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Deposition and distribution pattern of fogs generated by thermal pulse jet applicators throughout glasshouses

Afsætning og fordeling af sprøjtevæske i væksthus ved applikation med varmtågegenerator

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Summary

The deposition of spray liquid from themal pulse jet applicators was assessed by measuring droplets om magnesium oxide coated glass plates, by measuring fluorescent dye added to the spray liquid and by the control of 2nd instar of the glasshouse whitefly *Trialeurodes vaporariorum* Westw. obtained with deltamethrin. The methods showed that more than 90% of the spray liquid was deposited on horizontal upward directed surfaces and only a negligible part on downward directed surfaces. To obtain an even distribution of the spray liquid in a glasshouse the applicator had to be pulled through the house during fogging. The application efficiency with an aqueous solution was estimated to 15-34%

Key words: Thermal pulse jet applicator, fogging, deposition, distribution, glasshouse, *Trialeurodes vaporariorum* Westw.

Resumé

Afsætning af sprøjtevæske i væksthus ved applikation med varmtågegenerator blev målt med tre forskellige metoder: Afsætning på magnesiumoxid-belagte glasplader, afsætning af et til sprøjtevæsken tilsat fluorescerende farvestof og bekæmpelsesvirkningen af deltamethrin på 2. larvestadium af væksthusmellusen (*Trialeurodes vaporariorum* Westw.), som udelukkende sidder placeret på bladundersiden. Metoderne viste samstemmende, at mere end 90 pct. af den afsatte sprøjtevæske blev afsat på vandrette opadvendte flader, og kun en ubetydelig del blev afsat på vandrette nedadvendte flader. Stationær placering af tågegeneratoren gav en meget ujævn fordeling af sprøjtevæsken i væksthuset. Trækning af tågegeneratoren igennem huset gav en mere jævn fordeling. Applikationseffektiviteten med vandig sprøjtevæske blev anslået til 15-34 pct.

Nøgleord: Varmtågegenerator, tågning, afsætning, fordeling, væksthus, *Trialeurodes vaporariorum* Westw.

Introduction

Thermal pulse jet applicators have been acquired by Danish glasshouse growers in the past years. The recommended application technique is to use water as carrier and place the pulse jet applicator at one of the house ends directing it in the longitudinal direction of the glasshouse with the resonator raised 30°C above horizontal level. Using this easy application technique a visible fog gradually fills the whole glasshouse. *Mathes* and *Bau* (9), *Lindquist* and *Powell* (7) and *Stahl* (18) found, however, that thermal fogging by stationary application gives a very uneven deposition of spray liquid on the plants, a very poor penetration into a crop and an uneven distribution in the glasshouse. On this basis it was decided to test the deposition and distribution of thermal fogs in large glasshouses using equipment available in Denmark.

Thermal pulse jet applicators are jet engines where the spray liquid is added through one or more nozzels placed near the opening of the resonator (the exhaust pipe). The nozzles only dose the spray volume, and do not contribute to atomization of the liquid. This is primarily done by the exhaust gas separating the liquid in very fine droplets and distributing them in the glasshouse (14, 18). A part of the spray liquid evaporates in the warm exhaust gas. Condensation of a part of this vapour in the relative cool air of the glasshouse probably also contributes to the drop formation. The spray volume used amounts from 1.5-5.0 l per 1000 m^2 glasshouse area.

It is possible to measure the droplet spectrum from a pulse jet applicator with a laser particle sizer but it is problematic to measure all the droplets actually depositing on the plants. Droplets down to 10 μm can be measured by the magnesium oxide method (10). Smaller droplets, however, do not leave prints in the magnesium oxide coating or sink in a fluid protecting them from evaporation. Conserving very small droplets necessitates an instant sealing (4) which is not possible in a glasshouse where the fog has to settle all night. To solve these problems, two different sampling techniques were used to assess the deposition of spray liquid on the plants, the magnesium oxide method and addition of a fluorescent dye to the spray liquid. The efficacy of the application was also evaluated by assessing the control of a pest.

Materials and methods

Two types of thermal pulse jet applicator were included in the investigation, Igeba TF 30 and Igeba TF-W 160 HD. TF 30 is a small model equipped with one nozzle (∅ 1.2 mm), while TF-W 160 HD is a bigger model equipped with three nozzles (∅ 1.4 mm). Tap water with 10% methylentriglycol added was always used as carrier. Methylentriglycol makes the fog visible in a milky colour and should, according to Igeba Gerätebau GmbH, reduce the drop sizes. The surface tension of different concentrations of methylentriglycol in ion exchanged water at 18°C was measured by a tensionmeter.

