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Control of the spread of tulip breaking virus in tulips with mineral-oil sprays

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Abstract

Several mineral-oil sprays used to curtail the spread of stylet-borne tulip breaking virus (TBV) in tulips 'Elmus' were tested. The similarly concentrated sprays prepared with summer oil, winter oil, Albolineum, and Asepthion oil, decreased the spread of TBV considerably.

Control was improved by the more concentrated Albolineum sprays (2.5, 5, 10%), and spread was reduced more effectively, when variable quantities of emulsions providing good leaf coverage were used (2.5, 5%). The weight ratios of the bulb yields of plots given a 2.5% spray in all years and a 5% spray in 1972 and 1973 fluctuated closely (0–6%) around the value for the untreated plots, which was taken as 100. These ratios dropped by 11–19% after more concentrated sprays were used in variable quantities in 1971. Spraying was slightly more effective at weekly than at fortnightly intervals, but the weight ratios scarcely differed. Better control of TBV spread was obtained when spraying was started at the beginning of May; when started in June, the sprays were not effective. The weight ratios were not clearly influenced differentially except when spraying was begun in the first week of May.

The efficacy of mineral-oil sprays is discussed in relation to tulips and lilies, with reference to comparable experiments. The application of mineral-oil sprays for curtailing TBV spread in commercial tulip culture is discussed.

Introduction

The aphid-borne virus diseases occurring in tulips are caused by tulip breaking virus (TBV; Van Slogteren, 1971), cucumber mosaic virus (CMV; Van Slogteren, 1966), and lily symptomless virus (LSV; Derks and Asjes, 1975). The control of these diseases in tulip culture is laborious and must be applied every year. Special difficulties are encountered in the roguing of TBV-diseased plants of certain cultivars in which colour break of the flowers (Van Slogteren, 1971; Van Slogteren and Asjes, 1970) is absent or harder to detect, e.g. in white, yellow, dark violet, and double-petaled pink varieties. CMV is less difficult to control than TBV. The number of cultivars susceptible to CMV is relatively small, and the elimination of diseased bulbs can be performed rather easily during the storage period because of the expression of necrotic symptoms in material infected with this virus (Van Slogteren, 1966; Van Slogteren and Asjes, 1970). The incidental occurrence of LSV in tulips is reported for only a few cultivars (Derks and Asjes, 1975). Thus, the need to combat the aphid-borne virus diseases by spraying chemicals in addition to the normally applied negative mass selection is obvious for TBV and much less so for CMV and LSV.

The stylet-borne mode of virus transmission means that the use of systemic insecticides to limit infection would be unsuccessful (Broadbent, 1957), whereas the spray-

ing of mineral-oil emulsions in the field has given encouraging results for certain viruses of this type, including potato virus Y in potatoes (Bradley et al., 1966) and peppers (Loebenstein et al., 1970), cucumber mosaic virus in peppers (Loebenstein et al., 1970) and cucumbers (Loebenstein et al., 1966), iris yellow mosaic virus in irises (Deutsch and Loebenstein, 1967), and tulip breaking virus in lilies (Asjes, 1972, 1974).

The experimental results on the control of tulip breaking virus (TBV; */*:*/*:e/E: S/Ap; Van Slogteren, 1971) in field-grown tulips with certain insecticide and mineral -oil sprays, and the different effects of a given mineral-oil spray as influenced by spraying at different concentrations, intervals, and certain seasonal periods, are reported in this paper.

Materials and methods

Plant material and field situation. Apparently TBV-free bulbs of the late-flowering cultivar Elmus (size 9–10 cm) were used. TBV infection of the plants is easily recognized by the light colour break of the flowers (Van Slogteren, 1971). Bulbs of a stock of the late-flowering cultivar White Surprise totally infected by TBV were used as virus source. TBV was also present in adjoining rows of lilies infected with the 'brown ring formation' disease (Asjes et al., 1973; Asjes, 1974) in 1970 and 1971. In 1972 irises grew in adjacent plots, and in 1973 there were hyacinths near the tulips. The ratio of diseased to healthy plants was: 3/4 for tulips only and 3/2 with additional lilies as virus source in 1970; 1/2 for tulips and 3/2 with additional lilies in 1971; and 1/2 for tulips only in 1972 and 1973. The tulips growing in a rather open stand died early in July.

