Project Title:	Bulb/salad onions and leeks: A strategy for control of bean seed fly and onion fly
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Location:	ADAS High Mowthorpe and a number of onion crops in Essex, Norfolk and Vale of Evesham.
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Key words:	Bulb onions, salad onions, leeks, bean seed fly, onion fly, pest, monitoring, pesticide, model, sterile insect technique.

The results and conclusions in this report are based on a series of experiments conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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Growers Summary

Headlines

- Yellow water traps are a very effective monitoring tool for bean seed fly.
- Water trap data suggests that bean seed fly poses a significantly greater risk to onion crops than onion fly.
- Further work is necessary to confirm the pest status of onion fly.
- Force seed treatment gives excellent control of bean seed fly. Dursban WG was the most effective drench treatment followed by Dimilin Flo and the developmental product CERIO 14.
- The developmental seed treatment UKA 434 was most effective at controlling onion fly. Dursban WG was the best drench treatment.
- Sterile Insect Technique has proved effective for onion fly control in Holland. Adoption in the UK is unlikely in the near future, mainly because the pest status of onion fly is unclear.
- The German developmental model for onion fly may be applicable in the UK and help to predict the risk of crop damage. Further validation is required over a greater number of sites with known onion fly problems.

Background and expected deliverables

Bean seed fly (*Delia platura*, *D. florilega*) and onion fly (*Delia antiqua*) have become an increasing problem on salad onions, bulb onions and leeks in the past five years, at a time when there are few effective approved control measures. Both pests can cause significant crop losses. In the Breckland area of Norfolk there are approximately 2,500 ha bulb onions and about 5% are lost annually due to attack by bean seed fly and to a lesser extent onion fly. This equates to a financial loss of *c* £366,000 per year in this onion growing area along. In Essex, onion fly attacks are sporadic but economically important. For example, two years ago 12 ha of crop were ploughed in due to onion fly damage with a loss of approximately £60,000. Significant losses in salad onions due to fly larval attacks have also been reported in Kent, the south west and Vale of Evesham, but whether this was due to onion fly, bean seed fly or a combination of the two is unknown. Although the two pests are very closely related, they attack different stages of the crop and have different egg laying sites. However, it is not possible to confirm the species responsible for damage in the field, and microscopic examination is required to identify the larvae.

Bean seed fly reduces plant stands, either by preventing emergence, or by killing recently emerged plants. The risk of attack is dependent upon previous crop and most damage occurs following trashy crops or where stubble turnips are grown. Soil conditions in late April are also thought to be important with friable sites being at greatest risk (Tom Will, personal communication).

Onion fly can cause serious damage to bulb and salad onions. Leeks and shallots are also attacked but damage on these crops is less common and not so severe. The worst damage usually occurs in June and early July and small plants can rapidly wilt and collapse. Attacks can also occur in August and early September and in large plants maggots feed in the bulb of the onion or in the shank of the leek affecting crop marketability. Correct identification of bean seed fly and onion fly is essential as treatment strategies differ for the two pests.

Currently some allium growers in the UK are using seed treatments. There is a Specific Off-label Approval (SOLA) for tefluthrin (Force) on onions and leeks for control of bean seed fly and onion fly. However, by the time second generation onion fly attack occurs on bulb onions and leeks, the seed treatment is no longer effective. There are no approved drench, spray or granular treatments for control of either pest. Therefore insecticidal treatments for bean seed fly and onion fly are severely limited.

In Germany there is an established model for forecasting the timing of onion fly attack and in the Netherlands, the Sterile Insect Technique is used by some growers to control the pest. The German predictive model has been developed for onion fly in chives and in the Netherlands SIT is regularly used on 3,300 ha of onions. However, at present it is unknown whether the model or SIT would be applicable to the UK.

The current project will address the problems of control of bean seed fly and onion fly in onions and leeks, and the key deliverables will be:

- To monitor bean seed fly and onion fly populations to determine the optimum time for treatment.
- To evaluate the efficacy of a range of insecticides and plant parasitic nematodes against onion fly.
- To assess the relevance of a German predictive model for onion fly to UK conditions.
- To assess the potential for the use of Sterile Insect Technique (SIT) to reduce onion fly damage in the UK.

- To collate results from all the above to formulate guidelines for an effective strategy for bean seed fly/onion fly control.

Summary of the project and main conclusions

Pest monitoring

Bean seed fly and onion fly activity was monitored using yellow water traps in Norfolk, the Vale of Evesham and Essex in 2002 and 2003. The traps were very efficient at catching bean seed fly and the pest was present in the field from April until September, during which time there were three or four generations. Peak activity was during May.

Yellow water traps were less successful for onion fly than for bean seed fly. Only 113 onion fly were trapped in 2002 and 23 in 2003. As a single trap type was used to monitor flies, it is difficult to decide whether the low catches are a true reflection of pest numbers or are because yellow water traps are inefficient for onion fly. At present, results suggest that bean seed fly is a more important pest of onions than onion fly, but further work is required to confirm this.

Male onion fly, and to a lesser extent male bean seed fly, were more easily trapped than females. In the case of onion fly this is probably because the females spend most of the day away from host crop and only return at dusk. This may also be true for bean seed fly.

Evaluation of the efficacy of insecticides and parasitic nematodes against bean seed fly and onion fly

Force seed treatment was very effective at controlling bean seed fly and produced the most robust seedlings. Interestingly it appeared not to kill bean seed fly larvae but deterred them from feeding, possibly by creating a protective zone around the seed. None of the seed treatments evaluated against onion fly were as effective as Force against bean seed fly. The most promising was UKA 434, a developmental product from Bayer Crop Science. Force was ineffective against onion fly. A drench of Dursban WG at the crook stage gave 100% control of bean seed fly. Dimilin Flo and CERIO 14, a development product from Certis, were also very effective. Dursban WG was the only drench which gave control of onion fly. There was some evidence that the parasitic nematode *Steinernema feltiae* reduced numbers of bean seed fly larvae by about 50%.

The potential for sterile insect technique in the UK

Since 1981 SIT has been applied commercially for the control of onion fly in the Netherlands by a private company, de Groene Vlieg. The technique works by providing male flies with dominant lethal factors in their sperm so that fertilised eggs do not develop. In 1995, of 16,000 ha of onions grown in the Netherlands, 2,600 ha were treated against onion fly using SIT (16% of total onion area). While the pest status of onion fly in the UK remains unclear, it is unlikely that there will be any move to adopt SIT. Should the situation change and SIT become more attractive, then other practical considerations will need to be addressed such as cost, whether it can be used over sufficiently large area to make it effective, the efficacy of SIT in comparison with chemical control, how field distribution of onions will influence SIT and grower confidence in such a novel approach to pest control.

A developmental model to predict risk of onion fly damage

The German model SWAT (version 5.1) was evaluated against water trap catches of onion fly at Methwold Hythe, Norfolk, in 2002 and 2003. This site was chosen as it had the highest onion fly catches in both years. The model will also predict development of carrot fly and cabbage root fly. In 2002 there was some correlation between onion fly activity as predicted by the model and water trap catches. The model was less effective at predicting fly activity in 2003. However, very few onion flies were caught in 2002 and 2003, and it is proposed that further validation of the model is required over a greater number of sites, before any conclusions can be drawn about its suitability in UK conditions.

Guideline strategy for onion fly and bean seed fly control

A combination of cultural and chemical control options have been proposed for both pests.

Onion fly

It is vital to establish the pest status of onion fly in the UK. Very few onion fly were caught during this project and it is possible that some damage attributed to this pest was due to bean seed fly. Cultural control of onion fly is primarily reliant on crop rotation and onions grown in the year following an attack should be sown as far away from infested land as possible. Physical damage to the onion crop by farm implements should also be avoided, as this will increase the likelihood of onion fly attack.

UKA 434 was the only seed treatment tested that showed any potential against onion fly. Bayer Crop Science will need to be consulted regarding the target market of their developmental product. Force seed treatment was not effective against onion fly. Dursban WG was very effective as a drench against onion fly but is not approved for their use.

Bean seed fly
Sowing crops in conditions to encourage rapid germination will help reduce the risk of severe bean seed fly attack. Any organic matter should be properly buried. Yellow water traps are very effective at trapping bean seed fly and will help predict the risk and timing of attack. Force was easily the best seed treatment against bean seed fly. Once an attack is underway it is more difficult to control but Dursban WG was a very effective drench, although it is not approved for use against bean seed fly. Dimilin Flo and CERIO 14 were also effective as drenches. Dimilin Flo is not approved against bean seed fly and CERIO 14 is a developmental product so its target pests for possible label registration are unknown. Certis would need to be consulted for further information on both these products.

Financial benefits

Identifying an insecticide or a parasitic nematode which is effective against bean seed fly and onion fly, will help to limit potential losses due to these pests. In the Breckland area alone, losses of bulb/salad onions and leeks to bean seed fly and onion fly are estimated at 5% or *c*. £366,00/annum. If an effective insecticide or biological control agent could reduce losses to 1% this would save *c*. £293,000/annum. This saving would be considerably improved if the area of bulb onions not grown within the Breckland was also taken into account. In addition, the losses caused by bean seed fly and onion fly to salad onions and leeks have never been quantified but are believed to be substantial. Minimising these losses would improve significantly the financial benefits arising from this project. Improved knowledge of the biology and control of both onion fly and bean seed fly will help growers to avoid or control these pests and satisfy the requirements of assured produce protocols. This will have a financial benefit although it is difficult to quantify.

Action points for growers

- Consider yellow water traps as a means of monitoring bean seed fly activity and predicting when crops are likely to be at risk.

- Use previous cropping and soil conditions in late April to help predict the risk of bean seed fly attack. Damage is worse following trashy crops or where stubble turnips have been grown. Friable soils and those in which decayed organic debris has not been properly buried are at greatest risk of attack.

- Where there is sufficient risk of attack, consider using Force seed treatment to combat bean seed fly.

- Do not use Force seed treatment against onion fly. Evidence from this study, previous HDC work (FV 26: Control of bean seed fly and onion fly) and discussions with independent consultants, suggests that it is not sufficiently persistent to protect onion crops against the pest.

- Consider approaches to Dow Agroscience regarding Dursban WG and Certis regarding Dimilin Flo and CERIO 14 with regard to the possibility for their approval for bean seed fly/onion fly control. A drench of Dursban WG gave 100% control of bean seed fly and Dimilin Flo and CERIO 14 were also very effective against the pest. Dursban WG was the only drench to give control of onion fly.

Science Section

The Science section of this report is subdivided into five main sub-sections, each dealing with one of the primary objectives of the project. These are as below.

1. Monitoring bean seed fly and onion fly activity.
2. Evaluation of alternative chemical/biological control options for bean seed fly and onion fly.
3. Evaluation of the potential of the German predictive model for onion fly in the UK.
4. Evaluation of sterile insect technique (SIT) for onion fly control in the UK.
5. Overall conclusions and guideline strategy for onion fly and bean seed fly control.