The volume median diameter (VMD) of the fog from an Igeba TF 30 was measured by a Malvern 3600 E type Particle Sizer VA 6. The opening of the resonator was placed 0.25 m from and perpendicular to the laser beam. The measurement was repeated 4 times.

The application experiments were carried out in commercial glasshouses filled with plants since the purpose was to measure the deposition and distribution patterns under the physical conditions existing in production glasshouses. The glasshouses were 1400-1500 m^2 with 0.15-0.30m high potted chrysanthemum (*Dendranthema morifolium* (Ramat) Hemsl) placed closely on benches. The benches were placed perpendicular to a middle pathway running from one house end to the other. During fogging the pulse jet applicator was placed on a wagon lifting the applicator above the crop. The resonator was directed 30°C above horizontal level to prevent phytotoxic damage to the nearest plants. The foggings were carried out at sunset with the airing windows closed. The air temperature was raised 2°C to 21-22°C to prevent condensation on the plants. The relative humidity (R.H.) varied from 80-95%.

Three application techniques were tested: Stationary position of the pulse jet applicator with the resonator placed in and directed parallel to the middle pathway or the applicator pulled along the middle pathway from one house end to the other either with the resonator directed parallel to the middle pathway or with the resonator frequently moved from side to side.

The glasshouses were equipped with black out curtains used to induce flowering in the chrysanthemum plants. Some of the foggings were made with the black out curtains drawn and some without. The black out curtains consisted of black light-proof cloth and when drawn they built a horizontal roof in a height of 2.5 m. The trempler and the house ends were covered by vertically placed curtains.

The deposition of spray liquid was assessed by means of collectors with horizontally and vertically oriented surfaces representing plant parts as leaves and stems. The vertical surfaces were positioned toward the two house ends.

Drops per area were measured by the magnesium oxide (MgO) method using 2 × 5 cm coated glass plates. The fluorescent dye uvitex (Helios 010 EC, Ciba-Geigy Ltd.) was added to the spray liquid with 265 mg per l. The dye was collected on pieces of filter paper 2 × 5 cm. The glass plates and the filter papers were collected early in morning after the fogging. The filter papers were stored in darkness at 4°C until the uvitex was extracted by isopropanol and the concentration was measured using a Farrend Filter Ratio Flourometer - 2. The drop prints in the MgO coating were registered at 3 randomly chosen places totally 9.42 mm^2 per glass plate at 100 × magnification. The glass plates and filter papers were fastened to collectors. The collectors were placed in level with the top of the plants in one half of the glasshouse with 7 positions covering the longitudinal x 3 positions covering the transverse distribution i.e. all in all 21 positions. In two treatments fogging was carried out with and without black out curtains drawn respectively. Filter papers were fastened to the inside of black out curtains and window glasses respectively with 3 positioned at each house end and 7 positioned along the trempler in level with the top of the crop. On the roof formed of the black out curtains filter papers were placed at 21 positions above the collectors. In the treatment without black out curtains drawn filter papers were placed on the window glasses of the roof from the bottom and 5 m up at 6 positions and at two different places in the house. The window glasses were wet with condensed water, so the filter papers were soaked when placed on the glass.

The deposition of spray liquid was further evaluated by assessing the efficacy of a fog to control the sedentary pest, glasshouse whitefly (*Trialeurodes vaporariorum* Westw.). Small poinsettia plants (*Euphorbia pulcherrima* Willd.) infested with at least 50 second instar glasshouse whitefly per leaf were used. Poinsettia was used because the glasshouse whitefly is easy to rear on this spicies. The nymphs were exclusively positioned at the abaxial leaf surfaces. The plants were pruned to one leaf resembling the artificial collectors. The plants were placed at the 7 positions covering longitudinal direction of the glasshouse and near the middle pathway with 6 plants per position. The fogging was made with Igeba TF-W 160 HD using 5.8 l spray liquid with 8.3 g deltamethrin and 0.5 l methylentriglycol per 1000 m^2. This dose of deltamethrin was more than three times the one recommended by Igeba Gerätebau GmbH but the gardener insisted on using this high dose. The plants were collected next morning and moved to the research station where 6 control plants were kept. The efficacy of the fogging was assessed by counting 50 whiteflies per plant, assessing the part of emerging adults compared to the untreated control.

