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Prevention of plant injury by cabbage gall midge (*Contarinia nasturtii* Kieffer) and onion thrips (*Thrips tabaci* Lindemann) using emulsions of polyisobutylene

By H. DEN OUDEN[1], J. THEUNISSEN[1] and A. M. SHELTON[2]

Abstract

Non ionogenic emulsions of the artificial rubber polymer polyisobutylene were effective for control of the cabbage gall midge, *Contarinia nasturtii*, on cauliflower and cabbages under both field and laboratory conditions. Additional tests with these emulsions demonstrated excellent effectiveness in preventing feeding injury by onion thrips, *Thrips tabaci*, on onions in the greenhouse. These tests provide the first results for the use of these polymers to modify leaf surfaces for protection from insects.

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1 Introduction

In the Netherlands practical application of supervised control of Lepidoptera and cabbage aphids in cabbage (THEUNISSEN and DEN OUDEN 1985) is periodically frustrated by the need to control cabbage gall midge, *Contarinia nasturtii* (Cecidomyiidae). Adult gall midges lay their eggs in the developing meristem of brassica crops, and the emerging larvae feed in the meristematic tissue causing leaf distortion. Presently, broad spectrum insecticides are used to control the gall midge but they have not provided adequate control, possibly because timing for this pest is so critical or because they are not persistent enough. Additionally, continued use of these chemicals may disrupt biological control efforts or lead to resistance for Lepidoptera and cabbage aphids in brassica crops.

Onions and leeks (*Allium* spp.) are also important vegetable crops in the Netherlands and are normally infested by onion thrips, *Thrips tabaci* (Thysanoptera), especially during hot and dry seasons. Onion thrips puncture leaf cells and ingest the sap, leaving longitudinal, silver mottling or blotching on the leaves. Control of thrips is generally achieved by the use of broad spectrum insecticides but accurate timing and persistence of the materials is needed because thrips will migrate into the field throughout the season. On leeks there is a 21 day pre-harvest interval from the last spray and this presents problems when thrips come into the field during that period. Alternative strategies are needed for season long chemical control and for control late in the season.

As an alternative to broad spectrum insecticidal control of gall midge on brassica and onion thrips on *Allium* we have developed an approach using non-ionogenic emulsions of the artificial rubber polymer polyisobutylene. Sticky artifical rubber polymers have been used for trapping insects for monitoring purposes and for arresting pupating larvae of thrips and leaf miners (HELYER et al. 1983), and may have other uses for pest management. Herein are reported studies utilizing sprays of aquous emulsions of polyisobutylene (Oppanol) as a control method for preventing injury by the cabbage gall midge on cabbage and cauliflower and onion thrips on onions.

2 Material and methods

2.1 Polymers

The group of polyisobutylene polymers we utilized consists of low molecular (viscous) and high molecular (rubbery) types. They can be mixed into viscous sticky substances by dissolving the high molecular Oppanol 100 in hexane and mixing it with the low molecular Oppanol 1. The phytotoxic hexane must be evaporated and a non-ionogenic emulsifier added to the sticky mixture by intensive stirring using an ultraturrax. When an aquous solution of this mixture is sprayed, a thin layer of the non-phytotoxic polyisobutylene plus emulsifier is left on the treated surface after evaporation of the water. The stickiness of this layer can be changed by varying the ratio of Oppanol 100 and Oppanol 1 and the quantity of added emulsifier. The treated leaves are glossy and our preliminary observations indicate that very small, delicate insects such as gall midges become arrested in the sticky substance while larger insects, e.g. flies, are deterred from walking or feeding on the treated parts of the leaves. In cabbages only the apical meristem and surrounding area of the young plant is treated. In onions and leek the cover on the leaves is very thin because of their steep vertical position. The axils of the leaves, however, are protected very well and it is here that thrips are most abundant. For all the crops we have tested, the addition of a good spreader to the emulsion is necessary. Rain does not seem to influence the performance of the emulsions in terms of maintained stickiness, provided that the emulsion can dry on the plant to fix the polymers to the surface.

2.2 Crucifer tests

Two experiments with *C. nasturtii* were done in perspex cages of ca. 0.1 m^3 placed in a greenhouse at a temperature of 22 °C and 65 % relative humidity. In the first experiment cages contained 8 potted cauliflower plants, 10 weeks old, and there were 2 treatments and 1 control with 4 replicates each. Treatments consisted of spraying all or 50 % of the plants in the apical meristem with 3 ml of a 10 % Oppanol emulsion and then releasing >300 adult gall midges in each cage.

Symptoms of infestation were assessed 12 and 20 days after treatment by examining the apical meristem area. In the second experiment the procedures were identical except cages contained 6 potted plants and all plants in each cage were treated either with a 10 or 20 % Oppanol emulsion.

