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INFLUENCE OF A PROLONG APPLICATION OF MINERAL OILS ON BULB YIELD, QUALITY OF CUT FLOWERS AND SPREAD OF VIRUSES IN TULIP CULTIVATION

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ABSTRACT

The experiments were designed to evaluate the impact of two mineral oils: Sunspray 850 EC (85% of mineral oil) and Sunspray Ultra-Fine (98.8% of mineral oil) applied for a prolonged time (2 vegetation seasons) on yields of tulip of 'Leen van der Mark' cv. Tulips were treated 3 times (since the mid of April till the beginning of May) at weekly intervals with the oils at concentrations: 1.0, 1.5, and 2.0%. The oil preparations used at concentrations 1.0–1.5% had no negative influence on stem and tepals lengths at tulips grown in the field. No phytotoxicity symptoms on stems nor leaves were found. On plots protected with mineral oils, percentage of virus-infected plants was lower than for control, while high efficiency was recorded only in 2011 when using Sunspray 850 EC at 1.0–2.0% concentration. The oil preparations applied for a prolonged time at concentration of 2.0% caused a decline in commercial and the first choice bulb yields. No negative sequential effects of oils on quality of obtained flowers during tulip forcing in a greenhouse, was observed. The efficiency of mineral oils in reducing the virus spread evaluated based on the number of virus-infected flowers during forcing in the greenhouse depended on the year of study and type of the oil. The best results were achieved applying Sunspray 850 EC at concentrations of 1.0–1.5%. Oil preparations can be safely applied for tulip cultivation for a prolonged time if concentration does not exceed 1.5%. Despite of positive effects in reducing the virus spread in the field growing and forcing, three spraying treatments using mineral oils during vegetation season did not ensure a complete plant protection against viral infections.

Key words: bulbous plant, virus spread, biological protection, oily substances, phytotoxicity

INTRODUCTION

One of the most important issues in tulip growing are diseases due to viruses transferred in an unstable way by aphids [Romanow et al. 1986, Hammond and Chastanger 1989, Dekker et al. 1993, Mowat 1995, Lesnaw and Ghabrial 2000, Sochacki 2007, Sochacki and Podwyszyńska 2012]. Resistance to viruses is shown only by tulips belonging to botanical groups [Romanow et al. 1986, Sochacki 2007]. Most of varieties grown for a commercial scale are very susceptible to viruses [Romanow et al. 1986], and the only way to reduce their spread is compete aphids [Wróbel 2006, 2008, 2011a, 2011b]. According to Wilson [1999], the insecticide treatment on tulip reproduction plantations is made every 7–10 days, from

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achievement of 10 cm height by plants till the vegetation complete. Such large number of treatments has a negative influence on tulip plants and the environment. An alternative solution is to apply the ecological preparations that do not contaminate the soil and do not kill the useful insects. Preparations produced on a base of refined mineral oils form a protective layer on stem and leaf surface, thus efficiently reducing the populations of aphids, spider mites, thrips, and soft scales. They are commonly used to compete these pests in growing of orchard and ornamental plants [Mizell 1991, Soika et al. 2008, Damavandian and Moosavi 2014]. Paraffin and plant-origin oils also found their applications in protection of potato seed plantations against viruses. The oil blocks the oxygen supply making death of aphids by suffocation [Wróbel 2006, 2008, 2011a, 2011b, Milošević et al. 2012]. These preparations are posed to biodegradation, however, they are not neutral to plants [Goszczyński et al. 2003, Goszczyński and Tomczyk 2004] and can penetrate to deep layers of leaf and stem tissues [Tan et al. 2005]. It was shown that the oil preparations may negatively affect the potato tuber yields if higher concentrations (4.0%) and large number of treatments are applied. It also depends on the type of the oil used [Wróbel and Urbanowicz 2007]. Reducing the photosynthesis and cellular metabolites transport can lead to the decrease in yields, which makes producers discouraged to use that type of plant protection means. Studies conducted upon lily, tulip, irises, dahlias, and hyacinth prove that mineral oil preparations in combination with insecticides efficiently reduced the spread of viruses and the drop in yields was economically acceptable [Asjes 1980a, 1980b, 1991, Mizell 1991, Asjes et al. 1996, Asjes and Blom-Barnhoorn 2001, 2002].