Monitoring bean seed fly and onion fly activity

Introduction

Once an attack of bean seed fly or onion fly is underway it is very difficult to differentiate between the larvae in the field. Microscopic examination is necessary to determine which pest is present. Consequently it is difficult to say whether bean seed fly or onion fly poses the greater threat to onion crops. Therefore a monitoring programme was devised to attempt to determine the relative importance of these pests. This also provided information on the timing of pest activity and size of pest populations.

Materials and Methods

A pest monitoring programme was established in both 2002 and 2003. Three sites were monitored in each year. In 2002 these were Frating in Essex, Great Witley in Worcestershire, and Methwold Hythe in Norfolk. In 2003 the sites were Great Witley in Worcestershire, Methwold Hythe in Norfolk and St Osyth in Essex. Both onion fly and bean seed fly had been recorded at all sites in previous years. Sites were operated in collaboration with independent consultants. Peter Rickard was responsible for Frating and St Osyth, Gareth Skinner was responsible for Great Witley, and Clinton Grey and Tom Will managed the Methwold Hythe site.

Each site used identical apparatus for monitoring fly activity. This consisted of two yellow water traps with chicken wire covers to prevent birds from stealing the catch. Traps were three quarters filled with water and a drop of detergent and a Campden tablet added. The detergent broke the surface tension of the water and ensured any trapped insects sunk and drowned. The Campden tablet helped to preserve the catch. Traps were visited at approximately weekly intervals and the contents poured into a plastic kitchen sieve lined with a piece of muslin. The muslin was then stored in a collecting tube in 70% alcohol.

Collecting tubes were posted to the laboratory and the number of male and female bean seed fly and onion fly were counted. In 2002, traps were in position from early/mid May until early September and in 2003 they were trapping from late March until early September.

Results and Discussion

2002 – bean seed fly

The highest counts of bean seed fly in 2002 were at Great Witley (Figure 1). Most flies were caught in May with 87% of all flies caught by the end of this month. Peak catches were in early May with approximately 13 male and six female flies caught per trap per day. Subsequently, catches declined until trapping ended in the third week of August. Male flies were more frequently trapped than females.

At Frating (Figure 2) trends in trap catches were similar to Great Witley, although the number of flies caught was much lower. There was a peak of 6.1 males and 1.0 females per trap per day in mid-May and 86% of all flies were trapped before the end of May. After this month catches dropped dramatically. Male flies were more numerous than females as at Great Witley.

Lowest catches of bean seed fly were recorded at Methwold Hythe (Figure 3). Most flies were again caught in May with 81% the total catch trapped before the end of the month. The peak of male catches was 2.6/trap/day and of females 3.0/trap/day in the third week of May. In contrast to Great Witley and Frating, there was no difference between the number of males and females trapped.

The total catch of bean seed flies at all sites is summarised in Table 1. A total of 1,729 bean seed flies was trapped, of which 63% were male and 37% female.

Table 1. *Total bean seed fly catches at all sites in 2002.*

Site	Male	Female	Total	% Male	% Female
Frating	177	47	224	79	21
Great Witley	812	499	1311	62	38
Methwold Hythe	97	97	194	50	50
Total	1086	643	1729	63	37

Figure 1. Number of bean seed flies (number/trap/day) caught at Great Whitley, Worcs, 2002

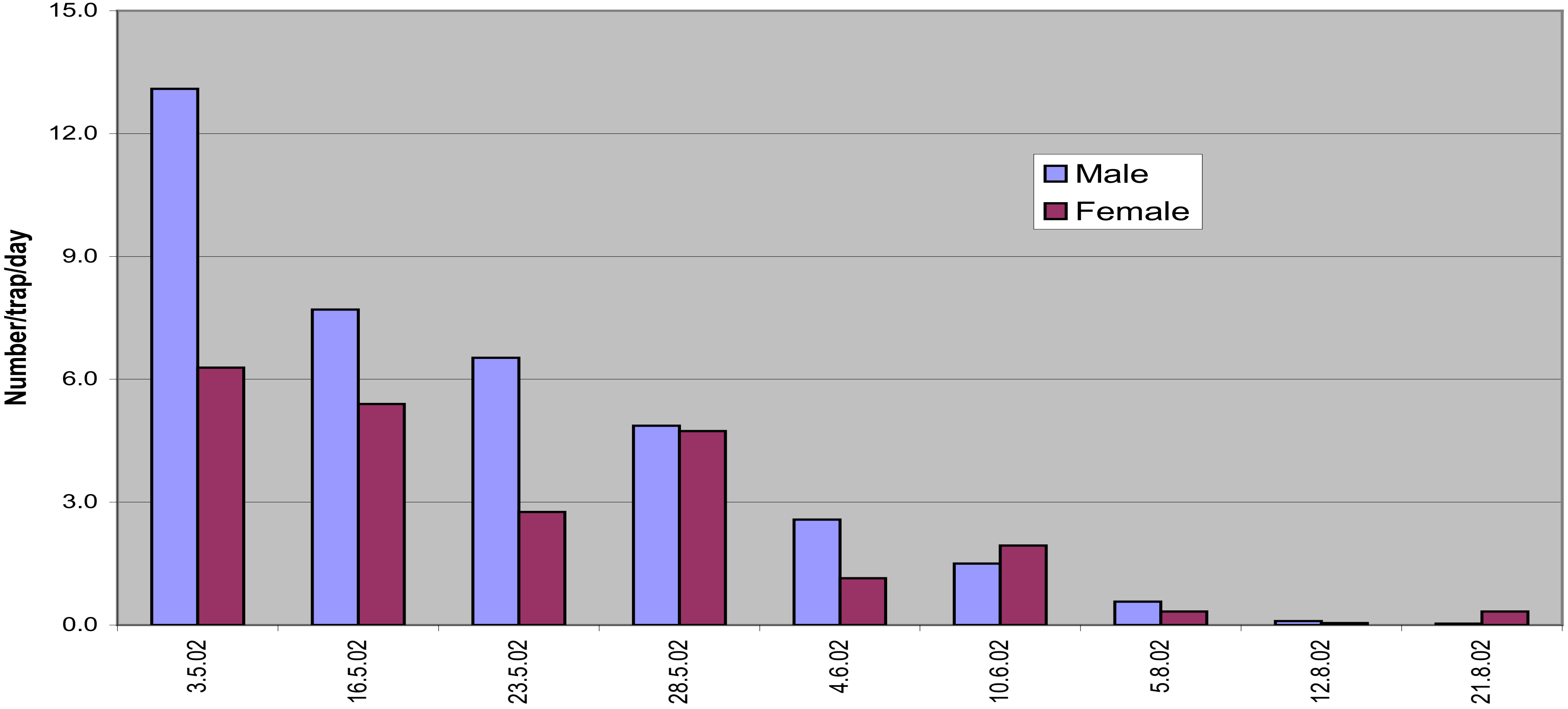


Figure 2. Number of bean seed flies (number/trap/day) caught at Frating (*) and St Osyth, Essex, 2002

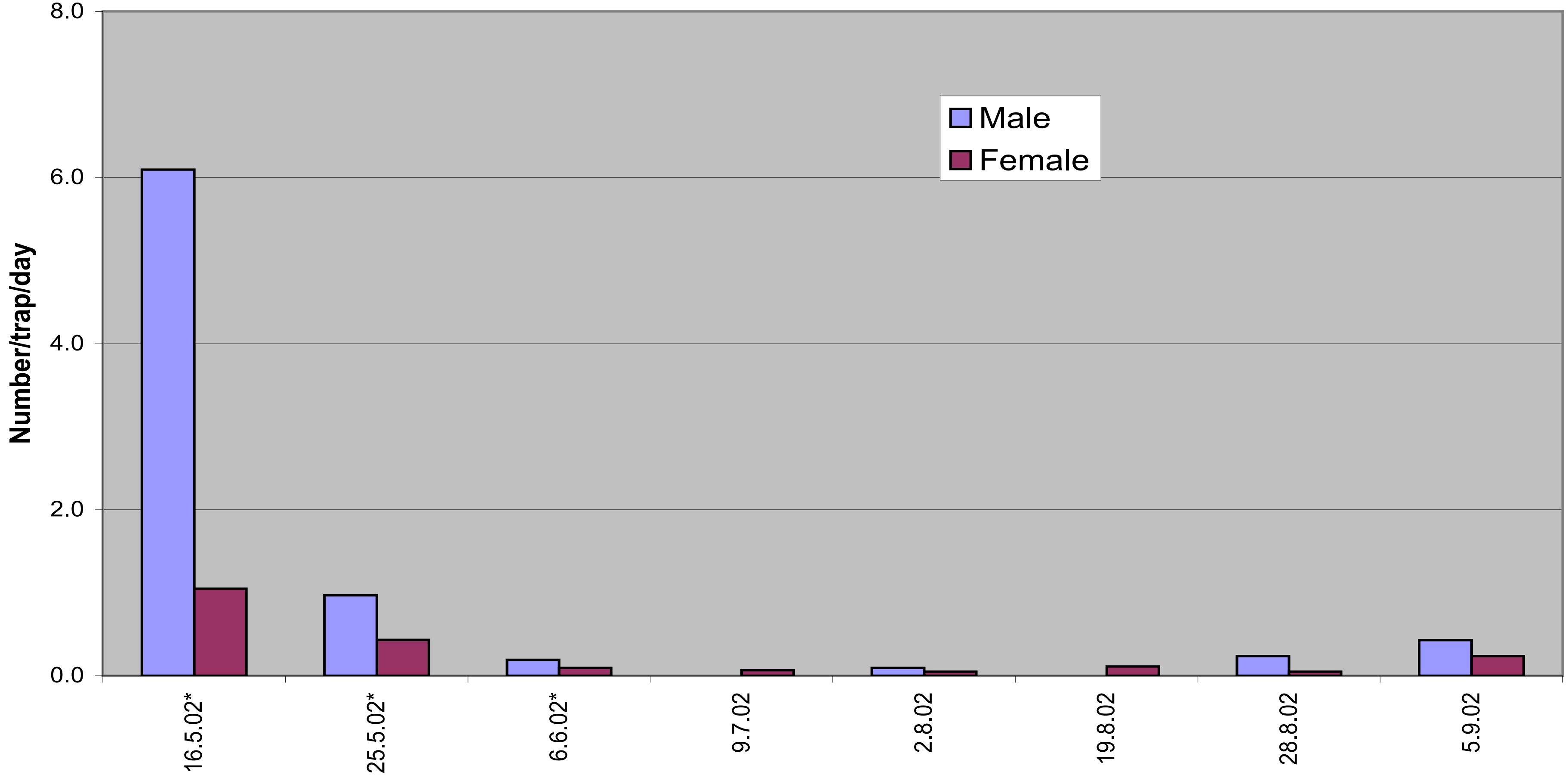
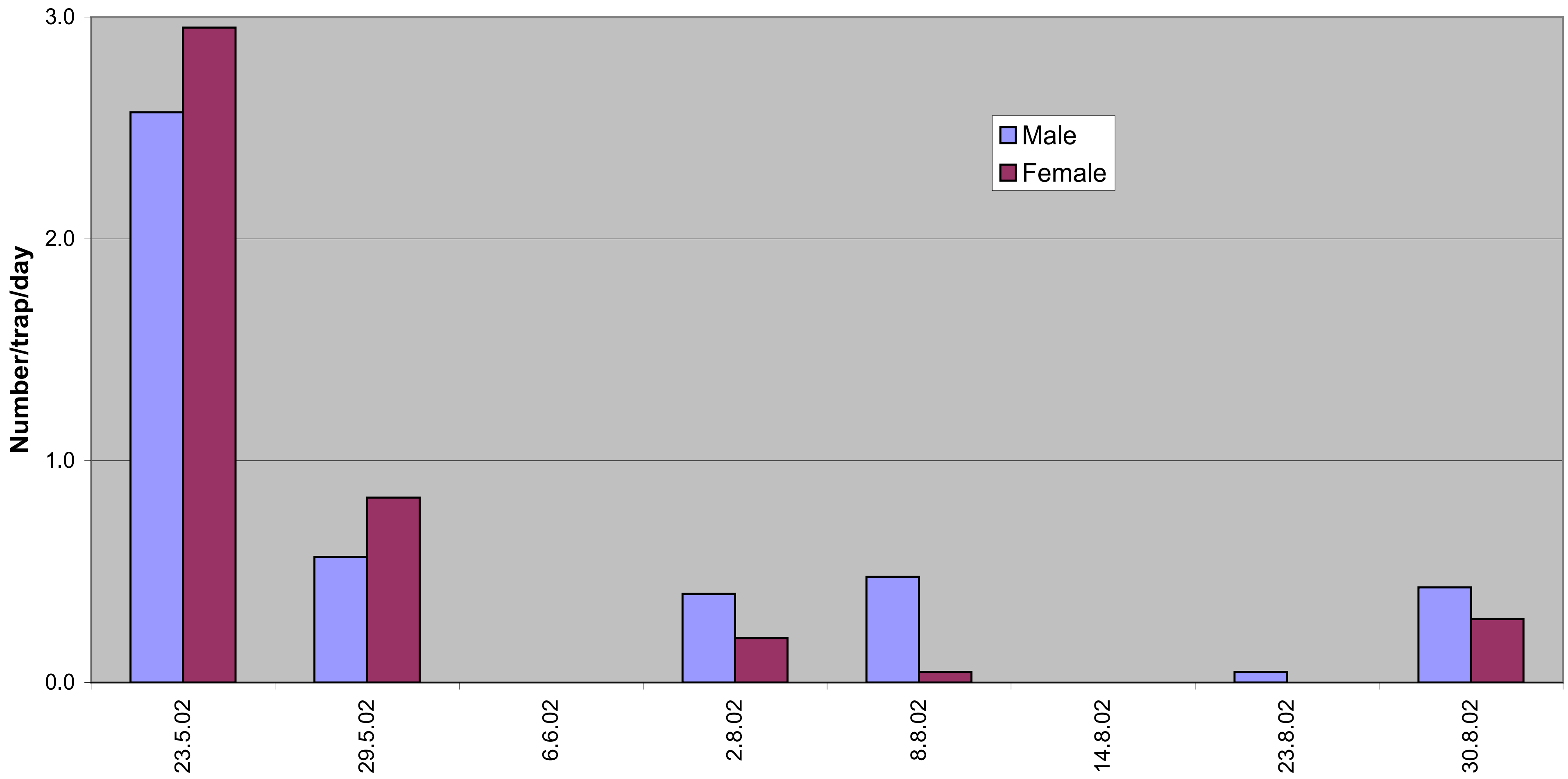