In the field, 10 potted cauliflower plants per tray in 4 replicates were infested by the local field population of gall midges from 10. 6. until 15. 7. The plants were treated with a 20 % Oppanol emulsion (6 % Oppanol 100) once a week, once per 2 weeks or not at all. After 8 weeks in the field the number of infested plants per tray was determined by examining the apical meristem for distorted growth.

In addition to examining the effect of Oppanol on reducing gall midge infestation in crucifers, additional field and laboratory studies examined several Oppanol mixtures for their effects on plant growth.

2.3 Onion tests

An experiment with *T. tabaci* was carried out in a commercial type greenhouse (ca. 22 °C and varying RH) where individual potted onion plants (6–8 leaf stage) were placed under cucumber plants which were heavily infested with *T. tabaci* and whose leaves were drying out, thus encouraging the thrips to move onto the onions. The onions had been treated with 20 % Oppanol emulsions containing the Oppanol 100 component in varying percentages. Ten or 5 ml of the emulsion were applied per plant. Twenty plants were used per treatment and there were 6 treatments including the control. One and 2 weeks after the application of Oppanol the plant injury caused by *T. tabaci* was assessed by a rating scale 0–5 (5 = 75 % of the leaf surface injured).

3 Results

3.1 Crucifer tests

The results of experiments A and B in cages after 12 days are summarized in table 1. Protection of the heart of cabbage plants by Oppanol emulsions provided a considerable reduction of the infestation by *C. nasturtii*. In Experiment A, treating 50 % of the plants resulted in a more than 50 % reduction of the infestation, probably due to a trapping effect from the treated plants. In Experiment B, the 20 % emulsion was superior to the concentration of 10 % Oppanol mixture according to an analysis of variance. Eight days after the first assessment, a second examination showed the same results.

Table 1. Percentage of plants infested by *C. nasturtii* in cauliflower plants in cages, treated with Oppanol emulsions

Experiment	A			B		
Replicates	Untreated	All treated	50 % treated	Untreated	10 % emulsion	20 % emulsion
1	88	0	13	100	33	66
2	88	0	0	80	16	50
3	75	0	13	80	0	0
4	50	0	13	100	33	0

Differences significant in A at $P < 0.005$, in B at $P < 0.01$

In the cauliflower experiment under field conditions, the untreated plants had an average rate of 40 % infestation compared to 8.25 and 2.5 % for the once a week and fortnightly treatments, respectively.

In this experiment (table 2) the growth habits of the treated cauliflower plants did not differ visually from that of the untreated ones but, because the plants were in pots, all plants were stunted.

Table 2. Percentage of plants infested by *C. nasturtii* in cauliflower plants in the field, treated with Oppanol emulsions

Treatments Replicates	Untreated	Once a week	Once per 2 weeks
1	50	13	0
2	10	0	0
3	60	0	10
4	–	20	0

Differences significant at $P < 0.005$ between treated and untreated. No significant difference between treatments

To obtain more information on possible phytotoxic effects of 20 % Oppanol emulsions on the growth of cauliflower, 3 treatments of 28 cauliflowers each (untreated, treatments once a week and once per 2 weeks) were conducted in a research greenhouse (22 °C and varying RH). Results from weighting each plant indicate no difference in plant weight, although under these greenhouse conditions no curds could be produced.

Field experiments with white and red cabbage and Brussels sprouts did not show any adverse effects in the final product from weekly (6 replicates) or fortnightly (3 replicates) treatments with a 6 % Oppanol 100 to Oppanol 1 emulsion. However, in spring cabbage these 2 treatments caused a 1 week retardation in growth and in broccoli serious deviations of flowerbud formation were observed. About 10 % of savoy cabbage plants showed an abnormal growth which could have been caused by increased fleabeetle attack of treated plants. The treatments cause a glossy appearance of the treated parts of the plant which made them more susceptible to fleabeetles (de Ponti 1984). In general, the fortnightly treatment had slightly adverse effects.

3.2 Onion tests

The results of the experiment with *T. tabaci* on onions are provided in table 3.