For a long time, viruses are a key problem in cultivation of different plant species. Up to 22 types of this pathogen were detected and described in tulip plants [Mowat 1995], while also new unknown to-date ones appear sometimes [Sochacki and Podwyszyńska 2012, Sochacki 2013]. The only one effective way to protect plants against this disease-forming factor is to prevent from the infection. Infected plants cannot recover. Attempts to treat the virus-infected *in vitro* cultures are led only for rare and valuable varieties, whereas their efficiency depends on the degree of virus-infection [Sochacki and Podwyszyńska 2012]. Most of wide-scale grown tulip varieties are very susceptible to infections, namely the TBV virus, that forms patterns of petals, while sometimes making inhibited growth and bulb yield decrease, which in consequence leads to the plant fading [Thomsen 1980, Romanow et al. 1986, Dekker et al. 1993, Lesnaw and Ghabrial 2000]. If infected plants are near the healthy ones and no rigorous selection is performed, viruses are quickly spread onto the intact plants through aphids that are the main vectors of majority of the most dangerous viruses [Hammond and Chastanger 1989, Wilson 1999, Wróbel 2011a, 2011b]. Sometimes, the virus spread is mediated by fungi (*Olpidium brassicae*), nematodes (*Trichodorus* spp.), and mites (*Acari* ssp.) [Sochacki 2013]. Viruses can be also transferred by a man an mechanical way during flowers cutting.

To compete aphids, insecticides are used that make a sudden death of these insects, however, these agents are not selective for useful insects. An alternative solution is the use of mineral oils that are the natural plant protection means. They show the insecticidal, miticidal, and fungicidal properties. In addition, they can protect plants against infection and disease-forming fungi development [Wojdyła 2012, 2013, Wojdyła and Łazęcka 2014, Wojdyła 2015]. The oils are subject to biodegradation due to ultraviolet radiation and do not contaminate soils like majority of pesticides used for plant protection. Advantage of the oils is also their action of insects determent and blockage of virus molecules on the aphid proboscis in such a way it cannot be actively transferred from infected to healthy plants [Wróbel 2006]. The oil particles are less moving within a plant as compared to the compounds contained in pesticides, while it was shown that they penetrate in an hour after treatment the internal leaf tissues, whereas reaching even the phloem and wood cells in stem within 48 hours. The oil penetration occurs through stomata and cuticle and its presence was found mainly in intercellular spaces. Oil can also diffuse to the palisade and spongy cells of the leaf parenchyma, not leading to the death of cell. However, it reduces the metabolites exchange [Tan et al. 2005].

Therefore, the study was undertaken aiming at evaluating the influence of two preparations based on the paraffin oils applied for a prolonged time (2 vegetation seasons) in the field cultivation of tulip, on their growth, yielding, and virus spread.

MATERIAL AND METHODS

The field and greenhouse experiments were carried out in 2009–2012 in the experimental farm Felin belonging to The University of Life Sciences in Lublin (Poland, 51°23'N, 22°56'E). The purpose of the study was to verify the impact of the mineral oils applied for two vegetation seasons on flowering and yielding of tulips. The experiments involved tulip bulbs of 'Len van der Mark' cv. obtained from experimental plots, where treatments using Sunspray 850 EC (85% of mineral oil, producer Sun Oil Company Belgium) and Sunspray Ultra-Fine (98.8% of paraffin oil, producer HollyFrontier GB) at concentrations of 1.0, 1.5, and 2.0% using 400 $L \cdot ha^{-1}$ water, were performed in the preceding season. From each plot, 45 bulbs each of >8 cm circumference were selected and planted in the mid of October onto the plots of $1m^2$ area. The experiment was established in randomized blocks pattern in 5 replicates. Tulips were sprayed 3 times using the same oil preparations: Sunspray 850 EC and Sunspray Ultra-Fine, according to the scheme used in the previous vegetation season (the first stage of the experiment). The oils were applied at weekly intervals since the mid of April till the beginning of May at the same concentrations (1.0, 1.5, and 2.0%) using 400 $L \cdot ha^{-1}$ water. The experiment included the control variant not treated with any oil preparations. The length of flower shoot from the soil surface to the end of tepals and length of tepals were measured at the stage of full flowering. Number of plants with visible virus-infection symptoms on petals was determined. Infested plants were removed and destroyed. At the end of June, the progeny bulbs were dug out, dried, cleaned, counted, and weighed. The total and commercial yields were estimated taking into account the bulbs of >11 cm circumference, as well as number and weight of the first choice bulbs (>12 cm circumference).