The relevant bulbs were weighed before planting (between October 15th and November 20th) and again after lifting, drying, and cleaning, to determine the increase. The weights for the sprayed plots are expressed as ratios of the unsprayed plots taken as 100. The assumption was made that yields were not influenced by current-season TBV infection, as had been found for the TBV infection of lilies (Asjes, 1974). The number of bulbs per plot was 150; all treatments were laid out in duplicate in 1970, 1971, and 1972, and in triplicate in 1973. The bulbs in the five rows of 'White Surprise' planted between the ten-row plots of 'Elmus' were not weighed. The experiments were performed in 1970, 1971, and 1972 in a field relatively well sheltered by shrubs and trees (Asjes, 1974), whereas in 1973 the plots were located in an open field.

The percentages of TBV-diseased 'Elmus' plants were determined on the basis of replanted bulbs flowering in the next growing season.

Spraying. The following materials were sprayed: the insecticides demeton-S-methyl (50.5% a.i.; Bayer, Leverkusen, Germany), parathion (25% a.i.; Asepta-fabriek, Delft, Holland), and Asepthion oil, a mixture of parathion and a mineral winter oil (Asepta-fabriek). The mineral oils tested were Mineramuls summer oil, Mineramuls winter oil (both kindly supplied by Asepta-fabriek), and Albolineum (ICI, Holland). In some cases a detergent, Agral L.N. (ICI) was added. Manual spraying of the plots with healthy 'Elmus' plants was performed at a height of 30–50 cm above crop level with a propane knapsack sprayer (AZO, Ede-Holland). The amount of spray liquid

was about 1,800 litres per ha at a 1% concentration in 1970, 1971, and 1972 for all sprays except Albolineum, which was 1.25% (nozzle 160 and non-perforated whirling pin in 1970, and nozzle 120 and perforated whirling pin in 1971, 1972, and 1973; pressure ca. 4 atmosphere). The 2.5% emulsion was sprayed at 900 litres/ha in 1971, 1972, and 1973. In 1971 the volumes of the more concentrated emulsions were variable and the liquid was applied such that the leaves were completely covered, whereas in 1972 and 1973 the volumes were proportional to the equivalent amount of pure Albolineum per hectare. The leaf surface of the plants was not entirely covered after the low-concentration sprays; this was improved by using more concentrated oil emulsions whirling more effectively among the plants. The first spraying was performed in the second week of May in 1970 and in the first week of May in 1971, 1972, and 1973. The last sprays were applied in the first week of July, about a week before the plants died. All sprays were applied during the day in dry weather within an hour after preparation.

Results

Insecticide and mineral-oil sprays. Table 1 shows that the spread of TBV varies from year to year and is not related to the number of diseased plants growing in the vicinity of healthy tulips. The insecticide sprays with demeton-S-methyl and parathion decreased TBV spread in 1971. Mineral-oil sprays with summer oil, winter oil, and Albolineum considerably decreased virus spread in 1970 and 1971. The best control was obtained with Asepthion oil.

The weight ratios were variable in 1970, whereas in 1971 each spraying decreased the bulb yields as compared with those of the untreated plots.

Quantity and concentration of Albolineum sprays with alternate addition of Agral L.N. Table 2 shows that the addition of the detergent Agral L.N. to the sprays was only effective in the 1.25% emulsions in 1970 and 1971. Control of the spread of TBV was

Table 1. Effect of insecticide and mineral-oil sprays applied at weekly intervals on the spread of tulip breaking virus in the tulip cultivar Elmus.

Spray	Percentage disease		Weight ratio	
	1970	1971	1970	1971
None	13	18	100	100
Demeton-S-methyl	10	9	93	83
Parathion	12	10	117	94
Asepthion oil	4	5	92	90
Summer oil	9	6	93	94
Winter oil	7	4	111	90
Albolineum	8	7	110	92
Ratio TBV-diseased to apparently healthy plants in surrounding material	3/2	3/2		

Tabel 1. Effect van wekelijkse bespuitingen met insekticiden en met minerale oliën op de verspreiding van tulpemozaïekvirus in de cultivar Elmus.

improved by the use of more concentrated sprays. The coverage of the leaves by variable quantities of more concentrated sprays in 1971 resulted in distinctly better control of TBV than was obtained in 1972, when proportional emulsified-oil volumes were sprayed. The control of the slow spread in 1973 approached the results obtained in 1971 more closely than those of 1972.