Results

A VMD of 31 ± 2.5 µm (95 % confidence limit) was found for Igeba TF 30 equipped with one nozzle (Ø 1.2 mm) applying tap water with 10 pct. methylentriglycol.

The surface tension of 10% and 20% methylentriglycol in water and of pure methylentriglycol was measured to 6.4 ± 0.2 µN, 5.9 ± 0.1 µN, and 4.2 ± 0.2 µN respectively. In comparison the surface tension of ion exchanged water was 7.2 ± 0.2 µN. All results are given with 95% confidence limit. These results confirm that adding methylentriglycol in water decreases the surface tension of the solution.

The number of droplets on MgO collectors and the deposition of fluorecent dye on filter papers after fogging with and without black out curtains drawn in 1500 m^2 glasshouses are shown in Table 1.

The vast majority of the spray liquid recovered was deposited on the horizontal upwards directed surfaces while almost nothing was deposited on the horizontal downward directed surfaces. Less than 10% of the spray liquid recovered was deposited on vertical surfaces. The sampling variations are high indicating an uneven distribution of the spray liquid. Fogging with black out curtains drawn gave a much hig-

Table 1. Deposition of droplets/cm² and ng fluorescent dye/cm² on collectors after fogging with 5.5 l spray liquid in a 1500 m² glasshouse with black out curtains drawn (treatment A) and with no curtains drawn (treatment B). Repetition 1 was carried out in February and repetition 2 in August. The pulse jet applicator was pulled from one house end to the other during the applications.
Afsætning af sprøjtevæske på stativer målt som dråber/cm² og ng flourescens/cm² efter tågning med 5,5 l sprøjtevæske i et 1500 m² væksthus med (forsøgsled A) og uden (forsøgsled B) mørklægningsgardiner trukket for. Gentagelse 1 blev udført i februar og gentagelse 2 i august. Tågegeneratoren blev trukket gennem husets midtergang under tågningen.

	No. of droblets/cm² *Dråber/cm²*				%[1]			
	Treatment A *Forsøgsled A*		Treatment B *Forsøgsled B*		A		B	
Position of collecting surface *Orientering af måleflade*	Repetition 1 *Gentagelse 1*	Repetition 2 *Gentagelse 2*	Repetition 1 *Gentagelse 1*	Repetition 2 *Gentagelse 2*	1	2	1	2
Horizontal upward *Horisontalt opad*	2577±837[2]	3149±975	687±106	437±217	96	94	97	96
Horizontal downward *Horisontalt nedad*	0	0	0	0	0	0	0	0
Vertical toward[3] *Vertikalt imod*	29±32	76±62	4±4	4±6	1	2	1	1
Vertical away from [4] *Vertikalt bortfra*	67±55	120±131	19±19	12±12	3	4	2	3

	ng fluorescent dye/cm² *ng fluorescens/cm²*				%[1]			
	Treatment A *Forsøgsled A*		Treatment B *Forsøgsled B*		A		B	
Position of collecting surface *Orientering af måleflade*	Repetition 1 *Gentagelse 1*	Repetition 2 *Gentagelse 2*	Repetition 1 *Gentagelse 1*	Repetition 2 *Gentagelse 2*	1	2	1	2
Horizontal upward *Horisontalt opad*	29.8±5.4	30.2±6.3	Missing *Manglende*	14.7±1.7	87	89	–	98
Horizontal downward *Horisontalt nedad*	0.5±0.1	0.2±0.1	–	0.1±0.2	1	1	–	1
Vertical toward[3] *Vertikalt imod*	1.6±0.4	1.5±0.6	–	0.1±0.2	7	4	–	1
Vertical away from [4] *Vertikalt bortfra*	2.3±0.6	2.1±0.8	–	0.1±0.2	5	6	2	1

1) Conversion of the factor recovered on each position of collection surfaces into per cent of the total number/amount recovered per repetition.
Omregning af mængde dråber/flourescens afsat på hver enkelt retning af målefladen i forhold til den totale mængde sprøjtevæske registreret pr. gentagelse.
2) 95% confidence limit
3) Toward the pulse jet applicator
Rettet hen imod tågegeneratoren
4) Away from the pulse jet applicator
Rettet bort fra tågegeneratoren

