Improving Control of *Duponchelia fovealis* (Lepidoptera: Pyralidae) by Rooting Media Related Strategies

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Abstract

Soil-dwelling predatory mites can be very effective as biological control agents against larvae of the lepidopteral pest *Duponchelia fovealis*. Some growing media were reported to have natural high level and stable populations of predatory mite. The objective of this experiment was to define conditions to establish stable predatory mite populations in the rooting medium and to assess the direct effect of the rooting media on pest development. Eight rooting media were prepared, including a range of degradabilities as measured with the Oxygen Uptake Rate method (OUR). The OUR range was created by mixing peat products, coir dust, bark, perlite, compost and wood fiber. Each treatment was split: half with and half without a commercially used mulch to create a drier top layer. Kalanchoës were grown on these rooting media. After one week soil-dwelling predatory mites (*Hypoaspis miles*) were added. Adults of the pest *Duponchelia fovealis* were released during a number of weeks. Both populations were counted. Results show that the OUR range was successfully achieved. The commercial mulch, a cork based fine granulate, reduced the numbers of *Duponchelia* by 32%. The number of predatory mites was related to the oxygen uptake of the rooting media (R^2=0.87). The predatory mite reduced the numbers of *Duponchelia* larvae on average by 58%. Thus, biological control by soil-dwelling predatory mites can be improved by offering rooting media with an increased degradability as measured by the oxygen uptake rate. The combined effects of using predatory mite and mulch layers are discussed.

INTRODUCTION

A number of pests in greenhouse crops are related to soil or rooting media. One of those is the relatively new, but widespread pest *Duponchelia fovealis* Zeller (Lepidoptera: Pyralidae) (Romeijn, 1992). The larvae of this moth prefer to live in a moist soil layer where they feed on either plant parts or organic matter. Biological control of this pest has proven to be very effective with soil-dwelling predatory mites. The commercially available species *Hypoaspis miles* (Berlese) was the most successful predator of the egg stages of *D. fovealis* (Messelink and van Wensveen, 2003). The success of controlling *D. fovealis* by these predatory mites however is variable. It was found that population levels of these mites vary between the different rooting media used (Messelink, pers. obs.). Soil-dwelling predatory mites are on the top of complex food webs (Coleman and Crossley, 1996) and their establishment is consequently related to the number of soil micro-arthropods that are suitable as prey organisms. In theory it might therefor be possible to upgrade levels of predatory mites and improve biological control by stimulating soil microarthropods. In this study it was hypothesised that a rich soil fauna is related to the turnover of organic material into carbohydrates and nutrients. Organic materials with a relatively high degradation rate such as composts and wood fiber might, as a result of a richer soil micro life, support larger predatory mite populations than slower degrading rooting media as peat and coir.

To examine this hypothesis, rooting media mixes were prepared, ranging from easily decomposable material to very stable material. It was recognized that by using increasing amounts of compost, the water content, salt level and possibly pH would

increase along with the degradability. To prevent interference of factors such as water content, EC and pH, mixes were to be designed to keep these factors as stable as possible while still increasing the degradability. Furthermore it is known that moths prefer moist rooting media above drier ones (Messelink, unpublished). It was therefore decided to add rooting media having a range of water contents with as little difference in degradability, EC and pH as possible.

MATERIALS AND METHODS

In total 32 treatments were prepared (Table 1). Eight initial treatments, A-H, were based on specific potting soil mixes. These treatments were split in half, one with a mulch layer and one without a mulch layer. This created sixteen treatments, A1-H1 and A2-H2. During the growing period half of each treatment received predatory mites after one week and half of each treatment did not receive predatory mites, creating a final 32 treatments with 5 repetitions each.

The potting soil mixes were designed with a proportional model into two ranges of four rooting media each, composed from seven constituents (Table 2). In the first range, A-D, water content increased while degradability and EC were kept as stable as possible. In the second range, E-H, the degradability increased with water content and EC kept as stable as possible. In both cases the pH was brought to pH 5.5 by adding lime.