The weight ratios decreased in 1971 with increasing concentrations of oil. In 1972 the yields were only slightly reduced by all of the sprays but one (10%-d), whereas in 1973 this treatment gave the highest bulb yield.

In 1971 the tulips of the 10%-spray plots died about ten days earlier than the plants of the 1.25% plots. In 1972 and 1973, all of the plants died at the same time.

Table 2. Effect of quantity, concentration, and added detergent in weekly sprays of Albolineum on the spread of tulip breaking virus in the tulip cultivar Elmus.

Spray		Percentage disease				Weight ratio			
		1970	1971	1972	1973	1970	1971	1972	1973
None		13	18	26	6	100	100	100	100
1,25%	− d*	8	7			110	92		
	+ d	5	4	22		103	86	101	
2,5%	− d		5	16	1		86	95	98
	+ d		6	16			89	94	
5%	− d		2	11	1		83	98	100
	+ d		2	13			81	97	
10%	− d			8	2		84	86	112
	+ d			6			82	96	
oil volume		variable		proportional		variable		proportional	

* − d: detergent not added; + d: detergent added.

Tabel 2. Effect van hoeveelheid, concentratie en toevoeging van uitvloeier bij wekelijkse bespuitingen met Albolineum op de verspreiding van tulpemozaïekvirus in de cultivar Elmus.

Table 3. Effect of concentration and application intervals of Albolineum sprays on the spread of tulip breaking virus in the tulip cultivar Elmus.

Spray	Year	Percentage disease			Weight ratio		
		interval		untreated	interval		untreated
		7 days	14 days		7 days	14 days	
1.25%	1970	8	7	13	110	111	100
1.25%	1971	7	8		92	91	
2.5%	1971	5	8	18	86	88	100
5%	1971	2			83		
2.5%	1972	16	17	26	95	99	100
5%	1972	11	14		98	95	
2.5%	1973	1	3	6	98	104	100
5%	1973	1	3		100	106	

Tabel 3. Effect van concentratie en tussenperiode van Albolineum-bespuitingen op de verspreiding van tulpemozaïekvirus in de cultivar Elmus.

Concentration of Albolineum sprays applied at weekly and fortnightly intervals. Table 3 shows that spraying at weekly intervals is slightly more efficient than fortnightly application. The weight ratios hardly reflect any profitable effect of fortnightly as compared with weekly spraying.

Weekly spraying of Albolineum for various seasonal periods. Table 4 shows that a more efficient control of TBV spread was obtained when the spraying was started at the beginning of May. Spraying begun in June had no effect on control. The weight ratios do not show any differential tendency indicating that the number of sprayings influenced the bulb yields proportionately in any of the treatments except one, namely the treatments started in the first week of May in 1971.

Table 4. Effect of weekly Albolineum sprays during various periods of the growing season on the spread of tulip breaking virus in the tulip cultivar Elmus.

Spray	Starting	Last spray		Percentage disease		Weight ratio	
	date	1970	1971	1970	1971	1970	1971
2.5%	May 4		26/5		6		101
	4		16/6		9		94
	4		30/6		4		87
1.25%	12	7/7		6		101	
1.25 %	26	7/7		9		92	
2.5%	June 2		7/7		21		95
1.25%	16	7/7		12		104	
2.5%	23		7/7		20		94
1.25%	30	7/7		12		90	
none				13	18	100	100

Tabel 4. Effect van wekelijkse Albolineum-bespuitingen gedurende verschillende perioden van het groeiseizoen op de verspreiding van tulpemozaïekvirus in de cultivar Elmus.

Discussion

The spread ot TBV in tulips proved to be as unpredictable as it had been found to be in lilies, and was unrelated to the virus sources around the plots (Asjes, 1974). The TBV infection rate of tulips was lower with such sprays as demeton-S-methyl and parathion than the disease incidence in the unsprayed plots. This effect was not observed for lilies. Contrary to the findings in lilies (Asjes, 1974), Asepthion oil was more effective than Albolineum in the control of TBV in tulips.