Treatment 1 shows 18 out of 20 plants with no injury (rating 0) or very light and still acceptable injury (rating 1) after one week exposure to very high populations of thrips. On plants with a rating of 4–5 >100 thrips (larvae and adults) could be found easily while few or none were seen on plants of treatment 1. Thrips were not stuck on the plants in treatment 1 but simply appeared not to feed. Two weeks after treatment, treatment 1 still provided the best control but generally a shift to a higher rating was observed. The plants of the other treatments were more injured but intermediary when compared to the untreated control. The lower proportion and concentration of component Oppanol 100 in treatments 3 and 4 evidently present a lower barrier to the

Table 3. Number of plants (from a total of 20) with a thrips injury rating one and two ( ) weeks after treatment

	Treatments		Rating 0	1	2	3	4	5
1	10 ml 15 % Oppanol 100	+0.5 % spreader	4	14(1)	2(12)	(5)	(2)	
2	10 ml 10 % Oppanol 100	+0.5 % spreader			6(1)	9(4)	5(7)	(8)
3	10 ml 6 % Oppanol 100	+0.5 % spreader		1	4	12(3)	3(13)	(4)
4	5 ml 6 % Oppanol 100	+0.05 % spreader			3	12(1)	4(7)	1(12)
5		0.05 % spreader				3	8	9(20)
6	untreated 6 plants				1		5(1)	(5)

feeding of *T. tabaci*. No phytotoxicity was noted although onion foliage became glossy.

4 Discussion

Development of a non-phytotoxic "arrestant" is necessary because of the need for improved control of *C. nasturtii* in cabbage, *T. tabaci* on *Allium* and other small insects on horticulturally important crops. This need is especially pressing for *C. nasturtii* since Diptera normally become rapidly resistant to the commonly used pyrethroid (BESEMER 1984).

Our results indicate Oppanol is very effective against infestation by small insects as a mechanical "arrestant", as shown for *C. nasturtii*, or as a feeding inhibitor, as in the case of *T. tabaci*. The reaction of other pest insects will vary greatly. For instance, different species of aphids have been observed walking from an Oppanol-treated upper leaf surface to the untreated underside where they can feed. On treated leaves walking carabid beetles were almost completely arrested by tarsal contact with the Oppanol whereas small winged insects were trapped when their wings touched the sticky surface. Flies were deterred when touching surfaces treated with Oppanol emulsions. The dried Oppanol emulsions described above generally are effective only as an arrestant of very small and short-legged insects. Because of economic aspects and application technique limitations, they cannot be applied where a thorough protection of large leaf surfaces is needed or where cosmetic problems may develop. Improvement of the stickiness of these leaf surface modifying agents is needed to obtain a more broad spectrum effect, although this may limit the potential of parasites and predators. From this point of view a (theoretical) mechanical protection to oviposition by non-sticky polymers might offer a more subtle solution for in situ application during susceptible periods of crops.

The results of this study are the first to indicate that very small pest insects which hide, oviposit and mature in hearts and axils of plants can be deterred or inhibited in their activities during susceptible periods of the crop. More effort should be made to modify this system to a wider range of crops and to reduce the risk of phytotoxicity while increasing residual activity.

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Zusammenfassung

Zur Vorbeugung von Pflanzenbeschädigungen durch die Kohlgallmücke, Contarinia nasturtii Kieffer, und den Zwiebelblasenfuß, Thrips tabaci Lindemann, durch Anwendung von Polyisobutylen

Die gezielte Bekämpfung von Blattläusen und Raupen in Kohl wird örtlich durch das Auftreten der Kohlgallmücke, *Contarinia nasturii*, gehemmt. Mit dem Gebrauch von nicht ionogenen Emulsionen des künstlichen Gummi-Polymers Polyisobutylen, ist eine mögliche, insektizidfreie Bekämpfung entwickelt worden.

Es wurden Laborversuche mit einer großen Anzahl, in Käfigen freigelassenen Mücken durchgeführt. Durch die Anwendung der Emulsionen konnte der Befall von Blumenkohl deutlich reduziert werden. Auch in Freilandversuchen wurden gute Ergebnisse erzielt. Bei einigen Kohlsorten traten, insbesondere wenn sie häufig gespritzt wurden, Wachstumsstörungen auf. Bei Behandlung von mit *Thrips tabaci* befallenen Zwiebeln konnte die Ernährung und Entwicklung der Thripse erheblich gehemmt werden. Eine weitere Verbesserung dieser, die Blattoberfläche verändernden Substanzen ist wünschenswert.

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Conspecific effects on pheromone production by the boll weevil, *Anthonomus grandis* Boh. (Col., Curculionidae)

By J. C. DICKENS and G. WIYGUL

Abstract

Conspecific effects were shown for aggregation pheromone production by male boll weevils. A single mating of males on day 3 following emergence lead to a significant decrease within 48 to 72 hrs in quantities of aggregation pheromone components I, II, and III, as well as total pheromone production relative to unmated control males. Recovery of production of each pheromone component as well as total pheromone production occurred within 3 or 4 days following mating to levels on days 9 and 10 which exceeded control males at this time. The results suggest that levels of pheromone may signal mating readiness and also facilitate genetic diversity

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