Figure 3. Number of bean seed flies (number/trap/day) caught at Methwold Hythe, Norfolk, 2002



2002 - onion fly

Onion fly were only trapped at Methwold Hythe (Figure 4). In total 113 flies were caught of which 97% were male (110 male, 3 female). Highest catches were during May (77% of total catch), as with bean seed fly. The remaining onion flies were all caught in August.

2003 – bean seed fly

The highest counts of bean seed fly in 2003 were at Great Witley (Figure 5). Most were in May with almost 60 males caught per trap per day. There were also peaks in catches in mid-April, mid June and possibly another in late August. Male bean seed fly were more frequently caught than females. The pest was present in the field from April right through until early September.

At St Osyth (Figure 6) far fewer flies were caught than at Great Witley but the general trends in trap data were similar. Peak activity was towards the end of May with almost 11 male flies caught per trap per day. There was a second peak in activity towards the end of June and a possible third in August. Male flies were more frequently trapped than females.

The peak of bean seed fly activity at Methwold Hythe was at the end of April with about 35 male bean seed fly caught per trap per day (Figure 7). Very few flies were caught beyond the end of May. This is possibly due to the hot dry weather when traps can dry out. Again more male flies were caught than females.

Table 2. *Bean seed fly catches at all sites 2003.*

Site	Male	Female	Total	% Male	% Female
Great Witley	2095	796	2891	72	28
Methwold Hythe	1010	108	1118	90	10
St Osyth	318	174	492	65	35
Total	3423	1078	4501	76	24

Across all sites 4,501 bean seed fly were trapped (Table 2). Of this total, 76% were male and 24% female.

Figure 4. Number of onion flies (number/trap/day) caught at Methwold Hythe, Norfolk, 2002

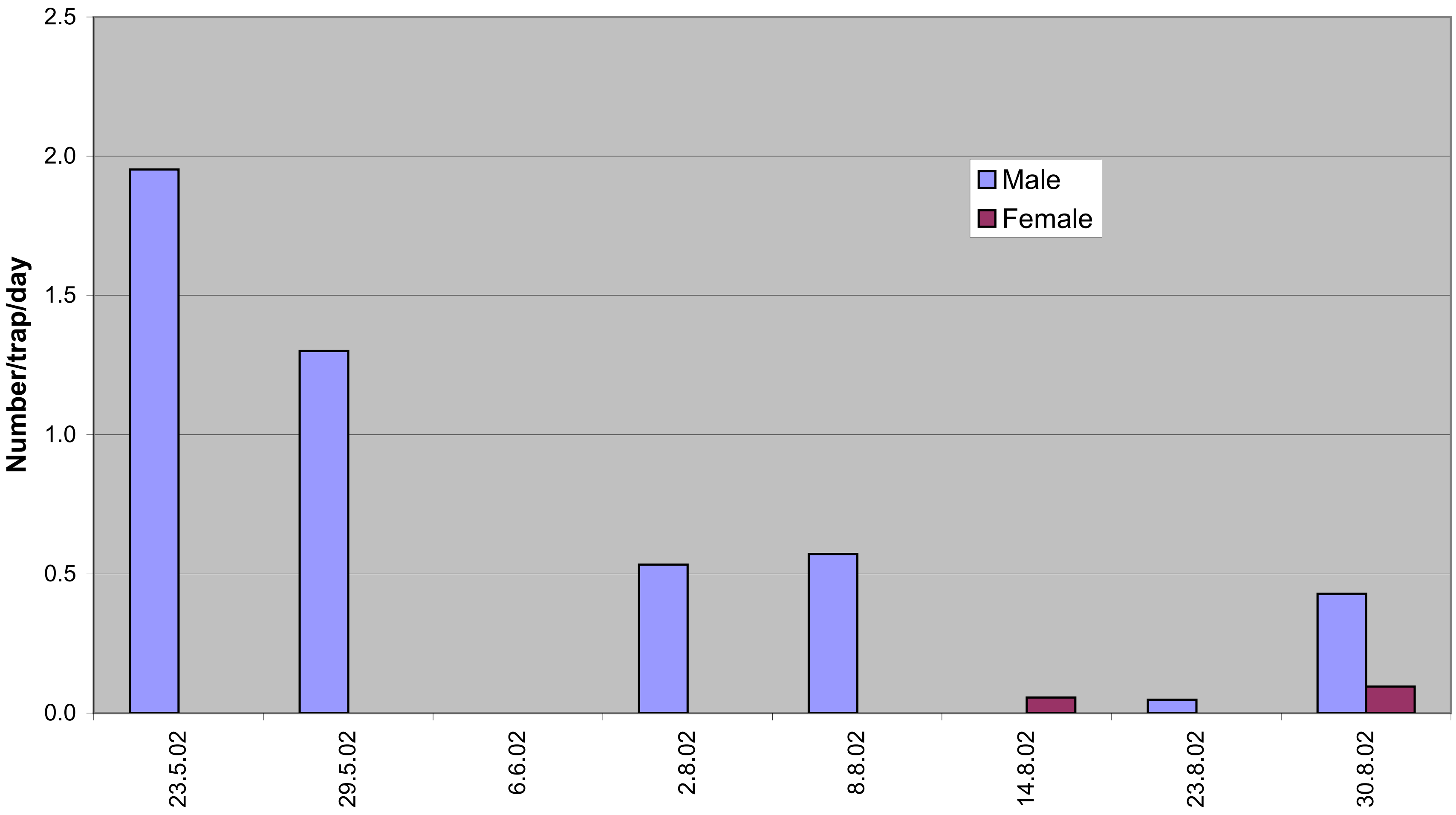


Figure 5. Number of bean seed flies (number/trap/day) caught at Great Witley, Worcs, 2003