The greenhouse experiment was set up in order to evaluate the sequential effects of applied oil preparations on the quality of cut forced tulip flowers and virus spread. From each plot, 5 bulb each of >12 cm circumference were selected and planted in the mid of October into the plastic containers. The subsoil consisted of the topsoil under cereal cultivation. Containers with bulbs were placed into the cooling room and rooted at 9°C for 6 weeks, than the temperature was lowered to 5°C. After 14 weeks of cooling, tulip plants were transferred to the greenhouse and forced at 16–18°C temperature. At the cumulative maturity (colored perianth leaflets), flowers were cut and measurements of the flower steam and tepals lengths, as well as stem weight, were determined. Plants with virus-infection symptoms on petals were also counted.

Results of biometric measurements were subject to the variance analysis for two-factor experiments. Differences between average values were evaluated using Tukey test at the significance level of $\alpha = 0.05$.

The percentage data were subject to Bliss transformation with subsequent variance analysis. Differences between mean values were evaluated by means of Duncan test or two-factor experiments at the significance level of $\alpha = 0.05$.

RESULTS

During the three analyzed vegetation seasons in autumn, the air temperatures and precipitation amounts ensured a good rooting of plants before winter. The most severe winter was recorded in 2010/2011, which however did not have any effect on tulip wintering. In each season, plants began their vegetation in the mid of March. Only in 2009, high temperatures occurred in April and almost complete lack of rainfalls (tab. 1). Tulip develops stems and leaves the most intensively that time. Such weather conditions affected negatively the yield of progeny bulbs as compared to other two vegetation seasons. In April, when treatments using mineral oils were carried out, the maximum air temperature in 2009 exceeded 20°C. In May, maximum recorded temperatures were 23.8°C and 23.0°C in 2009 and 2010,

Table 1. Average air temperature and precipitation measured in the Experimental Meteorogical Station of the University of Life Science in Lublin in the years 2008–2011

Month	Mean air temperature (°C)				Sums of rainfall (mm)			
	2008/ 2009	2009/ 2010	2010/ 2011	Mean for years 1951–2010	2008/ 2009	2009/ 2010	2010/ 2011	Mean for years 1951–2010
October	10.1	7.0	5.6	7.6	55.5	103.6	11.2	40.1
November	4.8	5.5	6.4	2.6	33.1	43.1	46.8	38.2
December	0.9	–1.7	–4.7	–1.6	43.8	37.7	32.4	31.4
January	–2.7	–8.2	–0.9	–3.7	20.2	35.6	24.8	23.4
February	–1.2	–2.3	–4.5	–2.8	36.9	34.6	25.2	25.8
March	1.4	3.4	2.4	1.0	69.6	18.6	8.1	28.0
April	11.4 (21.6)*	9.4 (15.7)	10.2 (14.4)	7.4	2.9	24.5	29.9	39.0
May	13.6 (23.8)	14.5 (23.0)	14.3 (19.5)	13.0	71.1	156.7	42.2	60.7
June	16.4 (29.4)	18.0 (22.1)	18.6 (22.4)	16.3	125.5	65.6	67.8	65.9

* Maximum temperature

Table 2. Influence of mineral oil spraying on the length of flower shoots and tepals of 'Leen van der Mark' tulip cultivated in the field

Oil substances	Oil concentration (%)	Length of flower shoot (cm)	Length of tepals (cm)
Control		42.4a	6.7a
Sunspray 850 EC	1.0	42.9a	6.7a
	1.5	43.3a	6.6ab
	2.0	42.9a	6.7a
Sunspray Ultra-Fine	1.0	43.3a	6.6ab
	1.5	42.4a	6.6ab
	2.0	42.7a	6.4b
Mean for years	2009	41.2A	5.8C
	2010	44.5A	7.5A
	2011	42.8A	6.6B

Means indicated by the same letter do not differ significantly at $P \leq 0.05$

Table 3. Influence of mineral oils on the percentage of virus contaminated 'Leen van der Mark' tulips cultivated in the field

Oil substances	Oil concentration (%)	2009 (%)	2010 (%)	2011 (%)	Means
Control		12.0a–e	9.8a–e	16.8a	12.8A
Sunspray 850 EC	1.0	10.5a–e	8.8a–e	6.0cde	8.4ABC
	1.5	3.8e	5.7cde	7.4b–e	5.6C
	2.0	10.5a–e	6.2cde	4.4de	7.0BC
Sunspray Ultra-Fine	1.0	4.9de	6.2cde	14.8ab	8.6ABC
	1.5	12.4a–d	7.5b–e	10.0a–e	9.9ABC
	2.0	13.5abc	5.7cde	14.1abc	11.1AB
Mean for years		9.6AB	7.1B	10.5A	

Explanations, see Table 2

Table 4. Influence of mineral oil spraying on the total and commercial yield of 'Leen van der Mark' tulip bulbs