The susceptibility of tulips to TBV is assumed on the basis of the results for the control of TBV spread in May (Table 4), to be highest during the period of the 'big leaf growth' in the latter part of April and the month of May (Kraayenga, 1960; Rees, 1972). The numbers of flying aphids indicated by yellow-pan catches (Moericke, 1950; Asjes unpublished) were much smaller in May than in June, but these aphids transmitted TBV efficiently during the period when susceptibility is assumed to be highest.

The efficacy of mineral-oil sprays was different for tulips than for lilies. The effect of more concentrated oil sprays on tulip leaves growing rather vertically was not observed as clearly on the leaves of lilies growing rather horizontally. The fortnightly sprays had greater efficacy on tulips than was reported for lilies (Asjes, 1974). The

control of TBV spread would have been more clearly expressed if the impeding effect of oily leaf coverage on virus transmission (Bradley, 1963; Vanderveken and Dutrecq, 1970) also holds for the acquisition of TBV from diseased tulips, which, however, were not sprayed under the experimental conditions.

The weight ratios of the bulbs were rather variable. There was a tendency within the experiments for weight ratios to decrease when Albolineum sprays curtailed TBV spread more distinctly. The reduction in bulb yields should not exceed a very small percentage, because the number of deliverable bulbs may decrease proportionately or even more (Timmer, 1971).

The application of mineral-oil sprays in commercial tulip culture to curtail TBV spread in particular and stylet-borne CMV and LSV simultaneously, is not yet sufficiently evident to be applied economically. Use of these sprays may be considered recommendable: a) until the search for and roguing of diseased plants is completed, and b) repeatedly: 1. on heavily infected stocks ultimately to be partially or completely rejected on the basis of commercial use of deliverable bulbs for home forcing but in the meantime, endangering the health of neighbouring cultivars during the growing season; 2. on non-flowering plant material; and 3. on small stocks of newly bred cultivars to keep them virus-free from the beginning of cultivation. This treatment gives a better guarantee that commercial stocks will be free of virus when mineral-oil sprays to curtail current-season virus spread above soil are used.

The need to cut down the labour cost involved in searching for diseased plants in the field means that further research is required to find additional possibilities for the use of mineral-oil sprays in the curtailment of aphid-spread and stylet-borne virus diseases in tulip culture.

Samenvatting

Bestrijding van de verspreiding van tulpemozaïekvirus door middel van bespuitingen met emulsies van minerale oliën

Bespuitingen met verscheidene minerale oliën werden beproefd om de verspreiding van het non-persistente tulpemozaïekvirus (TBV) in tulpen 'Elmus' tegen te gaan. De bespuitingen met onderling vergelijkbare concentraties van Zomerolie, Winterolie, Albolineum en Asepthion-olie beperkten de TBV-verspreiding aanzienlijk (Tabel 1).

De bestrijding werd verbeterd door toepassing van sterker geconcentreerde Albolineum-bespuitingen (2,5, 5, 10%). Deze beperkten de TBV-verspreiding beter na gebruik van variabele hoeveelheden van de emulsies (2,5, 5%), waarbij de oppervlakte van de bladeren na bespuiting zeer goed werd bedekt. De bolopbrengsten (kg) van objecten bespoten met een 2,5%-emulsie in alle jaren en een 5%-emulsie in 1972 en 1973, uitgedrukt in percentages van het gewicht van de onbehandelde objecten dat op 100 werd gesteld, verschilden slechts enkele procenten (0–6%; Tabel 2 en 3). Deze waren 11–19% lager bij bespuitingen met variabele hoeveelheden emulsies van hoge concentratie in 1971 (Tabel 2). De wekelijkse bespuiting was ter bestrijding van de virusverspreiding enigszins efficiënter dan de veertiendaagse; de verhoudingsgetallen van de gewichten verschilden nauwelijks (Tabel 3). De beste bestrijding van de TBV-verspreiding werd verkregen wanneer de bespuitingen in het begin van mei werden begonnen, terwijl de methode waarbij met bespuiten in juni werd begonnen, klaarblijkelijk niet effectief was (Tabel 4). De bolopbrengsten waren niet duidelijk afhan-

kelijk van het aantal bespuitingen, behalve wanneer de bespuitingen in de eerste week van mei werden begonnen.