Table 2. The control of 2nd instar glasshouse whitefly *Trialeurodes vaporariorum* (Westw.) on poinsettia obtained by one fogging with deltamethrin with an Igeba TF-W 160 HK in 1500 m^2 glasshouses with and without black out curtains drawn. Half of the application was made from the middle of the house and half from a house end.
Bekæmpelse af væksthusmellusens (Trialeurodes vaporariorum) *(Westw.) 2. larvestadie på poinsettia ved applikation af deltamethrin med Igeba TF-W 160 HK i et 1500 m^2 væksthus med og uden mørklægningsgardiner trukket for. Halvdelen af tågningen blev foretaget fra midten af husets midtergang og halvdelen fra gavlen.*

Treatment *Forsøgsled*	Mean no. of whiteflies per plant *Gnst. antal mellus pr. plante*			% dead whiteflies *% døde mellus*	No. of plants per treatment *Antal planter pr. forsøgsled*
	Living *Levende*		Dead *Døde*		
	Before *Før*	After *Efter*	After *Efter*		
1. Control *Ubehandlet*	150	147.9	2.1±0.8[1] a[2]	1	6
2. Black out curtains drawn *Mørklægningsgardiner trukket for*	150	137.1	12.9±1.6 b	9	42
3. Black out curtains not drawn *Mørklægningsgardiner ikke trukket for*	150	137.7	12.3±1.2 b	8	42

1) Confidence limit
2) Numbers followed by different letters differ significantly for $P < 0.05$
Tal efterfulgt af forskellige bogstaver er signifikant forskellige for $P < 0,05$

her deposit of spray liquid than fogging with no curtains drawn. These results were confirmed by both sampling techniques.

In repetition 2 from Table 1 the spray liquid deposited on the window glasses and on the black out curtains, when fogging without and with black out curtains drawn respectively, was quantified. The amount of fluorescent dye deposited on the glass and the black out curtains was equal and no difference was found in the amounts deposited on the roof, the tremblers, and the house ends. The average deposition amounted to 1.3 ng flourscent dye per cm^2 with a large variation. This was about 1% of the dye applied.

The control of 2nd instar whitefly obtained by fogging with deltamethrin is shown in Table 2.

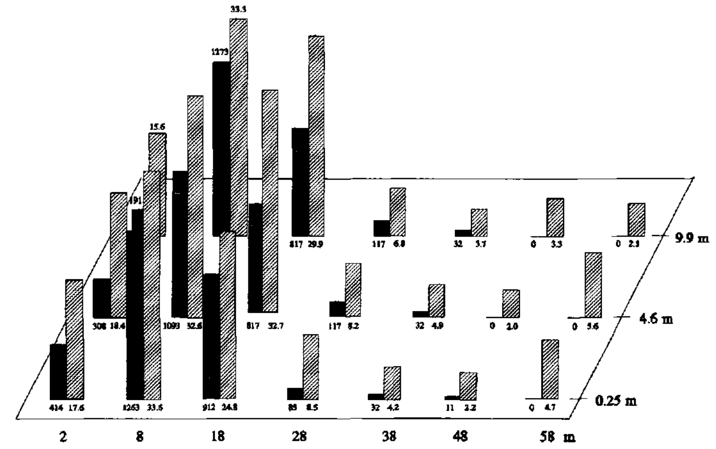
The effect on the glasshouse whitefly was only about 8% and no difference was found between fogging with and without black out curtains drawn.

Fig. 1 and 2 show the distribution of spray liquid in glasshouses after fogging using various application techniques.

All the application techniques tested gave an uneven distribution of the spray liquid, both longitudinal and transverse. Stationary position of the applicator gave the most uneven distribution with a heavy deposit of spray liquid 8-11 m in front of the applicator and a minor deposit in the farest end for the glasshouse. Pulling the applicator through the house during fogging gave the most even longitudinal distribution.