Oil substances	Oil concentration (%)	Commercial yield		Total yield	
		(pcs·m^{-2})	g·m^{-2}	(pcs·m^{-2})	g·m^{-2}
Control		34.0ab	990.4ab	141.7a	1600.0a
Sunspray 850 EC	1.0	35.3a	987.1ab	145.9a	1580.7ab
	1.5	33.2ab	944.3ab	143.5a	1563.1ab
	2.0	31.1b	881.3ab	136.5a	1504.1ab
Sunspray Ultra-Fine	1.0	35.4a	1000.6a	146.8a	1556.8ab
	1.5	33.9ab	929.3ab	145.3a	1478.8ab
	2.0	31.9b	873.7b	136.8a	1418.8b
Mean for year	2009	28.2C	631.6B	113.6A	1090.5B
	2010	32.8B	1090.7A	160.8A	1735.2A
	2011	39.6A	1109.0A	152.6B	1760.9A

Explanations, see Table 2

respectively. In April and May 2011, lower rainfall sums as compared to the many-year average and low air temperature amplitudes were observed (tab. 1). The main air temperature on dates of spraying in the year 2009 was: 12.3°C, 3.8°C and 9.1°C, respectively, the maximum temperature recorded was 16.6°C. In 2010 it was: 10.7°C, 12.8°C and 15.0°C, the maximum recorded temperature was 21.5°C. In 2011 it was: 10.6°C, 15.6°C and 5.2°C, the maximum recorded temperature was 22.2°C. Sprayings were done in the morning, on days without rainfall.

The mineral oil preparations applied for spraying plants at concentrations of 1.0–2.0% did not negatively affect the length of tulip flower stem. Tulips treated with Sunspray Ultra-Fine at 2.0% concentration formed shorter perianth leaflets as compared to the control plants. The oil used at concentrations of 1.0–1.5% had no impact on length of tepals. Tulips treated with 2.0% Sunspray Ultra-Fine developed shorter tepals only in comparison with control plants and those treated with 1.0% or 2.0% Sunspray 850 EC. Therefore, it cannot be concluded that Sunspray 850 EC at a concentration of 1.0–2.0% did not significantly affect the length of tepals. Sunspray 850 EC used at concentrations of 1.0–2.0% did not exert any negative influence on value of the tested feature (tab. 2).

Based on the number of virus-infected plants on the experimental plots evaluated during the full of flowering stage it was found that from 9.8 to 16.8% plants revealed the virus symptoms in the control combination in particular years of study. In 2009 and 2010, no significant differences after use of the oil preparations, were observed. However, it can by observed that viral infection was three times lower in case of plants sprayed with Sunspray 850 EC oil and twice lower in case of plants treated with Sunspray Ultra-Fine in concentration of 1.0% in comparison to not treated plants. The strongest infestation by viruses was recorded in 2011. That year, the lowest percentage of plants showing the virus-infection symptoms was found on plots where Sunspray 850 EC oil at concentrations of 1.0–2.0% was applied, in relation to the control. Average proportion of plants with virus symptoms in combinations where Sunspray Ultra-Fine was used for treatment, was close to that for control variant (tab. 3).

The total yield of progeny and commercial bulbs (>11 cm circumference) differed in individual years of study (tab. 4) and was closely associated with the weather conditions during the vegetation season (tab. 1). The lowest bulb yields were achieved in 2009. Tulips treated with mineral oils at concentration of 2.0% produced lower number of commercial bulbs, only compared to the plants treated with 1.0% mineral oils. No statistically significant influence of the oil preparations on the number of the total yield bulbs, was recorded. Tulips sprayed with Sunspray Ultra-Fine at 2.0% concentration produced lower weight of progeny bulbs compared to the control (tab. 4).

The yield of the first choice bulbs (>12 cm circumference) was very diverse in subsequent years of the study. The lowest number of bulbs was achieved in 2009. Based on the average results for three study years, it can be concluded that significantly lower number of these bulbs was produced by tulip plants treated with Sunspray 850 EC oil at concentration of 2.0% compared to the control. Our mineral oil applied at the highest tested concentration caused the decrease in the mas of first class bulbs yield, only compared to the plants treated with Sunspray Ultra-Fine with 1.0% concentration. The 'Len van der Mark' cv. do not produce a large number of progeny bulbs per a clone. Bulbs of 11–12 cm circumference are produced if the sequential bulb reaches 12 cm circumference. The largest number of this size bulbs was formed by tulip plants treated with Sunspray 850 EC oil at 2.0% concentration (tab. 5).