De efficiëntie van minerale olie-bespuitingen op tulpen en lelies is verschillend (Asjes, 1974). Bespuitingen, bijv. met een Albolineum-emulsie, om de TBV-verspreiding te beperken, kunnen worden overwogen bij de tulpecultuur: a) zolang het ziekzoeken en verwijderen van zieke planten tijdens het groeiseizoen nog niet is voltooid in alle partijen, en b) voortdurend (1) op gedeeltelijk of geheel afgekeurde, ernstig zieke partijen die tijdens het groeiseizoen een gevaar vormen voor de gezondheidstoestand van cultivars die in onmiddellijke nabijheid worden geteeld, (2) op partijen niet-bloeiend plantmateriaal en (3) op kleine partijen van nieuw-gewonnen cultivars vanaf het begin. De gezondheidstoestand van partijen tulpen ten aanzien van bovengronds verspreide virussen kan beter worden gegarandeerd na toepassing van bespuitingen met emulsies van minerale oliën.

References

Asjes, C. J., 1972, Prevention of the spread of the virus disease brown ring formation (bruinkringerigheid) in the lily Mid-century hybrid 'Enchantment' in the Netherlands. In: Lilies 1972 and allied plants. R. hort. Soc., London, 37–40.

Asjes, C. J., 1974. Control of the spread of the brown ring formation virus disease in the lily Mid-century hybrid 'Enchantment' by mineral-oil sprays. Acta Hortic. 36: 85–92.

Asjes, C. J., Vos, Neeltje P. de & Slogteren, D. H. M. van, 1973. Brown ring formation and streak mottle, two distinct syndromes in lilies associated with complex infections of lily symptomless virus and tulip breaking virus. Neth. J. Pl. Path. 78: 23–35.

Bradley, R. H. E., 1963. Some ways in which a paraffin oil impedes aphid transmission of potato virus Y. Can.J.Microbiol. 9: 369–380.

Bradley, R. H. E., Moore, C. E. & Pond, D. D., 1966. Spread of potato virus Y curtailed by oil. Nature, London, 209: 1370–1371.

Broadbent, L., 1957. Insecticidal control of the spread of plant viruses. A. Rev. Ent. 2: 339–354.

Derks, A. F. L. M. & Asjes, C. J., 1975. Lily symptomless virus in tulips. Neth. J. Pl. Path. 81: 14–21.

Deutsch, Miriam & Loebenstein, G., 1967. Field experiments with oil sprays to prevent yellow mosaic virus in irises. Pl.Dis.Reptr 51: 318–319.

Kraayenga, D., 1960. Groeimetingen bij de tulpebol. Meded. Landb. Hogesch. Wageningen, 60: 1–53.

Loebenstein, G., Alper, Miriam & Levy, S., 1970. Field tests with oil sprays for the prevention of aphid-spread viruses in peppers. Phytopathology 60: 212–215.

Loebenstein, G., Deutsch, Miriam, Frankel, H. & Sabar, Z., 1966. Field tests with oil sprays for the prevention of cucumber mosaic virus in cucumbers. Phytopathology 56: 512–516.

Moericke, V., 1950. Ueber das Farbsehen der Pfirsichblattlaus (*Myzodes persicae* Sulz.). Z. Tierpsychol. 7: 265–274.

Rees, A. R., 1972. The growth of bulbs. Applied aspects of the physiology of ornamental bulbous crop plants. Acad. Press, London and New York, 311 pp.

Slogteren, D. H. M. van, 1966. Necrosis in bulb scales of sensitive tulip varieties caused by cucumber mosaic virus. Meded. Rijksfac. Landb. Wetensch. Gent 32(3): 986–994.

Slogteren, D. H. M. van, 1971. Tulip breaking virus. Description of plant viruses, no. 71. C.M.I./A.A.B.

Slogteren, D. H. M. van & Asjes, C. J., 1970. Virus diseases in tulips. Daffodil Tulip Yb. 35: 85–97.

Timmer, M. J. G., 1971. Some aspects of the relationship between the biological and the economic yield of tulip bulbs. Acta Hortic. 23: 137–141.

Vanderveken, J. A. & Dutrecq, A., 1970. Contribution à l'étude de l'action inhibitrice d'une huile minérale sur la transmission aphidienne des phytovirus. Anns Phytopath. 2: 387–402.

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