The very low amount of spray liquid registered 1 m from the house end in Fig. 2C is due to

A



B

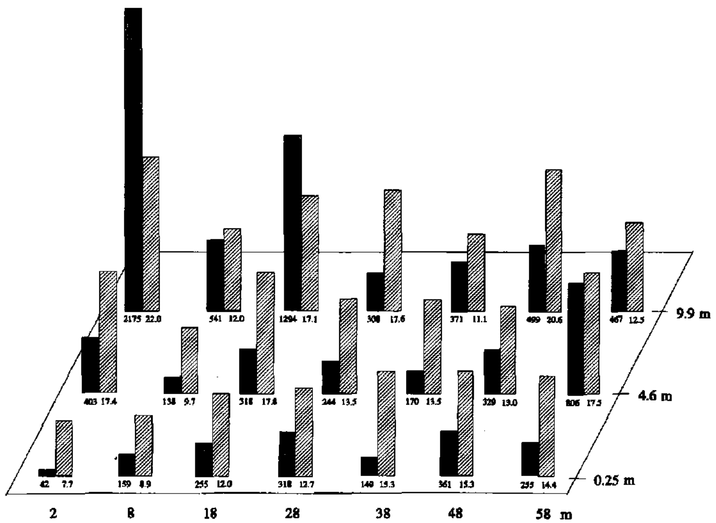


Fig. 1. The distribution of spray liquid measured on collectors as drops/cm^2 (black bars) and ng fluorescent dye/cm^2 (grey bars) after fogging with an Igeba TF 30 in 20×70 m glasshouses. Each pair of bars represent one collector. The base rectangle represents one half of the glasshouse area with the middle pathway placed in front of the horizontal frontline. The figures along the frontline and along the right vertical line give the distance of the collectors from the house end and the middle pathway respectively.

A. Stationary position of the applicator at left house end with the resonator placed in and parallel to the middle pathway.

B. The applicator was pulled from right house end to the other through the middle pathway moving the resonator from side to side.

Fordeling af sprøjtevæske i et 20×70 m væksthus efter tågning med en Igeba TF 30. Sprøjtevæsken blev registreret på målestativer som dråber/cm^2 (sorte søgler) og ng fluorescens/cm^2 (grå søjler). Hvert søjlepar repræsenterer et målestativ. Figurens rektangler illustrerer den ene halvdel af væksthusets grundareal med husets midtergang placeret lige foran den forreste horisontale linie. Tallene langs forreste horisontalt linie og højre vertikale linie angiver afstanden fra målestativer til husgavl henholdsvis midtergang i m.