Table 5. The influence of oil spraying on the yield of 'Leen van der Mark' tulip bulbs with circumferences >12 cm and 11–12 cm

Oil substances	Oil concentration (%)	Yield of bulbs >12cm circumference		Yield of bulbs 11–12 cm circumference	
		(pcs·m^{-2})	(g·m^{-2})	(pcs·m^{-2})	(g·m^{-2})
Control		28.3a	855.2ab	5.6b	135.1ab
Sunspray 850 EC	1.0	27.0a	819.8ab	8.2a	167.3ab
	1.5	26.0ab	802.5ab	7.1ab	141.8ab
	2.0	22.5b	705.0b	8.6a	176.3a
Sunspray Ultra-Fine	1.0	29.0a	879.1a	6.3ab	121.5b
	1.5	27.6a	800.3ab	6.2ab	128.9ab
	2.0	25.7ab	748.8b	6.2ab	124.8ab
Mean for years	2009	18.4C	437.8C	9.7A	193.8A
	2010	27.2B	950.0A	5.6B	140.7B
	2011	34.2A	1016.7A	5.3B	92.3C

Explanations, see Table 2

Table 6. A post-treatment influence of mineral oils on quality of forced 'Leen van den Mark' tulip cut flowers in greenhouse

Oil substances	Oil concentration (%)	Length of flower shoot (cm)	Length of tepals (cm)	Fresh mass of flower hoot (g)
Control		34.1a	5.6a	32.0a
Sunspray 850 EC	1.0	34.5a	5.5a	31.6a
	1.5	35.3a	5.5a	31.6a
	2.0	35.2a	5.5a	31.1a
Sunspray Ultra-Fine	1.0	35.0a	5.6a	31.8a
	1.5	34.6a	5.6a	31.9a
	2.0	34.6a	5.7a	32.7a
Mean for years	2010	37.2A	5.2C	29.4C
	2011	29.1B	5.9A	32.2B
	2012	37.9A	5.6B	33.8A

Explanations, see Table 2

Table 7. A post – treatment of mineral oils on percentage of virus contaminated forced 'Leen van der Mark' tulips in greenhouse

Oil substances	Oil concentration (%)	2010 (%)	2011 (%)	2012 (%)	Means
Control		12.0bcd	40.0ab	44.0a	30.6A
Sunspray 850 EC	1.0	8.0cd	23.3a–d	4.0d	11.6B
	1.5	4.0d	20.0a–d	16.0d	13.3B
	2.0	8.0cd	30.0a–d	36.0abc	24.6AB
Sunspray Ultra-Fine	1.0	8.0cd	30.0a–d	40.0ab	26.6AB
	1.5	4.0d	20.0a–d	24.0a–d	16.0AB
	2.0	4.0d	30.0a–d	16.0a–d	16.6AB
Mean for years		6.8B	27.6A	25.7A	

Explanations, see Table 2

The use of mineral oils during bulb reproduction had no negative sequential influence on the quality of cut tulip flowers obtained from plant forcing in winter in greenhouse. Length of the flower stem and tepals, as well as fresh weight of the stem, were comparable within all tested combinations (tab. 6).

Number of virus-infected plants achieved during tulip forcing differed between individual growing seasons (tab. 7). In 2010, in control combination, an average of 12% plant showed the virus-infection symptoms on the petals. In variants where bulbs originated from plants protected with the mineral oils, from 4 to 8% plant with virus symptoms, were recorded. In 2011 in the control combination, 40% of tulip plants revealed virus-infection symptoms. Remaining combinations gave from 20 to 30% virus-infected flowers. These differences were not statistically significant. In the last experimental year, when virus press in the field cultivation was quite high, also after forcing about 44% of virus-infected plants were observed in the control combination. Significantly less virus-infected tulip plants were harvested from variants where bulbs for forcing originated from plants treated with Sunspray 850 EC oil at concentrations of 1.0–1.5%, and also Sunspray Ultra-Fine at 2.0% concentration (tab. 7).