The respiration rate was measured with the Oxygen Uptake Rate method (Veeken et al., 2003). The OUR is a measurement of the pressure drop in a closed vessel in which an amount of rooting media is decomposing. The pressure drop is interpreted as the amount of oxygen used for microbial decomposition of the material studied. The microbial breakdown is carefully kept at optimal temperature, moisture and oxygen levels while chemicals prevent pressure effects of gaseous carbon dioxide and nitrogen. The EC, pH and initial water content were measured after mixing.

The rooting media thus prepared were used to fill 800 1 L containers of 13 cm diameter. In these containers Kalanchoë cuttings were planted. The Kalanchoë were grown for 16 weeks. The pots were monitored for weight. During the cultivation period it was noted that the weight and feel of the more degradable soil mixes changed. Therefore the penetration value of the soil mix as found in the rooted container was measured after the cultivation period. This was done with an Instron Universal Testing Machine using an existing method for substrate testing. A flat round head with a diameter of 10 mm was pressed some 70 mm into the material. The average resistance was recorded in kPa. The method was slightly adapted to deal with the larger than usual sample height.

An average number of 10 predatory mites per plant were added one week after planting. Adults of the pest *Duponchelia fovealis* were released during six following weeks, in total about 600 adults (45% ♀). Population development of *Duponchelia* was followed by biweekly counting, starting 8 weeks after planting. Populations of soil micro-arthropods, including predatory mites, were assessed once 14 weeks after planting by analyzing soil samples of 300 ml/plot. Soil micro-arthropods present in these samples were extracted by heat using Tullgren funnels. Organisms were collected in 70% ethanol, filtrated on a filter paper and identified under a microscope. Numbers of counted organisms were transformed on a log scale and analyzed by ANOVA, followed by mean comparisons by the least significant difference method.

RESULTS AND DISCUSSION

The predicted and measured values for degradability, water content at container capacity and EC were compared (Table 3). The water contents calculated correlated poorly to the actual measured water contents. This was probably due to the effect of interstitial filling. As the smaller particles fill the air filled voids between the coarser material, the water content of the mix is not lowered by the coarser material but resembles that of the pure finer material. It is evident that the estimation of water content of mixes based on the pure single constituents has to be improved (Verhagen, 1997). The range of respiration rates has been achieved quite successfully. The EC values measured and

calculated are fairly equal when the amount of fertilizers added to the mixes was included. Only treatments G and H contained more potassium and borium than anticipated (Table 4). All EC and pH values during growing were acceptable.

The penetration resistance of the rooting media E-H probably started at values well above 200 kPa. The values declined within a few months (Table 3). This is interpreted as an effect of the microbial breakdown of organic matter. The breakdown is believed to decrease the amount of material present in the container quite fast. However, in this experiment, this did not result in a visual loss of volume. It is likely that the emerging roots of the Kalanchoë more or less kept the volume of the remaining rooting medium unchanged. The containers did however, lose weight, a part of their moisture retaining capacity and rooting resistance. The loss in water retaining capacity is reflected by a loss in water content and the loss in rooting resistance correlated well with the OUR measurement (Table 3).

The number of predatory mites correlated with the OUR measurement of the rooting media (R^2=0.87, Fig. 1). The predatory mite reduced the numbers of *Duponchelia* on average by 58% (Fig. 2). The commercial mulch, a cork based fine granulate, reduced the numbers of *Duponchelia* by 32% (Fig. 3).

Concluding, biological control by soil-dwelling predatory mites can be improved by offering rooting media with an increased degradability. A complicating factor is that by increasing the degradability of a medium many other properties change, such as water and air contents at various suction levels, the EC and pH and the elemental composition of the nutrition. In this experiment, the mixes used were fairly comparable for these parameters but the degradation itself caused large changes in properties of the potting soil. The 10% drop in water content at saturation and the 10-30% density loss within a three month period limit the use of highly degradable mixes to plants with a short cultivation period. Another thing to bear in mind is that by changing the mixes the potting soil may become more attractive to some other pests, and also diseases.

The combined effects of using predatory mites and mulch layers in this experiment were quite interesting. In a commercial greenhouse, however, usually only mulched or only un-mulched containers are offered. The pest then does not have a choice but to lay its eggs in the mulched plants. It is not yet clear whether mulch just repels the adult insects or also decreases the number of hatched larvae. Until this is clear a grower might use some un-mulched plants as traps to attract any *Duponchelia* present.