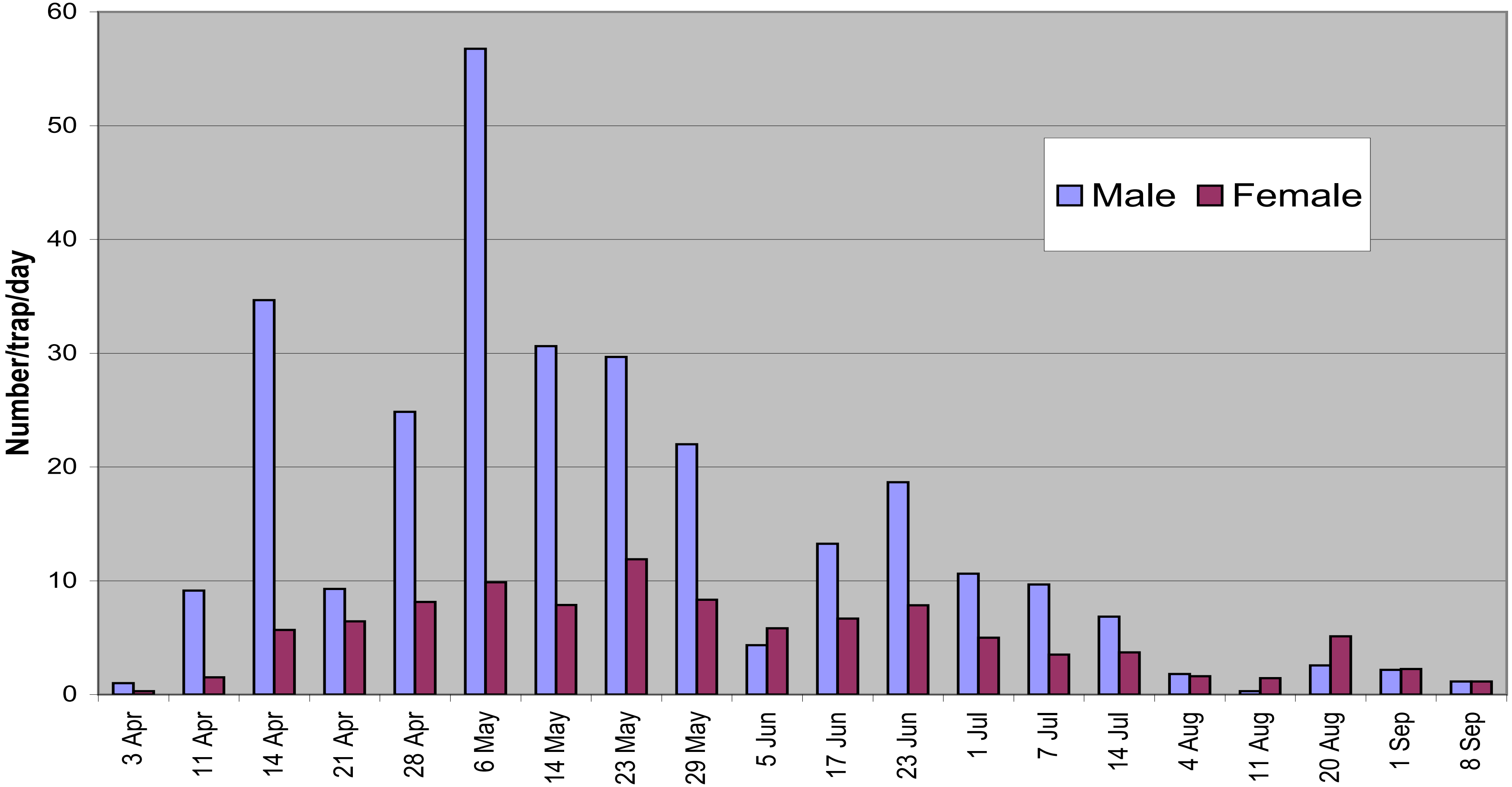
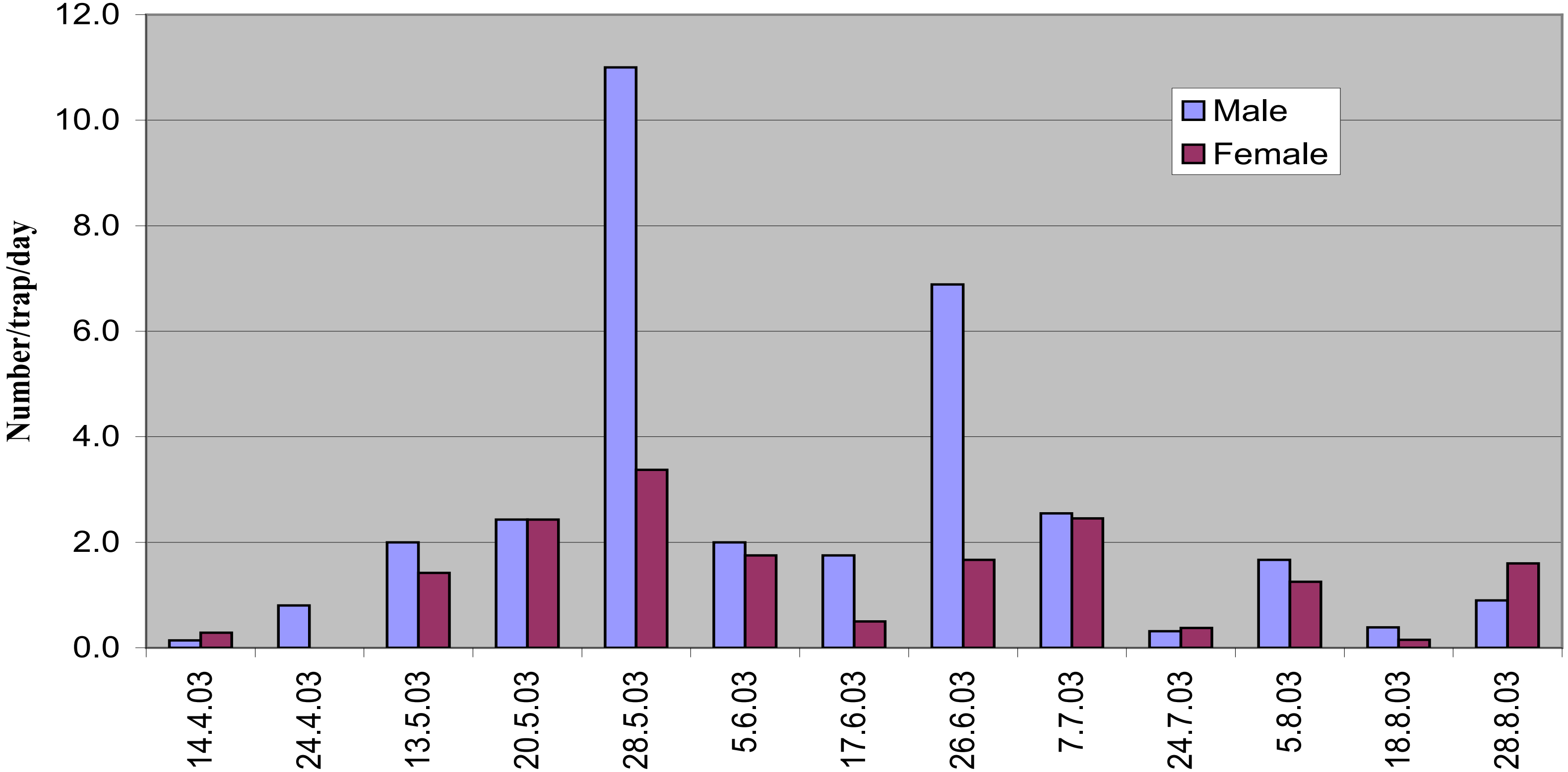


Figure 6. Number of bean seed flies (number/trap/day) caught at St Osyth, Essex, 2003



2003 - onion fly

Catches of onion fly were very low in comparison with bean seed fly at all sites. In total only 23 onion fly were trapped (Table 3), with 15 at Methwold Hythe, seven at Great Witley and one at St Osyth. At Methwold Hythe, 13 flies were caught between 8 and 21 April and two flies towards the end of May. At Great Witley two flies were caught in mid-April, one in mid-May and four in early August. The single onion fly caught at St Osyth was trapped towards the end of June. The low numbers of flies caught make it difficult to comment on the pattern of trapping. However, at Great Witley there is a suggestion of a first generation of onion fly in mid-April, followed by a second generation in August. This is consistent with the pattern of activity suggested by Gratwick (1992).

Table 3. *Onion fly catches at all sites, 2003.*

Site	Male	Female	Total	% Male	% Female
Great Witley	7	0	7	100	0
Methwold Hythe	14	1	15	93	7
St Osyth	1	0	1	100	0
Total	22	1	23	96	4

Only one female onion fly was caught throughout the monitoring period. This is equivalent to 96% males and 4% females. In 2002, traps were deployed much later than in 2003 and this undoubtedly contributed to the lower catches of bean seed fly. If the patterns of trap catches in 2003 are typical, then it is possible that the peak activity of the pest was missed in 2002. Catches of onion fly, albeit only at Methwold Hythe, were higher in 2002 than 2003. Peak activity in 2002 appeared to be during May but may have been earlier if traps had been in position. In both 2002 and 2003 very few female onion fly were trapped.

The reason why males of onion fly, and to a lesser extent bean seed fly, are more easily trapped than females is unclear. Female onion fly are known to be crepuscular (McKinlay, 1992) in that they avoid the host crop for most of the day and only return at dusk. In contrast, males remain in the host crop. Therefore catches of females might be lower than those for males as the female flies spend less of the day in the vicinity of the traps than males. Also, at dusk, the traps may be less visible and/or attractive than during the day. If female bean seed flies show the same behaviour, then this would also explain why their catches are much lower than of males.

Results of the water trapping suggest that bean seed fly poses a much greater threat to onion crops than onion fly. However, it is also possible that yellow water traps are not as effective for onion fly as they are for bean seed fly. It has been suggested that white traps are most effective for onion fly (T J Everaarts, personal communication). It would be worth evaluating a range of trap types for both bean seed fly and onion fly. This would indicate which is most efficient for which fly species and also determine whether onion fly is a significantly less important pest than bean seed fly.

Conclusions

- Yellow water traps are an effective monitoring tool, particularly for bean seed fly.
- Yellow water trap data suggests that bean seed fly poses a significantly greater threat to onion crops than onion fly.
- Further work is necessary to confirm whether onion fly is an insignificant pest or whether low catches are a function of trap type.
- Bean seed fly was active in 2003 from April until September and there were three or four generations of the pest.
- Male onion fly, and to a lesser extent bean seed fly, were more easily trapped than females. This may be because female onion fly are crepuscular. If bean seed fly females show the same behaviour then this would also explain why three times as many male as female bean seed fly were trapped.

Evaluation of alternative chemical/biological control options for bean seed fly and onion fly

Introduction

Currently only Force seed treatment (a.i. tefluthrin, Bayer Crop Science) is available as a specific off-label approval for control of bean seed fly and onion fly. However, by the time second generation onion fly attack occurs on bulb onions and leeks the seed treatment is no longer effective. Previous ADAS trials in the late 1970's and early 1980's, and HDC funded work (FV 26: Control of bean seed fly and onion fly), identified potential products for bean seed fly and onion fly control. However, none of these are still available. Therefore the current experiments were designed to evaluate a range of currently available and developmental products.

Bean seed fly - materials and methods

A pot experiment was set up in August 2003 to evaluate a range of chemical and biological control agents against bean seed fly. This included seed treatments, drenches, granular formulations and parasitic nematodes. The complete treatment list and rate of application is given in Table 4.

Table 4. *Treatments evaluated for efficacy against bean seed fly 2003*

Treatment	**a.i.**	**Rate of application**
1. Untreated	-	-
Seed treatments		
2. Force	Tefluthrin	-
3. Gaucho Hort	Imidacloprid	-
4. UKA 334	-	-
Drenches		
5. Garlic liquid	Garlic concentrate	2% solution
6. Dimilin Flo	Diflubenzuron	300 ml/ha
7. CERIO 14	-	200 ml/ha
8. CERIO 15	-	300 ml in 100 l water
9. Tracer	Spinosad	200 ml/ha
10. Dursban WG	Chlorpyrifos	1 kg/ha
Granular formulations		
11. Garlic granules	Garlic concentrate	16 kg/ha
Parasitic nematodes		
12. Steinernema feltiae	As per treatment	1.0 million/m^2
13. Steinernema kraussei	As per treatment	1.0 million/m^2

The parasitic nematodes were chosen as *S. feltiae* had been shown to give some control of cabbage root fly (Hart and Wilmot, 2002) and *S. kraussei* has been specifically developed to be effective at low soil temperature.