DISCUSSION

Despite of numerous advantages and ecological properties that can be utilized in integrated protection of many crops, mineral oils can have negative impacts on respiration and photosynthesis [Goszczyński et al. 2003, Goszczyński and Tomczyk 2004]. The time the oil molecules remain within the plant depends on the oil dose and plant species (type of plant tissue), as well as ambient temperature. In orange leaves, the presence of oil was observed even 16 months after the treatment, while it did not transfer to young leaves that appeared the subsequent year [Tan et al. 2005]. Tulips are characterized by short vegetation season in spring. Most of cultivated varieties flower at the end of April and beginning of May. After flowering, growth of the above parts is stopped, while starting an intensive gain of the progeny bulbs, that lasts till the mid of June; then the above ground parts fade [Khodorova and Boitel-Conti 2013, Marcinek et al. 2013]. Thus, there is no problem with the oil remains in stems and leaves. It is only important not to limit the photosynthesis and assimilates transport to the bulb. The own studies involving tulip of economically important and wide-scale grown variety ‘Leen van der Mark’ indicate that paraffin oils used in the experiment can be applied with no harm to plants if a concentration of 1.5% is not exceeded. Higher concentrations (2.0%), at longer application, can negatively affect, namely the yield of commercial and the first choice bulbs that are used later for forcing. No negative impact of mineral oils on the qualitative traits of flowers after forcing, was recorded. Efficiency of oil in reducing the viral spread depended on the weather conditions in a given year and associated aphid population. If spring is early, aphids may appear on plants quite soon as well, and even single individuals can make remarkable damage [Asjes 1980a, 1980b]. The largest aphid intensification can be usually observed at the end of June [Wróbel 2008, Karczmarz 2010, 2012a, b], when tulip plants start fading and protection treatments are usually given up. It is serious mistake, because plants can be infected at the end of vegetation, which appears later during flower forcing. Tulip has leaves arranged in such a way on a stem that they cannot be covered with the oil layer from beneath during treatment, which limits the efficiency of preparations applied. The observations indicate that no clear differences in the number of virus-infected plants were recorded at the low intensity of viral occurrence in combinations with oils as compared to the control. Meanwhile in years with great virus intensity, the oils showed a protective action, although their efficiency not always was sufficient, which was confirmed by research involving potato plants [Wróbel 2011a, b]. The potato seed plantations require 5 to 7 oil treatments and reduction in the viral spread depended on the oil type and aphid population. Great differences in particular vegetation seasons were found. Tulips is a plant sensitive towards high concentrations of foliar-applied preparations. Concentrations of fertilizers higher than 1% are not recommended; better effects can be achieved by applying larger number of treatments, while at lower concentration of the agent (unpublished data). Studies conducted in The Netherlands upon the use oil preparations indicated that lower concentration of the oil did not cause the yield decrease, instead it allows for efficiently reduce the viral spread [Asjes et al. 1996, Asjes and Blom-Barnhoorn 2001, 2002]. Therefore, there is no reasonable reason to apply higher concentrations. The oil preparations can be combined with fungicides and insecticides, which usually intensifies the effects and makes possible to use lower doses of pesticides [Asjes 1991, Horst et al. 1992, Asjes et al. 1996, Rae 2002, Wojdyła 2012], although not always results indicate the purposefulness of such activities [Wojdyła and Łazęcka 2014]. Three treatments were used in own experiments – at the end of April or at the beginning of May. That number of mineral oil spray at concentrations of 1.0–1.5% positively affected the reduction in the virus-infection of plants grown in the field with no negative impacts on the progeny bulb yield. Three treatments are sufficient and safe for tulip plants, but can be made at larger time intervals if the aphid press is quite high. The last spraying should precede intensive flights of aphids in June. Mineral oils applied at concentrations of 1.5–2.0% cause the leaf color changes, while no tissue damage nor earlier plant fading was observed. Mizell [1991] reported that Sunspray Ultra-Fine preparation at 2.0% concentration used three times at weekly intervals was not toxic for shrubs and trees grown in nursery orchard (30 different taxa were subject to evaluation), even if air temperature during the treatment was over 30°C. Number of treatments should be adjusted to the plant species, and even to individual varieties. Wilson [1999] proved that excessively high number of sprayings using mineral oils, despite of low concentrations, invoked strong toxic effects, reduction in the plant growth, and in consequence drop in irises yield.

The oil preparations applied for a prolonged time allow for reducing the viral spread, while not ensuring a complete efficiency. It is associated with the fact that viruses are transferred very readily and rapidly even at several-seconds lasting aphid's prey and their detection in plants is mainly based on a visual assessment of leaves and flowers. This does not allow for elimination of plants that are infected just before flowering and later. It is therefore problem that forces to search for other efficient protection means and diagnosing techniques in terms of these dangerous pathogens [Polder et al. 2010].

CONCLUSIONS

1. Mineral oils applied three times at weekly intervals for spraying tulips at concentrations of 1.0–1.5% during two vegetation seasons did not cause any phytotoxic symptoms and no negative impact on the stem and tepals lengths of 'Leen van der Mark' cv.

2. Mineral oils used for two vegetation seasons at concentration up to 1.5% did not cause the decrease in the total, commercial and the first choice bulb yields. They had neither the influence on the quality of flowers produced after forcing.