ACKNOWLEDGEMENTS

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Tables

Table 1. The treatments in the experiment: each treatment represents 5 replicates of 5 plants each.

Rooting media		A	B	C	D	E	F	G	H
Mulch	Predator mite								
With	With	A1a	B1a	C1a	D1a	E1a	F1a	G1a	H1a
Without	With	A2a	B2a	C2a	D2a	E2a	F2a	G2a	H2a
With	Without	A1b	B1b	C1b	D1b	E1b	F1b	G1b	H1b
Without	Without	A2b	B2b	C2b	D2b	E2b	F2b	G2b	H2b

Table 2. Mixture composition by constituents in percentage volume.

Rooting media	A	B	C	D	E	F	G	H
Constituent								
Coir dust	5	18	35	80	35	25	20	
Bark	50	40	30	20				
Compost*						10	20	30
Perlite	10				15	20	20	30
Coarse Irish peat					50	38	10	0
Baltic white peat**	30	37	30				5	10
Wood fiber	5	5	5			7	25	30

*Compost with 50% wood fiber.
**Baltic white peat 0-20 mm.

Table 3. Values for degradability (RR), water content (WC), EC and penetration resistance (PR) as predicted by model and as measured for all rooting media.

Rooting media	Unit	A	B	C	D	E	F	G	H
RR model	*	3.2	3.3	3.3	3.1	1.5	3.2	6.1	7.5
RR measured	*	3.4	2.7	3.4	2.4	1.6	3.6	6.2	8.5
WC model	%-V	65	70	75	78	58	56	57	56
WC 1 before	%-V	77	81	81	81	81	83	83	78
WC 2 after	%-V		82	83	83	79	76	74	71
EC model	$dS.m^{-1}$	0.3	0.3	0.4	0.4	0.3	0.5	0.6	0.8
EC measured**	$dS.m^{-1}$	0.6	0.8	0.8	0.9	1.0	0.9	1.5	1.3
PR***	kPa	163	153	187	215	234	202	129	109

RR: Respiration rate
WC1: Water content at laboratory container capacity before cultivation.
WC2: Water content at laboratory container capacity after cultivation.
EC: Electro conductivity.
*In mmol $O_2.g^{-1}FW.h^{-1}$ (FW = Fresh weigh).
**EC including 0.5 $dS.m^{-1}$ caused by the fertilizers added.
***PR: Penetration resistance of a flat circular head of 10 mm diameter

Table 4. The elemental composition of the rooting media A-H.

	Unit	A	B	C	D	E	F	G	H
NH_4	$mmol.L^{-1}$	0.1	0.2	0.8	0.8	2.0	1.3	1.8	1.6
K	$mmol.L^{-1}$	2.0	2.4	2.8	3.2	2.5	2.9	5.7	6.8
Na	$mmol.L^{-1}$	0.6	0.6	0.7	0.9	0.8	1.0	1.4	1.4
Ca	$mmol.L^{-1}$	0.6	1.1	1.2	1.2	1.0	0.7	1.0	0.9
Mg	$mmol.L^{-1}$	0.7	1.0	0.9	0.5	1.0	0.6	0.6	0.5
NO_3	$mmol.L^{-1}$	2.2	3.6	4.2	4.5	5.3	3.6	5.2	5.2
Cl	$mmol.L^{-1}$	0.3	0.5	0.5	0.8	0.5	1.2	2.2	2.7
SO_4	$mmol.L^{-1}$	0.9	1.1	1.1	1.0	1.2	1.0	1.5	1.6
HCO_3	$mmol.L^{-1}$	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
P	$mmol.L^{-1}$	0.46	0.59	0.66	0.62	0.92	0.95	1.07	0.8
Si	$mmol.L^{-1}$	0.15	0.16	0.11	0.1	0.1	0.16	0.22	0.16
Fe	$micromol.L^{-1}$	2.4	4.5	4.6	2.8	3.9	5.0	4.7	7.5
Mn	$micromol.L^{-1}$	2.5	4.3	4.2	3.9	3.1	6.4	8.8	8.4
Zn	$micromol.L^{-1}$	4.9	4.4	2.8	1.6	2.8	1.5	4.8	4.4
B	$micromol.L^{-1}$	3.4	4.9	8.3	14.0	6.4	10.0	22.0	23.0
Cu	$micromol.L^{-1}$	0.6	0.8	0.9	0.9	1.3	0.4	0.4	0.6
Mo	$micromol.L^{-1}$	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5

Underscored: high values.

