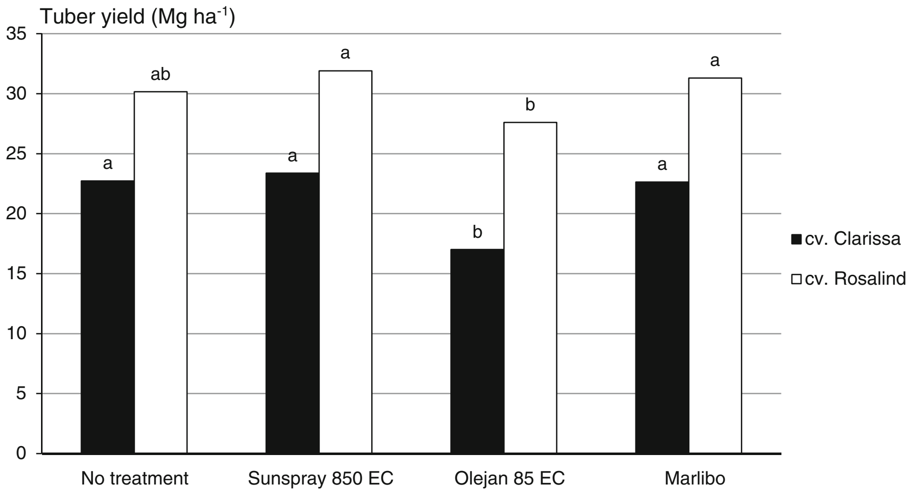

Fig. 3 Effect of oil treatment on total tuber yield of potato crops (means across the years 2005–2007) Means with the same *letter* do not differ significantly according to the Tukey test (α=0.05)

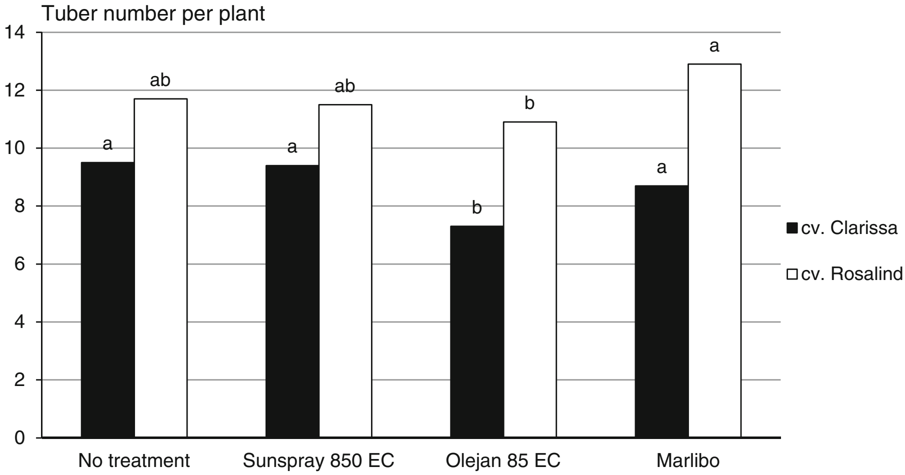

Fig. 4 Effect of oil treatment on the number of tubers per plant (means across the years 2005–2007). Means with the same letter do not differ significantly according to the Tukey test (α=0.05)

explanation of this phenomenon may be a consequence of the decreased productivity of potato plants themselves, which is connected with there being an oil layer on the leaves. According to Goszczyński et al. (2003), who studied gas exchange of rose leaves following the application of Sunspray 850 EC, a higher concentration limited photosynthesis and reduced CO_2 assimilation by 10% as soon as 24 h following the application. This phenomenon was observed for 3 days after the treatment. Mineral oil application also can lead to yield depressions caused by reduction in CO_2 uptake, e.g., in tomato (Gudin et al. 1976) and apple (Ayres and Barden 1975).

Regarding mineral oil effects on potato yield, some authors found a negative impact of oil protection (Kostiw and Iskrzycka 1976; Schepers et al. 1978; Turska 1980, 1984; Kurppa and Hassai 1989), while others registered a stimulating activity (Sepulveda and Navarrete 1996; Traicevski et al. 2002), although their research was not concerned with potato.

For seed potato production, a yield of tubers of 30–50 mm diameter is a more relevant parameter than the total yield. A higher yield of tubers in the size 30–50 mm was recorded after the application of Marlibo oil than after all other treatments in cv. Rosalind and then after Olejan 85 EC treatment in cv. Clarissa (Table 8). No significant impact of oil concentration on this yield parameter was recorded.

Table 8 Impact of the applied oil treatment on tuber yield (Mg ha^{-1}) in the seed grade (30–50 mm) for two cultivars (means across the years 2005–2007)

Oil	Cv. Clarissa	Cv. Rosalind
No treatment	10.6 ab	15.1 b
Sunspray 850 EC	12.0 a	15.5 b
Olejan 85 EC	9.2 b	15.3 b
Marlibo	11.4 a	19.9 a

Means within a cultivar with the same *letter* do not differ significantly according to Tukey's test (α=0.05)

Conclusions

The effectiveness of the protective capabilities of rapeseed oils against PVY and PVM infection was much weaker than in the case of mineral oil. In spite of this, it is worth mentioning that Olejan 85 EC reduced PVY infection across years compared with untreated plants in a more resistant cultivar (Clarissa), especially in smaller concentration (2% vs 4%).

Protection of cultivars which are susceptible to viruses, PVY in particular, by rapeseed oils is difficult, especially in regions that are not favorable for seed production. Adequate localization and spatial isolation are always important elements. No other treatments are as effective as proper isolation of healthy plants from infected ones. If one cannot provide such isolation, no treatment is capable of adequately protecting the crop against infection when there is high virus pressure. If there is a lack of direct means of protection for organic seed crops, Olejan 85 EC can be an alternative for cultivars susceptible to PVY (i.e., grade 5.5 or lower in scale 1–9, in which 1 means no resistance and 9 extreme resistance).

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