3. Mineral oils applied at 2.0% concentration in the field cultivation for two vegetation seasons affected negatively the number and weight of the commercial bulbs and bulbs of > 12 cm circumference.

4. The Sunspray 850 EC oil used at concentrations of 1.0–1.5% three times per vegetation season reduced the number of virus-infected tulip plants in the field cultivation and viral spread during forcing. Efficiency of the preparation depended on the viral press during the vegetation.

REFERENCES

Asjes, C.J. (1980a). The application of mineral oil to control the spread of hyacinth mosaic virus in hyacinthus (1). Bloembollencultuur, 90(51), 1396–1397.

Asjes, C.J. (1980b). The application of mineral oil to control the spread of hyacinth mosaic virus in hyacinthus (2). Bloembollencultuur, 91(1), 16–17.

Asjes, C.J. (1991). Control of air-borne field spread of tulip breaking virus, lily symptomless virus and lily virus X in lilies by mineral oils, synthetic pyrethroids, and a nematicide in the Netherands. Neth. J. Pl. Path., 97, 129–138.

Asjes, C.J., Piron, P.G.M., van Oosten A.M. (1996). Control review of air-borne tulip breaking virus and lily symptomless virus in lilium in the Netherlands. Acta Hortic., 432, 290–297.

Asjes, C.J., Blom-Barnhoorn, G.J. (2001). Control of aphid-vectored and thrips-borne virus spread in lily, tulip, iris and dahlia by sprays of mineral oil, polydimethylsiloxane and pyrethroid insecticide in the field. Ann. Appl. Biol., 139, 11–19.

Asjes, C.J., Blom-Barnhoorn, G.J., (2002). Control of aphid vector spread of Lily Symptomless Virus and Lily Mottle Virus by mineral oil/insecticide sprays in Lilium. Acta Hortic., 570, 277–281.

Damavandian, M.R., Moosavi, S.F.K. (2014). Comparison of mineral spray oil, Confidor, Dursban, and Abamectin used for the control of *Phyllocnistis citrella* (Lepidoptera: Gracillaridae), and an evaluation of the activity of this pest in citrus orchards in northern Iran. J. Plant Prot. Res., 54(2), 156–163.

Dekker, E.L., Derks, A.F.L.M., Asjes, C.J., Lemmers, M.E.C., Bol, J.F., Langefeld, S.A. (1993). Characterization of potyviruses from tulip and lily which cause flower-breaking. J. Gen. Virol., 74, 881–887.

Goszczyński, W., Tomczyk, A. (2004). Comparison of two mineral oils on photosynthesis andrespiration of tomato. Prog. Plant Prot./Post. Ochr. Rośl., 44(1), 99–103.

Goszczyński, W., Tomczyk, A., Bednarek, A. (2003). Influence of mineral oil Sunspray 850 (Ultra Fine) on gass exchange of rose leaves. Prog. Plant Prot./Post. Ochr. Rośl., 43(2), 648–650.

Hammond, J., Chastanger, G.A. (1989). Field transmission of tulip breaking virus and serologicaly related potyviruses in tulip. Plant Dis., 73, 331–336.

Horst, R.K., Kawamoto, S.O., Porter, L.L. (1992). Effect of sodium bicarbonate and oils on the control of powdery mildew and black spot of roses. Plant Dis., 76(3), 247–251.

Karczmarz, K. (2010). Numerical strength dynamics of *Chromaphis juglandicola* (Kalt. 1843) on common walnut (*Juglans regia* L.) in Lublin town plantings. Acta Sci. Pol. Hortorum Cultus, 9(4), 121–132.

Karczmarz, K. (2012a). Numerical strength dynamics and bionomy of *Panaphis Juglangis* (Goeze, 1778) (*Homoptera*, *Phyllaphididae*) on common walnut (*Juglans regia* L.) in Lublin town plantings. Acta Sci. Pol., Hortorum Cultus, 11(2), 53–70.

Karczmarz, K. (2012b). Arthropods settling rose 'Bonica' 82' in the urban greenery of Lublin. Aphids Hemipter. Insects, 18, 37–55.

Khodorova, N., Boitel-Conti, M. (2013). The role of temperature in the growth and flowering of geophytes, Plants, 2, 699–711.

Lesnaw, J.A., Ghabrial, S.A. (2000). Tulip Breaking: past, present, and future. Plant Dis., 84(10), 1052–1060.

Marcinek, B., Hetman, J., Kozak, D. (2013). Influence of cultivation method and bulbs planting depth on the growth and yield of tulips. Acta Sci. Pol. Hortorum Cultus 12(5) 97–110.