Figures

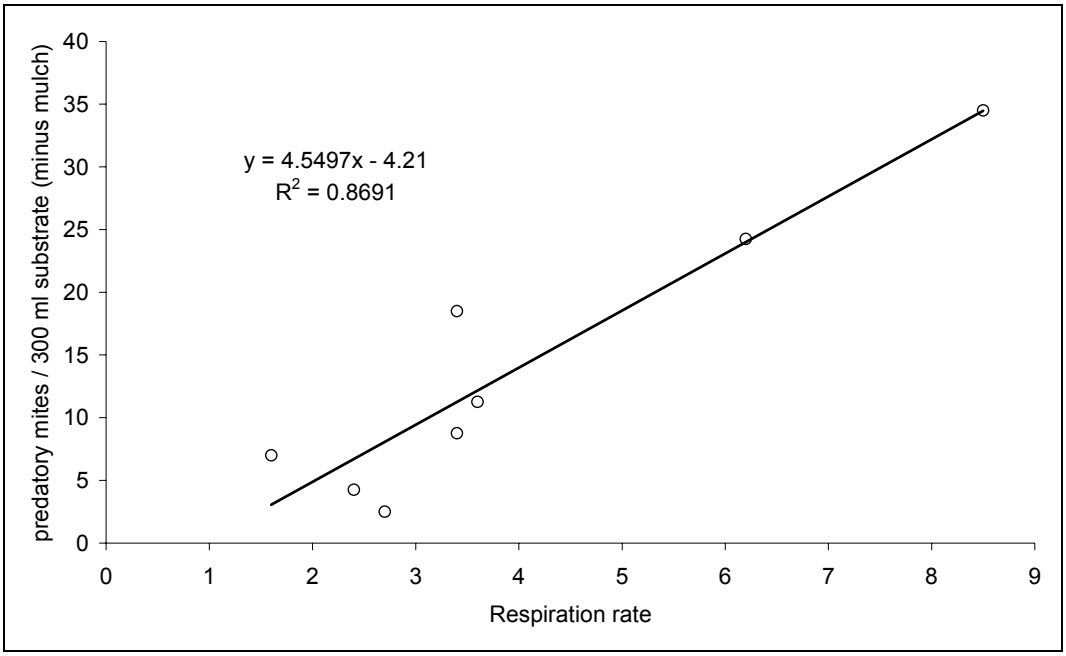

Fig. 1. Number of predatory mites found per 300 ml of substrate against respiration rate as measured with the OUR method.