Preparation of experimental pots

The experiment was done in 15 cm diameter plant pots filled with sieved soil. A total of 20 salad onion seeds (cv White Lisbon) were sown in each pot. There were five replicates of each of the 13 treatments giving 65 pots in total. Batches of 100 seeds of each of the seed treatments and the untreated seed were retained for a germination test. This was done by spreading the seeds over four layers of number 1 filter paper within a Petri dish. The filter paper was moistened and the Petri dishes covered and stored in darkness at room temperature. These were observed for 23 days to determine how many had germinated.

Oviposition by bean seed fly adults

The pots of salad onions were transferred to an outdoor insectary where they were open to the elements and egg laying by bean seed fly. To encourage egg laying the surface of each pot was sprinkled with fish meal according to EPPO Guideline no PP1/34(2). It was intended to apply the drenches, granules and parasitic nematodes, when the seedlings reached the crook stage. However, bean seed fly rapidly invaded the pots with the result that many seedlings awaiting drench treatment, and still effectively untreated controls, were killed. Therefore it was decided to undertake a seed treatment experiment and one to evaluate drenches, garlic granules and parasitic nematodes. All pots awaiting drench treatment or an application of garlic granules or parasitic nematodes, were used as extra replicates of the untreated control.

For the drench experiment it was necessary to replace some of the pots with substitute untreated pots which had not received any fish meal. This ensured that the seedling numbers in each pot were relatively uniform. A count of seedling numbers was made at the crook stage.

Drench/nematode/granule application

The drench treatments were applied with an Oxford Precision sprayer equipped with a 2 m boom and F110 nozzles to deliver a medium spray quantity. Nematodes were applied using a syringe. A sample of nematode solution was retained from each treatment to check whether the target number of nematodes had been applied to the pots. Garlic granules were applied by sprinkling a pot dose over the soil surface and incorporating with a spatula.

Assessments

The efficacy of the applied treatments was assessed in terms of seedling number, the number of bean seed fly larvae and/or pupae per pot and seedling dry weight. Bean seed fly larvae and/or pupae were extracted using flotation in saturated magnesium sulphate.

Approach to statistical analysis

Pots were laid out in the insectary in a randomised complete block design. Data were subjected to the analysis of variance. Where data did not conform to the assumptions of the analysis of variance it was transformed or an alternative non parametric test was used.

Results and Discussion

Seed treatment experiment

The viability of seed did not differ significantly between seed treatments (Table 5). However, there was a trend for the Gaucho Hort treated seed to be least viable.

Seed viability was used to calculate the expected number of seedlings that would emerge in each treatment. This was then represented as a percentage of actual emergence. Any value less than 100% was assumed to indicate seedling loss as a result of bean seed fly attack. Seedling emergence differed significantly between treatments (**F = 16.65, df = 117**, $P<0.001$, Table 6). Force was the best treatment. Seedling emergence in the untreated control was also better than with UKA334 or Gaucho Hort. It is possible that this was due to phytotoxicity which made seedlings more susceptible to pest attack.

Table 5. Seed treatment viability

Treatment	**Viability $^{+}$/- 95% Confidence limits**	**Viability range**
Untreated	0.98 $^{+}$/- 0.03	0.95 – 1.00
Force	0.97 $^{+}$/- 0.04	0.93 – 1.00
Gaucho Hort	0.88 $^{+}$/- 0.07	0.81 – 0.95
UKA 334	0.95 $^{+}$/- 0.05	0.90 – 1.00

Table 6. The effect of seed treatments on bean seed fly control 2003: seedling emergence as a percentage of expected emergence (SED = standard error of the difference between means, df = error degrees of freedom).

Treatment	**Seedling emergence (% of expected emergence)**
Untreated	55.1
Force	95.9
Gaucho Hort	4.0
UKA 334	36.3
SED (117 df)	10.03

Target and actual rate of nematode application

The target application rate for both nematodes was 20,000 nematodes per pot. A total of 20 ml was retained from each solution and this was examined under a microscope to determine if the target population was applied. With both nematode species the actual application rate was within 20% of the target application rate**.**

Table 7. Target and actual application rates for *S. feltiae* and *S. kraussei*

Nematode treatment	Number/ 20 ml	Number /ml	Quantity of solution applied per pot (ml)	Actual application rate	Actual application as % of target
S. feltiae	40,250	2,013	8	16,104	81
S. kraussei	27,200	1,385	16	22,160	111

Drench, garlic granules and parasitic nematode experiment

Seedling emergence was assessed just before harvest and expressed as a percentage of seedling numbers at the time drenches, garlic granules and parasitic nematodes were applied. This value is presented as seedling survival in Table 8. Seedling survival differed significantly between treatments (**F = 26.71, df = 48**, *P* <0.001). The biggest differences were due to the seed treatments which were retained as part of this experiment. There was little difference between the other treatments although garlic liquid, CERIO 14 and Force protected 100% of seedlings. In general, seedling survival was much better in the experiment with drenches, garlic granules and parasitic nematodes than in the seed treatment experiment. This suggests that bean seed fly is only an important pest during the early stages of seedling development and that once plants become established they are far less susceptible to pest attack. The susceptibility of onion and leek seedlings to bean seed fly attack is an area worthy of further investigation.

The number of larvae, pupae and the combined total of larvae and pupae also differed significantly between treatments (**F = 1.89, df = 48**, *P* = 0.059 for pupae, **F = 4.53, df = 48**, *P* <0.001 for larvae **F = 3.45, df = 48**, *P* <0.001 for larvae + pupae). Dursban WG was the most effective treatment and gave 100% control of bean seed fly. CERIO 14 and Dimilin Flo were also very effective. The parasitic nematode *Steinernema feltiae* reduced numbers of larvae and pupae by 50% in comparison with the untreated control, suggesting that it is worthy of further investigation.

It was interesting that Force seed treatment or garlic liquid protected 100% of seedlings despite relatively large numbers of larvae and/or pupae being recovered from their pots. It is possible that these treatments deter larval feeding. Alternatively it may be that the larvae found in the garlic liquid or Force pots resulted from late laid eggs. By the time these had hatched, plants may have been less susceptible to pest attack.

Most larvae were found in pots treated with garlic granules. However, it was probably an unfair test of this product as it was very difficult to distribute a small quantity of granules uniformly over the pot surface. It is also possible the garlic granules attracted bean seed fly oviposition but were too few in number to give any significant control of the pest. This might also explain why numbers of bean seed fly larvae and pupae were much higher in garlic granule treated pots than in the untreated control.

Seedling dry weight differed significantly between treatments (**F = 47.11, df = 48**, *P* <0.001). Force seed treatment produced the most vigorous and robust seedlings.

Table 8. The effect of seed treatment, soil drenches, parasitic nematodes and a granular formulation on seedling survival, number of bean seed fly larvae and pupae and seedling dry weight per plant (SED = standard error of the difference between means, df = error degrees of freedom).

Treatment	Seedling survival (%)	Number of larvae	Number of pupae	Number of larvae + pupae	Seedling dry weight/plant (g)
1. Untreated	94.5	10.8	4.2	15.0	0.014
2. Force	100.0	12.6	9.6	22.2	0.029
3. Gaucho Hort	20.0	13.0	8.6	21.6	0.002
4. UKA 434	4.4	12.4	4.0	16.4	0.002
5. Garlic liquid	100.3	8.6	6.0	14.6	0.013
6. Dimilin flo	98.0	0.4	3.2	3.6	0.014
7. CERIO 14	102.6	0.4	0.6	1.0	0.016
8. CERIO 15	94.0	5.8	7.8	13.6	0.013
9. Tracer	97.8	5.4	8.2	13.6	0.015
10. Dursban WG	96.4	0	0	0	0.015
11. S. feltiae	94.6	3.8	4.0	7.8	0.015
12. S kraussei	94.7	7.6	9.0	16.6	0.014
13. Garlic granules	90.9	12.4	13.6	26.0	0.014
SED (48 df)	8.77	3.28	3.97	6.14	0.0018

Onion fly - materials and methods

Two pot experiments were set up in November 2003. The first was designed to evaluate a range of seed treatments and the second to evaluate a range of drenches and parasitic nematodes against onion fly. The complete treatment lists are given in Tables 9 and 10.

Table 9. Seed treatments evaluated for efficacy against onion fly, 2003.

Treatment	**a.i.**
1. Untreated	-
2. Force	Tefluthrin
3. Gaucho Hort	Imidacloprid
4. UKA 334	-
5. Cruiser 350 FS	Thiomethoxam

Rearing onion fly

As the number of onion flies caught in water traps was very low, it was decided to rear the pest in a glasshouse and inoculate eggs onto the experimental pots. Approximately 200 onion fly pupae were supplied by HRI Wellesbourne in vermiculite. Approximately 100 pupae in vermiculite were placed in a Petri dish in each of two insect cages in a heated glasshouse at 20ºC. Sodium glasshouse lights were used to simulate 16 hours day length.

Fly emergence was monitored daily and the approximate number of flies hatched was noted. Once hatch was underway the flies were provided with food and water. Four Petri-dish lids were placed in each cage and filled with absorbent cotton wool. Marmite was smeared over the cotton wool in two dishes and a crushed yeast tablet was sprinkled over the top of this. A concentrated sugar solution was made up and poured over the cotton wool in the remaining Petri dishes.

Table 10. Soil drenches and parasitic nematodes evaluated against onion fly, 2003.

Treatment	**a.i.**	**Rate of application**
1. Untreated	-	-
Drenches		
2. Garlic liquid	Garlic concentrate	2% solution
3. Dimilin Flo	Diflubenzuron	300 ml/ha
4. CERIO 14	-	200 ml/ha
5. CERIO 15	-	300 ml in 100 l water
6. Tracer	Spinosad	200 ml/ha
7. Dursban WG	Chlorpyrifos	1 kg/ha
Parasitic nematodes		
8. *Steinernema feltiae*	As per treatment	1.0 million/m^2
9. Steinernema kraussei	As per treatment	1.0 million/m^2

Oviposition sites were also provided for the flies. These consisted of half onions on fine sand. The sand was kept moist as were the pupae and vermiculite. Any eggs were collected with a fine paint brush and stored on moist black filter paper in Petri dish within a refrigerator.

Preparation of experimental pots

The experiment was done in 15 cm diameter plant pots filled with sieved soil as with bean seed fly. There were five replicates of each treatment in both the seed treatment (25 pots in total) and drench and parasitic nematode experiments (50 pots in total). Salad onion seed (cv White Lisbon) was sown in each pot (20 seeds per pot).