Milošević, D., Stamenković, S., Perić, P. (2012). Potential use of insecticides and mineral oils for the control of transmission of major aphid-transmitted potato viruses. Pestic. Phytomed. (Belgrade), 27(2), 97–106.

Mizell, R.F. (1991). Phytoxicity of Sunspray Ultra-Fine Spray oil® and Safer Insecticidal Concentrate® Soap on selected ornamental plants in summer in north Florida and south Georgia. J. Arboric., 17(8), 208–210.

Mowat, W.P. (1995). Tulip. In: Virus and virus-like diseases of bulb and flower crops, Loebenstein, G., Lawson, R.H., Brunt, A.A. (eds), John Wiley & Sons, Chichester–New York–Bribone–Toronto–Singapore, 352–383.

Polder, G., van der Heijden, G.W.A.M., van Doorn, J., Clevers, J.G.P.W., van der Schoor, R., Baltissen, A.H.M.C. (2010). Detection of the tulip breaking virus (TBV) in tulips using optical sensor. Precision Agric., 11(4), 397–412. DOI: 10.1007/s11119-010-9169-2.

Rae, D.J. (2002). Use of spray oils with synthetic insecticides, acaricides and fungicides. In: Spray oils – beyond 2000, Beattie G.A.C. et al. (eds), University of Western Sydney, 248–284.

Romanow, L.R., van Eijk, J.P., Eikelboom, W. (1986). Investigating resistance in tulip breaking virus and to its transmission. Acta Hortic., 177, 235–239.

Sochacki, D. (2007). Detection of TBV virus in tulip species and their cultivars. Zesz. Probl. Post. Nauk Rol., 517, 705–710.

Sochacki, D. (2013). The occurrence of the viruses in tulip crops in Poland. J. Hortic. Res., 21(1), 5–9.

Sochacki, D., Podwyszyńska, M. (2012). Virus eradication in narcissus and tulip by chemoterapy. Floric. Ornam. Biotechnol., 6(2), 114–121.

Soika, G., Łabanowski, G., Chałańska, A. (2008). Usefulness of parafin oil to control of pests of ornamental trees and shrubs. Prog. Plant Prot./Post. Ochr. Rośl., 48(2), 734–741.

Tan, L.B., Sarafis, V., Beattie, G.A.C., White, R., Darley, E.M., Spooner-Hart, R. (2005). Localization and movement of mineral oil in plants by fluorescence and confocal microscopy. J. Exp. Bot., 56(420), 2755–2763.

Thomsen, A., (1980). Infection trials with tulip mosaic virus. Acta Hortic., 109, 469–471.

Wilson, C.R. (1999).The potential of reflective mulching in combination with insecticide sprays for control of aphid-borne viruses of iris and tulip in Tasmania. Ann. Appl. Biol., 134, 293–279.

Wojdyła, A.T. (2012). Effect of vegetable and mineral oils on the germination of spores *Diplocarpon rosae* Wolf. Acta Sci. Pol. Hortorum Cultus, 11(4), 143–156.

Wojdyła, T.A. (2013). Effect of vegetable and mineral oils on the development of Diplocarpon rosae Wolf – the causal agent of black spot of rose. Ecol. Chem. Engineer., 20(2), 175–185.

Wojdyła, T.A. (2015). Effect of vegetable and mineral oils on the development of *Sphareotheca pannosa* var. rosae – the casual agent of powdery mildew of rose. Bul. J. Agric. Sci., 21(4), 855–862.

Wojdyła, A.T, Łazęcka, U.W. (2014). Protection of roses against *Diplocarpon rosae* with mixture of fungicides and oils. Zesz. Nauk. Inst. Ogr., 22, 157–166.

Wróbel, S. (2006). Role of mineral oil in potato protection against aphids and viral infection. Acta Sci. Pol. Agricultura, 5 (1), 83–92.

Wróbel, S. (2008). Dynamics of aphids occurrence in natural conditions after application of various oil substances. Prog. Plant Prot./Post. Ochr. Rośl., 48(4), 1383–1387.

Wróbel, S. (2011a). Adjuvants in seed potato protection against PVY and PVM infection. Biul. IHAR, 259, 251–262

Wróbel, S. (2011b). The influence of mineral oil and insecticide mixtures on the occurrence dynamics of aphids on potato plants. Prog. Plant Prot./Post. Ochr. Rośl., 51(2), 625–629.

Wróbel, S., Urbanowicz, J. (2007). Reaction of 9 potato cultivars to mineral and plan adjuvants. Prog. Plant Prot./Post. Ochr. Rośl., 47(2), 375–379.