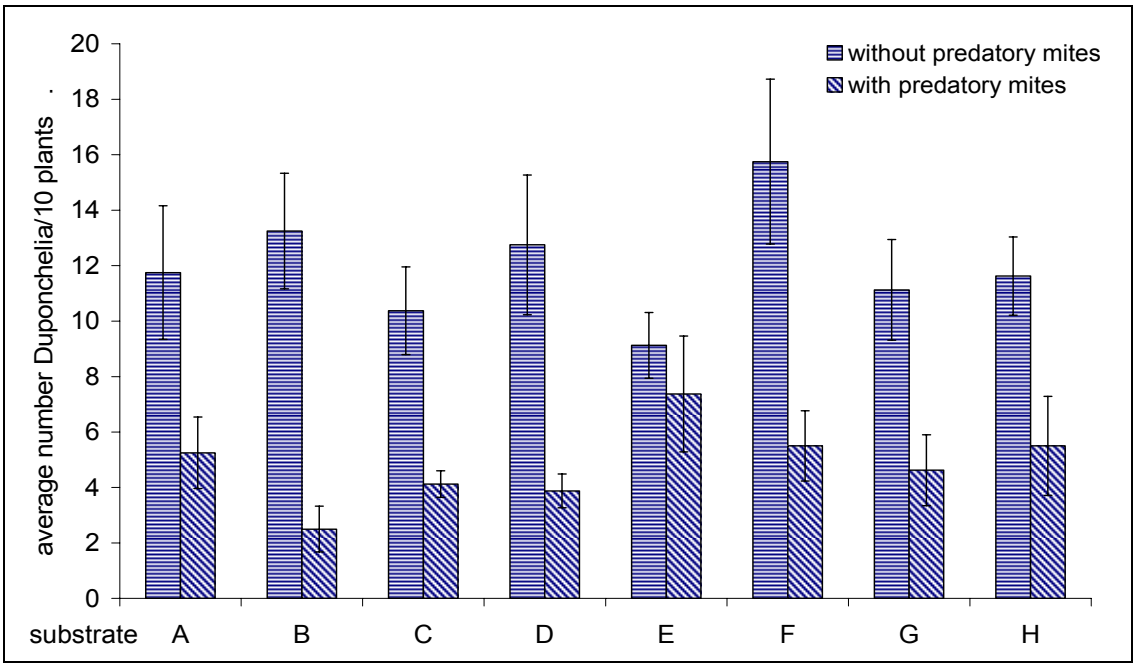

Fig. 2. Number of *Duponchelia* found per 10 Kalanchoë plants per 10 plants with and without predatory mites added to eight different rooting media A-H.

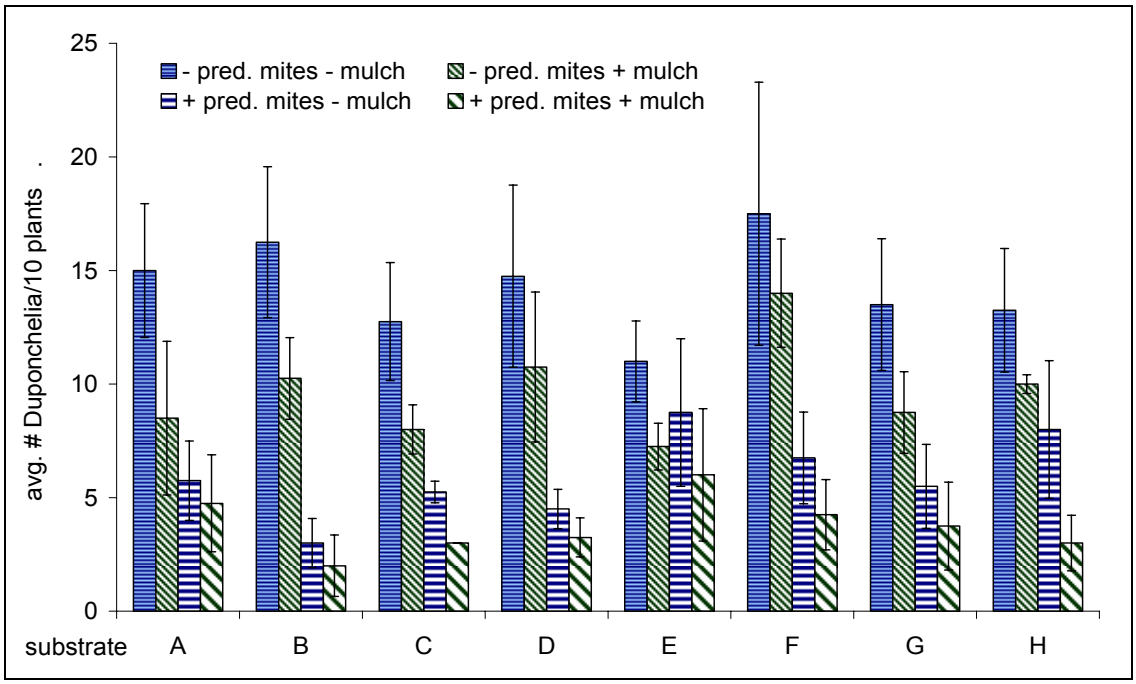

Fig. 3. Number of *Duponchelia* found per 10 Kalanchoë plants on eight different rooting media either with and without predatory mites added, and with or without mulch layer added.