Inoculation with onion fly eggs

When sufficient eggs had been collected they were inoculated into the experimental pots. The seed treatment experiment was inoculated first followed by the drench and parasitic nematode experiment when the plants had reached the crook stage. The total number of eggs to be inoculated was divided equally between the number of pots. Eggs were then counted onto pieces of moist filter paper. A shallow trench was created in the soil surface of the pot, the filter paper held over this with forceps and the eggs washed off using a wash bottle of water. The trench was filled once inoculation was complete. Inoculation took place over three days in the seed treatment experiment and a total of 25 eggs were inoculated per pot. In the drench and parasitic nematode experiment 15 eggs were inoculated per pot over 10 days.

The viability of inoculated eggs was checked by retaining any spare eggs on moist filter paper within a covered Petri dish held at room temperature. These eggs were checked daily and the number hatched and unhatched eggs were recorded.

Drench/nematode application

The drench treatments were applied with an Oxford Precision Sprayer equipped with a 2 m boom and F110 nozzles to deliver a medium spray quality. Nematodes were applied with a syringe. A sample of nematode solution was retained for each treatment to check whether the target number of nematodes had been applied to the pots.

Assessments

The efficacy of the applied treatments was assessed in terms of seedling number, the number of onion fly larvae and or pupae per pot and seedling dry weight. Onion fly larvae and/or pupae were extracted using flotation in saturated magnesium sulphate.

Results and Discussion

Egg viability

There were sufficient spare eggs to assess egg viability from three inoculation dates (Table 11). These were for eggs inoculated on 5 (5 eggs/pot) and 8 December (20 eggs/pot) to the seed treatment experiment and for eggs inoculated on 18 December (9 eggs/pot) to the drench and parasitic nematode experiment.

Table 11. Viability of eggs inoculated on onion fly pot experiments, December 2003.

Experiment	Inoculation date	Number of eggs	Number hatched	Number unhatched	% viability
Seed treatment	5.12.03	26	22	4	85
Seed treatment	8.12.03	100	95	5	95
Drench and parasitic nematodes	18.12.03	36	33	3	92

Levels of egg viability were generally high. If representative of hatch for inoculation on dates when no spare eggs were available, then 23 eggs would have hatched out of 25 in the seed treatment experiment and 14 eggs out of 15 would have hatched in the drench and parasitic nematode experiment.

Target and actual rate of nematode application

The target application rate for both nematodes was 20,000 nematodes per pot as with bean seed fly. A sample of 20 ml of each nematodes solution was retained. The number of nematodes present in this was assessed in the same way as in the bean seed fly study.

Table 12. Target and actual application rates for *S. feltiae* and *S. kraussei*

Nematode treatment	Number /20 ml	Number /ml	Quantity of solution applied per pot (ml)	Actual application rate	Actual application rate as a % of target
S. feltiae	90,000	4500	16	72,000	360
S. kraussei	45,500	2275	13.3	30,258	151

The actual rate of nematode application significantly exceeded the target rate with both nematode species (Table 12). This suggests that the original samples were labelled incorrectly or that nematodes were not thoroughly mixed in water. If nematodes are ineffective at these rates of application then they are unlikely to be an economic option for onion fly control.

Seed treatment

The number of emerged seedlings differed significantly between treatments (**F = 14.56**, **df = 16**, $P < 0.001$, Table 13). Pots sown with Force treated seeds produced most seedlings followed by Gaucho Hort and UKA 434. Cruiser was the least effective seed treatment against onion fly. Low numbers of larvae and pupae were recovered from pots and these data were not subjected to statistical analysis. Most larvae and pupae were found in Force pots and least in the untreated and UKA 434 pots. Mean numbers of larvae, pupae and the combined total of larvae and pupae are presented in Table 13 together with their standard errors. Seedling dry weight differed significantly between treatments (**F = 11.03, df = 16**, $P < 0.001$). The biggest and most robust seedlings were where UKA 434 had been used followed by Cruiser. Although most seedlings were found in Force treated pots, this treatment did not produce as healthy plants as UKA 434. This suggests that had pots been retained for many more days the Force treated plants would probably have died and that this treatment is not as effective for onion fly control as for bean seed fly. However, the rate of egg inoculation in this experiment (23 viable eggs per pot) is equivalent to 1,278 eggs/m^2. This is a very heavy level of oviposition and it is possible that Force would be more effective under reduced pest pressure in the field. That UKA 434 was able to produce the most healthy robust plants under such heavy pest pressure, suggests that it is worthy of further investigation.

Drench and parasitic nematode experiment

Seedling dry weight per pot differed significantly between treatments (**F = 1.99, df = 32,** $P < 0.001$, Table 14). Dursban WG produced by far the most robust seedlings. CERIO 14 was the next best treatment but its seedlings were only 13% of the weight of those in Dursban treated pots. There was little difference in seedling dry weight between the remaining treatments. As Dursban WG was the only treatment to produce healthy seedlings, it was decided not to undertake a plant count in each pot. The dry weights recorded for all other treatments were for dead or dying seedlings which were in various stages of decay.

Table 13. The effect of seed treatments on onion fly control measured as seedling number per pot, number of onion fly larvae and pupae per pot and seedling dry weight per plant (SED = standard error of the difference between means, SE = standard error, df = error degrees of freedom. Standard errors are quoted where data sets were not subjected to the analysis of variance.)

Treatment	**Seedling number**	**Number of larvae**	**Number of pupae**	**Larvae + pupae**	**Seedling dry weight/plant (g)**
1. Untreated	3.4	0.2	0	0.2	0.0027
2. Force	17.6	1.4	0.6	2.0	0.0020
3. Gaucho Hort	13.6	0.6	0.4	1.0	0.0008
4. UKA 434	13.6	0.2	0	0.2	0.0203
5. Cruiser 350 FS	9.6	1.4	0	1.4	0.0093
SED (16 df)	1.99	-	-	-	0.00346
SE	-	+/-0.38	+/-0.16	+/-0.40	

There was no significant difference in the number of onion fly larvae or pupae or their combined total between pots. Dursban treated pots contained most larvae and pupae and this was probably because it was the only treatment to produce healthy seedlings on which the pest could feed. In the other treatments it is likely that as seedlings were quickly killed, the onion fly larvae had no source of food and probably died of starvation.

Table 14. The effect of soil drenches and parasitic nematodes on seedling number and number of onion fly larvae and pupae per pot (SED = standard error of the difference between means, df = error degrees of freedom).

Treatment	**Seedling dry weight**	**Number of larvae**	**Number of pupae**	**Larvae + pupae**
1. Untreated	0.014	0.6	0.4	1.0
2. Garlic liquid	0.016	1.8	0.8	2.6
3. Dimilin Flo	0.018	0.8	2.0	2.8
4. CERIO 14	0.026	0.4	0.8	1.2
5. CERIO 15	0.012	1.2	0.4	1.6
6. Tracer	0.016	1.8	0.8	2.6
7. Dursban WG	0.196	3.0	0.2	3.2
8. *Steinernema feltiae*	0.030	0.8	1.0	1.8
9. *Steinernema kraussei*	0.014	0.6	0.6	1.2
SED (32 df)	0.0276	0.89	0.69	1.16

Conclusions

- Force was by far the most effective seed treatment for control of bean seed fly and produced robust plants.
- UKA 434 was the best seed treatment for control of onion fly. Less seedlings emerged than in Force treated pots but those that did survive were more robust and healthy than in any other treatment.
- Dursban WG was the best drench for control of both bean seed fly and onion fly and gave 100% control of bean seed fly larvae.
- CERIO 14 and Dimilin Flo were also very effective against bean seed fly but no other drench gave control of onion fly.
- Garlic concentrate, CERIO 14 and Force effectively protected seedlings against bean seed fly but only CERIO 14 reduced numbers of larvae.
- The parasitic nematode *S. feltiae* showed potential against bean seed fly but was ineffective against onion fly despite an application rate that was significantly higher than had been planned.
- *S. kraussei* was not effective against bean seed fly or onion fly.
- Results suggest that bean seed fly is only a pest of onion crops during the early stages of seedling development and that seedlings become less susceptible to attack as they mature.

A developmental model to predict the risk of onion fly damage

Introduction

A simulation model, SWAT (version 5.1), has been developed in Germany as a means of predicting the development of cabbage root fly (*Delia radicum*), carrot fly (*Psila rosa*) and onion fly (*Delia antiqua*). The model graphs the numbers of eggs, larvae pupae and adult flies over a year using air temperature at 2 m, soil temperature at 5 cm and windspeed.

The model has been developed by Dr Martin Hommes, Federal Biological Research Centre, Institute for Plant Protection in Horticulture, Messeweg 11/12, D-38104 Braunschweig (Tel: +49 (0) 531 299 4404, Fax: + 49 (0) 531 299 3009, email: M.Hommes@bba.de). The programme is freely available for scientific purposes via the link http://www.bba.de/inst/g/swat/swat-bi3.html. It is currently in German although an English version is in production.

This section of the report aims to assess the relevance of the German model to UK conditions by comparing predicted dates for onion fly emergence with actual data from the monitoring programme for this pest.

Materials and Methods

In general, catches of onion fly were low throughout the two years when the pest was monitored. In 2002, 113 flies were trapped but only 23 in 2003. In both years most flies were caught at Methwold Hythe and so this site was chosen at which to validate the German model. Meterological data was obtained from Marham, Norfolk (the nearest synoptic meteorological station to Methwold Hythe) for both 2002 and 2003. Marham is approximately 10 miles due north of Methwold Hythe and at a similar elevation (10 m above sea level.

Results and Discussion

The model produces a line graph to show how numbers of onion fly eggs, larvae, pupae and adults vary throughout the year. The *y* axis which indicates number does not have any units. Examples of the output of onion fly adults are shown at Figures 7 and 8. The model has a number of interactive features, one of which is a cursor at the base of the *x* axis which allows you to pinpoint peaks in the various stages of fly development. This was used to compare the timing of predicted peaks in adult flies in comparison with water trap data from the monitoring site.

The predicted activity pattern for adult flies (Figures 7 and 8) show three distinct peaks for both 2002 and 2003. In 2002, the first peak between 30 April and 4 May was much greater than either the second (7-27 July) or third (31 August) peaks. In 2003, the second peak on 14 July was much greater than either the first (12 May) and third (9-11 September). The three peaks in adult activity are likely to represent three generations of onion fly, although in the UK a third generation is usually the exception rather than the norm (Gratwick, 1992). A third generation may occur in southerly sheltered locations or when the summer is exceptionally warm (McKinlay, 1992).

In 2002, the model predicts earlier activity than was recorded in water traps (Table 15). However, the traps were not set until mid-May and so may have missed earlier fly activity. A second peak of activity was predicted from 7-27 July, although in the field this was not recorded until 2-8 August. The predicted and actual date of the third activity peak were very similar.