A. Stationær placering af tågegenerator ved venstre husgavls midte med tågerøret pegende langs med husets midtergang.

B. Tågegeneratoren blev trukket gennem husets midtergang, mens tågerøret blev drejet fra side til side.

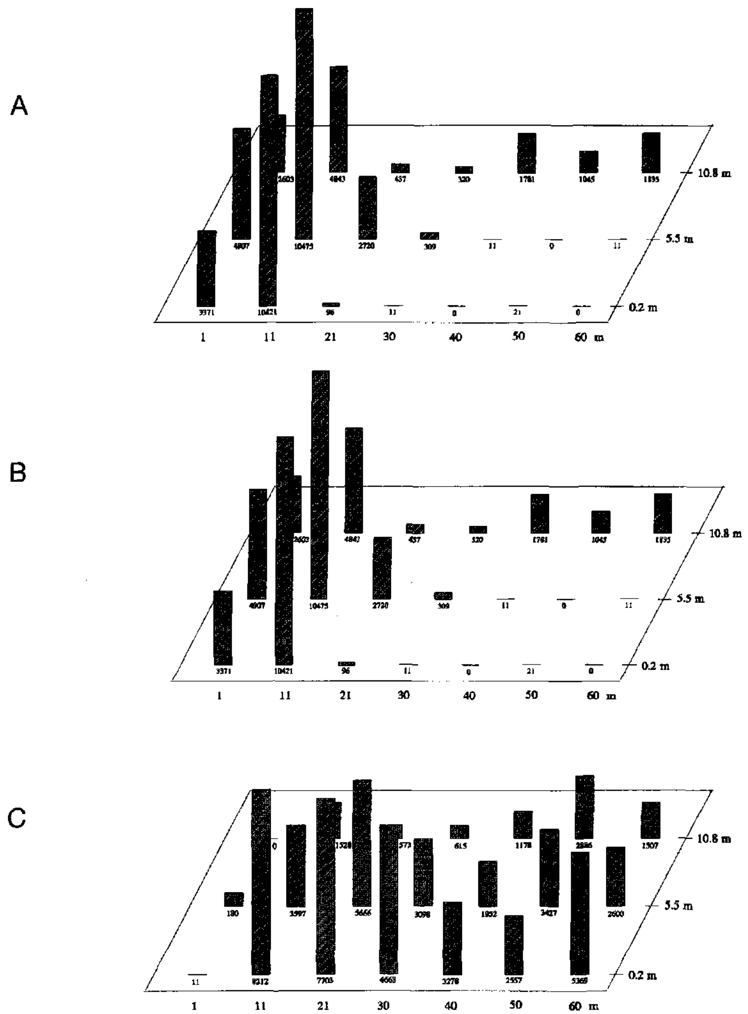


Fig. 2. The distribution of spray liquid measured on collectors as drops/cm^2 after fogging with an Igeba TF-W 160 HD in 23×65 m glasshouses. A bar represents a collector. The base rectangle represents one half of a glasshouse with the middle pathway placed in front of the horizontal frontline. The figures along the frontline and along the right vertical line give the distance of the collectors from the house end and the middle pathway respectively. The resonator was placed in and parallel to the middle pathway in all treatments.

A. Stationary position of the applicator at left house end.
B. Half the fogging from the middle of the house and half from left house end.
C. The applicator was pulled from right house end to the left.

Fordeling af sprøjtevæske i 23×65 m væksthuse efter tågning med en Igeba TF-W 160 HD. Sprøjtevæsken blev registreret på målestativer som dråber/cm^2. Hver søjle repræsenterer et målestativ. Figurens rektangel illustrerer den ene halvdel af væksthusets grundareal med husets midtergang placeret lige foran den forreste horisontale linie. Tallene langs forreste horisontale linie og højre vertikale linie angiver afstanden fra målestativer til husgavl henholdsvis midtergang i m. Tågegeneratoren var i alle forsøgsled placeret i midtergangen med tågerøret pegende langs med midtergangen.

A. Stationær placering af tågegenerator ved venstre husgavl.
B. Halvdelen af tågningen foretaget fra venstre husgavl og den anden halvdel fra midten af huset.
C. Tågegeneratoren blev trukket gennem midtergangen.

the applicator being pulled too slowly. The spray liquid was used up before the house end was reached.

Discussion

A VMD of 31 µm, as found for Igeba TF-30 equipped with a 1.2 mm nozzle applying water containing 10% methylentriglycol, is in accordance with *Mathes* and *Bau* (9) who, as an average of several thermal pulse jet applicators found a VMD of 20-30 µm for aqueous solutions of pesticides. Further the result is in accordance with *Preuss,* Igeba Gerätebau GmbH (personal communication) who found a VMD of 32 µm of an Igeba TF-30 with a 1.7 mm nozzle applying 100% methylentriglycol. In the last case the smaller VMD expected when using 100% methylentriglycol, compared to the 10% used in the present investigation is probably counteracted by using a bigger nozzle size.

The results of the MgO method and the fluorescent dye method were concordant in showing that the majority of the spray liquid was deposited on upward directed horizontal surfaces and only a neglible part was deposited on downward directed surfaces. The result is in agreement with results by *Morgan* (12) and *Lindquist* and *Powell* (7,8). The cause of this very uneven deposition pattern is that deposition exclusively takes place by sedimentation because application is made up above the crop and the droplets possess only little energy. It is not possible to direct the fog into the crop because the very concentrated spray liquid would cause phytotoxic damage.

The physical measurements were supplemented with a biological test with glasshouse whiteflies. The second instar glasshouse whitefly was chosen because it is positioned exclusively on the abaxial leaf surface, it is immobile, and the second stage is very sensitive to pyrethroids (20). The pyrethroid deltamethrin was used because it is a contact insecticide with a very low vapor activity. This means direct contact with the insects is required for the insecticide to expose its effect. An effect of only about 8%, as found in the test, confirms the results of the physical measurements. The fact that any effect was observed on the whitefly nymphs at all is probably due to poinsettia leaves not being strictly horizontal, as the artificial collectors, but curl back a little exposing the abaxial leaf surface. The result is in accordance with *Mboob* (11) and *Bjugstad* (3). There was no difference in the control of the whitefly obtained by fogging with or without the black out curtains drawn. This is in accordance with the physical measurements where the deposition on the downwards directed surfaces did not differ whether the curtain was drawn, or not.

Fogging with black out curtains drawn increased the total deposition of spray liquid on the collectors considerably compared to fogging with no curtains drawn. The increased deposition is probably partly due to the drops remaining for longer in the glasshouse because the tightly woven curtains reduce the air change and partly due to the curtain roof reflecting the liquid stream from the applicator. The fact that the deposit of fluorescent dye measured on the curtain roof was not significantly higher than on the tremble and house ends, even though the resonator was directed towards the roof during fogging, confirms this view.