In 2003, water traps were set in late March and caught onion fly from 8-21 April, although the model predicted peak activity around 12 May. A second peak in trap catches was recorded between 21-28 May, although the model predicted that this would occur on approximately 14 July. No more onion flies were caught at Methwood Hythe after 28 May although the model predicts a third activity peak for 9-11 September.

In general, the model was most accurate for the first and third activity peaks (generations) in 2002 but less accurate for 2003. This could be a reflection of the number of onion flies trapped. Only 23 flies were caught in 2003 and although 113 were trapped in 2002 this is still a low catch. The meteorological data from Marham also may not have fully reflected prevailing weather conditions at Methwold Hythe. Therefore it is difficult to form any firm conclusions regarding the validity of the model under UK conditions.

SWAT is a user friendly package which predicts the activity patterns of three important pests of vegetable crops, and limited onion fly data from 2002 suggests that further work should be undertaken to assess its accuracy in the UK.

Figure 7. Predicted activity of adult onion fly at Methwold Hythe, Norfolk in 2002

Onion Fly – Population

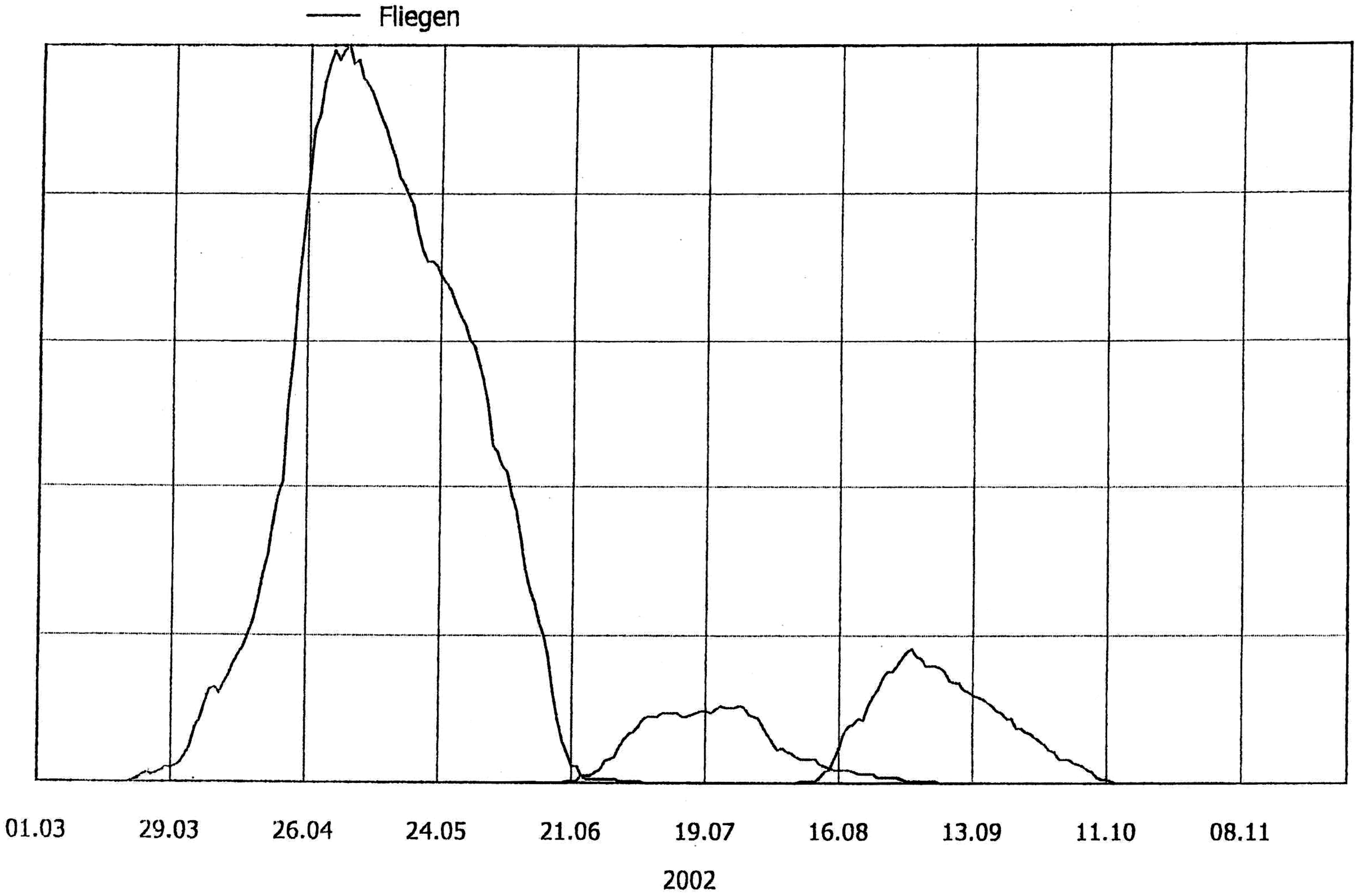


Figure 8. Predicted activity of adult onion fly at Methwold Hythe, Norfolk in 2003
Onion Fly – Population

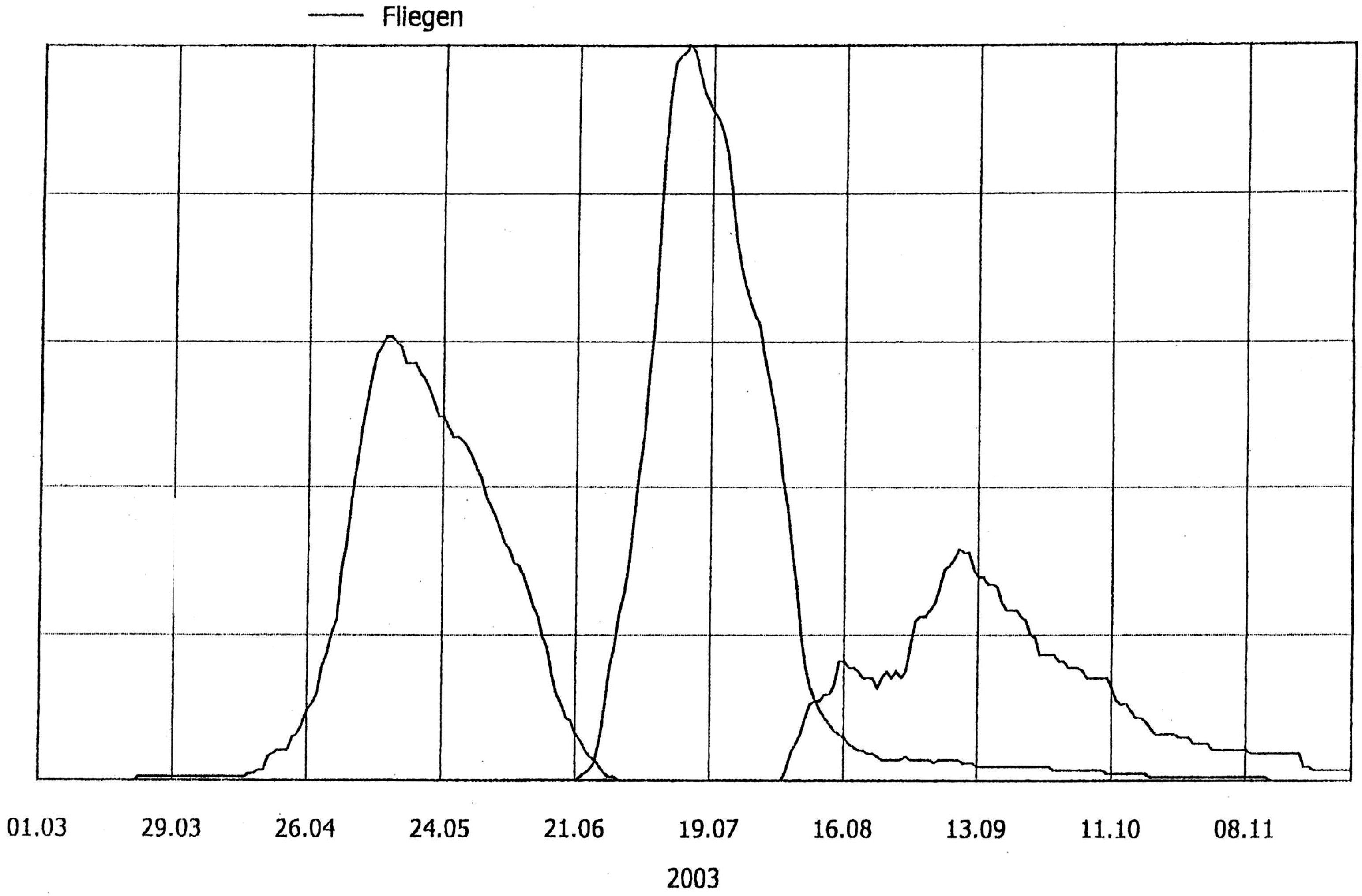


Table 15. A comparison of the dates of peak activity of onion fly adults in 2002 and 2003 as recorded from water trapping or as predicted from the German developmental model.

	Peaks of onion fly activity					
	1		**2**		**3**	
Year	**Water trap**	**Model**	**Water trap**	**Model**	**Water trap**	**Model**
2002	16.5 - 29.5	30.4 - 4.5	2.8 - 8.8	7.7 - 27.7	23.8 - 30.8	31.8
2003	8.4 - 21.4	12.5	21.5 - 28.5	14.7	-	9.9 - 11.9

Conclusions

- The German model SWAT is a user friendly package that can be used to predict the activity patterns of onion fly, carrot fly and cabbage root fly.

- Evaluation against limited onion fly monitoring data in 2002 suggested some correlation between onion fly activity as predicted by the model and water trap catches.

- In view of low onion fly catches it is proposed that further validation using a greater number of sites is undertaken.

Sterile insect technique (SIT) for control of onion fly in the UK

Introduction

Since 1981 the sterile insect technique (SIT) has been applied commercially for the control of onion fly in the Netherlands. SIT is managed by a private company called de Groene Vlieg. This section of the report provides some background to the technique, its practical application, how successful it has been and the problems encountered. Loosjes (1976) details the ecology and genetic control of the onion fly and Loosjes (2000) describes the methodology used in the Netherlands and some of the problems encountered. Much of the material in this section has been taken from these two sources.

Background and practical application

Mass rearing of flies

The flies to be released are mass reared on an aseptic artificial medium, based on carrot powder, at a constant temperature of 22°C or 17°C, under day length conditions of 16 hours for producing non-diapausing pupae and 10 hours for diapausing pupae. Non-diapausing pupae can be stored for at least a year at 3°C although the flies become less fit with time. Pupae should be 15-20% of the way through their life cycle when transferred to cold storage.

Flies emerge about 12-13 days after the pupae are transferred to 21°C and are kept in perspex cages, usually 60 x 40 x 40 cm. About 2,500 flies are kept in each cage and are given water, dry food and onion odour. At its most efficient, the facility can produce about 400 million pupae per year and is used to treat 2,600 ha of onions or 16% of the Dutch onion crop area. The rearing process produces about 2-10% of aberrant males which have characteristics intermediate between males and females.