There was no difference in the amount of fluorescent dye deposited on the black out curtains and the window glasses of the house. This result suggests that most of the fluorescent dye on the window glasses was deposited directly and not by condensation, even though conditions for condensation were present at the time of fogging (15). A heavy deposit found on the glass roof 3 m above the benches corresponds to the direction of the resonator during fogging.

Both sets of Igeba equipment included in this investigation gave a very uneven distribution of the spray liquid in the 65-70 m long houses when positioned stationary at one house end. The results clearly show that a more even londitudinal distribution of the spray liquid in glasshouses with low plants can only be obtained when the thermal pulse jet applicator is pulled from one house end to the other during fogging. Stationary position of the applicator causes a heavy deposit of spray liquid 8-11 m in front of the applicator. The results are in accordance with *Mathes* and *Bau* (9), *Lindquist* and *Powell* (7,8) and *Stahl* (18). In most of the quoted investigations a heavy deposit was registered 4-5 m in front of the resonator. This distance was not included in the present investigation, however, *Powell et al.* (14) showed that the heavy zone of deposit in front of the applicator could be avoided by raising the delivery angle 30° or more compared to horizontal level. This result has not been verified in the present investigation where a heavy deposit zone was registered in all experiments with stationary position of the applicator even though the delivery angle was always 30°.

The results of the transverse distribution of the spray liquid are not unequivocal but show that there is no problem in reaching the trempler even with the resonator directed parallel to the middle pathway.

The efficiency of application of Igeba TF 30 can be estimated on the basis of an expected amount of flourscent dye per area by 100% efficiency and the amount actually registered on the collectors placed level with the top of the plants. 100% efficiency is here defined as all the fluorescent dye added to the pulse jet applicator being deposited on the ground area of the house (where the plants are positioned) with no loss to the pulse jet machine, to the window glass area etc. The effeciency of repetition 1 and 2 in treatment A in table 1 (fogging with black out curtains drawn) is 34% and 32% and of repetition 2 in treatment B (no curtains drawn) only 15%. These results are well above the efficiency of the 5% found by *Morgan* (13) and 1-2% found by *Lindquist* and *Powell* (8), in the same magnitude as the 26-42% reported by *Lindquist* and *Powell* (7) and below the efficiency of 55% found by *Jarrett et al.* (5).

Mathes and *Bau* (9) calculated the energy account of a Swingfog SN 10, a thermal pulse jet applicator comparable to Igeba TF 30. The energy performance of the engines is the same and the temperatures in the resonators are comparable (1 and 2). *Mathes* and *Bau* (9) found that 6 l water per hour evaporate when the spray liquid is injected to the heated exhaust air in the applicator. The fluorescent dye from the evaporated liquid is probably lost to the air. The remaining 14 l spray liquid per hour in the Igeba TF 30 will reach a temperature below 100°C and be applied as droplets. The fluorscent dye uvitex is termostable to more to than 100°C. This result in a loss of flourscent dye in the applicator of 30%. Further a loss of flourscent dye to the black out curtains and window glasses of about 1% was registered. The remaining loss is probably due to evaporation of the aqueous droplets. A drop 50 µm in diameter falls 1 m in 13.4 s (16) and a 50 µm water drop evaporates in 14 s at 20°C and 80% RH (6). In the present investigation the drops were applied more than 1 m above the crop and the VMD was well below 50 µm. This implies that a part of the spray liquid evaporated before settling out. Another part of the falling drops was diminished in size and consequently the warm ascending air from the heating pipes beneath the benches carried them up again and they evaporated. The free floating dye particles from the evaporated droplets are too light to settle and are carried out of the glasshouse by the air change which amounts to 0.2-0.8 times per hour depending among other things on the air tightness of the glasshouse (17 and 19). This also explains why the longitudinal distribution of spray liquid from a stationary positioned applicator is so uneven even though a visible fog is seen to fill the entire glasshouse. Use of low volative carrying agents will be a way to improve the application efficiency.

Conclusions

Thermal pulse jet applicators give a very uneven deposition of spray liquid on the plants. More than 90% is deposited on horizontal upward directed surfaces.

To obtain an even distribution of the spray liquid in a glasshouse the applicator must be pulled through the house during fogging.

The application efficiency is low with an aqueous spray solution probably due to a high evaporation loss. Fogging with black out curtains drawn increased the application efficiency considerably.

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