Sterilisation of flies

Onion fly pupae are sterilised shortly before emergence (about 85% of way through their life as pupae). The sterilising agent is a 3 kR Gamma radiation Cobalbt 60 source. This dose makes the females completely infertile and only about 0.6% of the eggs of non-irradiated females mated to irradiated males hatch. A sterile male has competitive sperm which contains dormant lethal factors so that fertilised eggs do not develop. Interestingly, fertile females when mated with irradiated males live 1.3 times longer than normal and their fecundity is increased by a factor of 1.6-1.8. This may need to be taken into account when determining the number of flies to be released as 0.6% of eggs laid by non-irradiated females will hatch after mating with irradiated males as already discussed.

A few years ago, the Dutch government decommissioned a radiation plant which was used for pupal irradiation. Pupae now have to be irradiated in Belgium and this is expensive and inconvenient.

Marking and release of flies

At emergence, flies are marked with a fluorescent powder, which they retain in their retracted ptilinum. Dyed flies have been shown to be no less fit than undyed flies. Flies are then stored for a short period at 3°C and loaded into the release containers by weight. These containers consist of two gauze screens which form a cage of about 40 x 60 x 4 cm, each containing up to 40,000 sterilised flies.

The flies are transported to the onion fields by car Both sexes are released by hand, with the release containers being emptied along the borders of the onion fields. The females have no effect on onion fly control. Three traps are placed in every field. Onion flies are removed from these weekly and checked for the presence of dye. This data can then be used to adjust the numbers of flies released the next week.

Previous field experiments (Mijs, 1974) showed that SIT resulted in an effective sterility of 88.5% on the experimental field. Damage in the trial field was only 2.4% compared with 17.4% in the control field. The reproduction factor on the control field was 13 in comparison with 0.25 on the trial field.

Practical considerations and applicability to the UK

The Dutch experience suggests that SIT can be an effective means of controlling onion fly. However, there are a number of practical considerations and or problems that need to be taken into account before the technique can be adopted in the UK. These are described below.

Is onion fly an economically important pest in the UK?

Despite reports of increased problems with onion fly from a number of areas of England, (East Anglia, Essex, Kent, the southwest and the Vale of Evesham) pest monitoring (Section 1 of this report) has failed to locate significant populations of the pest. In contrast, bean seed fly appears to be ubiquitous and present in the field from April until September, suggesting that some reports of onion fly attack have been incorrectly diagnosed. To date only one type of trap has been used to monitor bean seed fly and onion fly and it is possible that this is more suited to the former than the latter. The most appropriate trap for onion fly should be determined and this will help to quantify the scale of problem that this pest poses to UK producers. At present it would be very difficult to make a case for the use of SIT against such a minor pest.

Are the costs of adopting SIT prohibitive?

If it is assumed that onion fly is an important pest causing significant economic loss to onion producers, then the cost of adopting SIT must be considered. The initial cost of establishing a continuous mass rearing and sterilising programme is likely to be significant. HRI Wellesbourne currently have a culture of the pest, but this would need to be scaled up to meet the needs of a SIT programme.

The cost to the farmer of SIT is also important. In the Netherlands the initial cost of SIT was about 66% of that of chemical control. However, this led to distrust as farmers could not understand how a cheaper technology could produce effective pest control. In fact, the numbers of customers increased when the price was raised to about the level of the cost of chemical control. At present de Groene Vlieg, who manage SIT commercially in the Netherlands, state that their price does not cover costs, but making the technique more expensive would lower participation. During the first two years of the introduction of SIT in the Netherlands, the scheme was supported financially by the government as it was perceived to benefit the environment. Subsequently, this support was withdrawn as the novelty of the technique wore off. Not only did this affect the cost of providing SIT but was also considered by farmers to be a negative sign as they were unclear why government support had been withdrawn. On the basis of the Dutch experience, achieving a price that is acceptable to the provider of SIT and the farmer is difficult.

Will farmers adopt SIT over a wide enough area to make it practical?
To date this has only been partially achieved in the Netherlands. This is due to the limited participation of growers and their lack of confidence in the technique. This lack of confidence is in part due to the fact that most farmers are used to the simple application and the visible effects of chemical control. There is greater trust in a chemical that they apply overall the field than flies released onto their fields by others. Also the flies could fly into and benefit their neighbours crop.

How does the efficacy of SIT compare with chemical control?
At high populations levels SIT is less effective than chemical control. To reduce populations to an acceptable level the number of flies to be released must be related to the size of the wild population. The number of flies released has to be exponentially dependent on the number of wild flies. So the cost of treatment increases with the increasing size of the wild population. In contrast, the cost of chemical control is independent of population size and remains the same if all the plants or only a small proportion are being attacked.

Some farmers believe that SIT does not work, particularly if there is high pest pressure. However, once populations are reduced, SIT becomes very effective in comparison with chemical control. Where there is a high pest pressure, SIT can be used as part of an integrated control programme. Once the number of sterile flies required becomes difficult to produce, the grower is advised to spray. Approximately equal proportions of sterile and fertile flies are killed so that when more sterile flies are released, their ratio to the wild population will improve.

Can growers take advantage of release of sterile flies on neighbouring farms?
In the regions of the Netherlands where SIT is marketable, approximately 40% of growers do not use the technique. Some prefer to use cheaper chemical control but others do nothing and hope to benefit from sterile flies released in their neighbours fields. This generally does not work well as the number of flies that migrate into their fields are low and the wild population of fertile flies increases.

Can the changing distribution of fields cropped with onions influence SIT?
Every year onions will be grown in different fields. Consequently when the flies emerge in the spring they have to search for their host crop. This results in a redistribution of populations among onion fields. Therefore, fields where flies have not been well controlled, or not controlled at all, can have a significant detrimental effect on the implementation of SIT.

Conclusions

SIT has been proven to be an effective means of controlling onion fly in the Netherlands and is more environmentally benign than chemical control. However, adoption in the UK is unlikely in the near future, primarily because the pest status of onion fly is unclear. Should this situation change, then the experiences of the Dutch will provide a useful model to help with implementation of SIT in the UK.

Guideline strategy for onion fly and bean seed fly control

Based on the results of the current project, the following strategies are proposed for control of onion fly and bean seed fly. Also included are topics for future research which would contribute to improved control of both pests.

Onion fly

It is vital to establish the pest status of onion fly in the UK. Despite two years of monitoring at sites thought to have a problems with this pest, very few were caught. This suggests that some reports of onion fly attack have been incorrectly diagnosed and may be due to the bean seed fly.

Cultural control

Where feasible, crop rotation should be practised and onion fields should be situated as far apart as possible. Onions grown in the year following an attack should be sown as far away from infested land as possible. If damaged plants are removed, care should be taken to ensure the maggots or pupae are not left in the surrounding soil.

It is also important to avoid any physical damage to the onion crop. The use of implements that damage plants can greatly increase the likelihood of attacks from onion fly. Similarly, crops should be harvested in such a way as to minimise physical damage so that flies are not attracted to any injured bulbs laying in windrows.

Chemical control

Of those seed treatments tested, only UKA 434 showed nay potential against the pest. Force appeared to enhance emergence but did not give persistent control of onion fly larvae. Bayer CropScience will need to be consulted regarding the target market of their developmental product.

Dursban WG was a very effective drench treatment but is not approved for use for control of onion fly. Also further work is necessary to evaluate further the potential for phytoxicity. Dow Agroscience should be consulted regarding the possibility of a SOLA for Dursban WG for onion fly control, although the product can be legally used on onions for cutworm control.

Bean seed fly

Cultural control

Soil conditions

Sowing crops when rapid germination is probable will reduce the likelihood of severe attack by bean seed fly. Rapid germination is encouraged by early cultivation, adequate moisture freedom from compaction and proper burial of any organic debris. Sowing seed into stale seedbeds may also help.

Avoiding pest attack

Results suggest that plants become less susceptible to bean seed fly attack as they mature. Further work is now needed to determine precisely the growth stage at which to target control measures.

Predicting the timing of pest attack

Yellow water traps are particularly effective at trapping bean seed fly. These should be employed on a regular basis to indicate when crops are likely to be at risk of attack. Further work should also be undertaken using sequential sowings of salad onions to determine whether there is a relationship between bean seed fly activity and the risk of damage. In particular, is there a threshold catch below which damage will be minimal and control will not be cost effective?

Chemical control

Force remains the best seed treatment for bean seed fly control. Thiomethoxam (Cruiser 350 FS) has also given good control of the pest on beans (Michael Tait, Syngenta, personal communication) but was not evaluated in this study. Once an attack is underway, then it is more difficult to control. However, as an alternative to seed treatment, Dursban WG is the best option as a drench for larval control but does not have a label recommendation for bean seed fly. Dimilin Flo and CERIO 14 were also very effective. These are not approved on onions and Certis should be consulted regarding whether the situation is likely to change in the future.

Further research

1. A comparison of trapping methods for onion fly.

Yellow water traps were very effective at trapping bean seed fly but very few onion fly were caught. It is possible that this is a true reflection of onion fly populations or may be that yellow water traps are ineffective for this pest. It is proposed that a range of trap types are evaluated at site at which onion fly is believed to have a history of onion fly attack. This will help to determine the scale of the onion fly problem in the UK.

2. An investigation of the susceptibility of onion/leek seedlings to bean seed fly attack.

Results suggest that the greatest risk of bean seed fly attack is during the early stages of seedling development and that plants become significantly less susceptible as they mature. An experiment is proposed in which different ages of onion/leek seedlings are exposed to natural oviposition by bean seed fly.

3. An evaluation of fish meal as a means of avoiding bean seed fly oviposition.

Sprinkling fish meal over the surface of pots sown with salad onions was particularly effective at attracting bean seed fly oviposition. This experiment would investigate whether this can be used as a means of cultural control of the pest as an environmentally benign alternative to chemicals.

4. Is the risk of bean seed fly attack related to pest activity?

Bean seed fly is active from April until September but there is little information available to relate pest activity to crop damage. A series of sequential sowings could be used to provide seedlings that emerge at various stages during the six months in which the pest is active. Crop damage will be compared to determine when crops are most at risk from the pest.

Technology Transfer

The following technology transfer activities have been undertaken.

a. A summary of the results for the first year of the project was prepared for an HDC member to discuss at a meeting of the European Quality Onion Growers in Poland, autumn 2002.

b. A paper was presented summarising the pest monitoring programme and pot experiments to evaluate the efficacy of a range of products for bean seed fly control at the UK onion and Carrot Conference and Exhibition, 26-27 November 2003.

c. An article summarising the UK Onion and Carrot Conference and Exhibition presentation appeared in "The Vegetable Farmer", January 2004, page 16.

d. An article “Onions face fly threat” was published in “HDC News”, No 101, March 2004 pages 14-15.

e. An invitation has been received to present a summary of the project at the Vegetable Consultants Association Conference in November, 2004.

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