The State of Israel
Ministry of Agriculture and Rural Development
Extension Service
Plant Protection and Inspection Services

Development of an environmentally friendly pest management programme in almond orchards with a focus on targeting the carob moth

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A joint initiative of Extension Service—Ministry of Agriculture and Rural Development
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Ha'emek Agricultural Centre, instructors, orchard coordinators at Zabar-Kama, Yizrael, Lavi, Malkia, Magal, Mishmar HaEmek, Ginegar

Carob moth—the predominant pest in most almond orchards in Israel

- The carob moth produces 3-4 generations in a year.
- During winter, moths mostly exist as larvae in almond fruit that remain on trees from the previous season and in additional hosts, including carob, citrus, pomegranate, loquat, and others.
- Reports on increasing moth population, infestation, and crop damage have become more prevalent in recent years.
- According to data from 'Field-In' (2018): "Farms have reached over 13 % (national average) of carob moth infestation and damage, which renders the fruit unsuitable for marketing…"

Ectomyelois ceratoniae Zell. (carob moth)

Distribution: Southern and central Europe, Africa, Central and South America, USA, Asia (Iran), Middle Eastern countries

Hosts: almonds, carobs, citrus, Acacia farnesiana Willd, pomegranate, pistachios, macadamia, dates, persimmon, dry fruit in orchards such as figs, raisins, nuts, dry fruits in storage, nut trees…

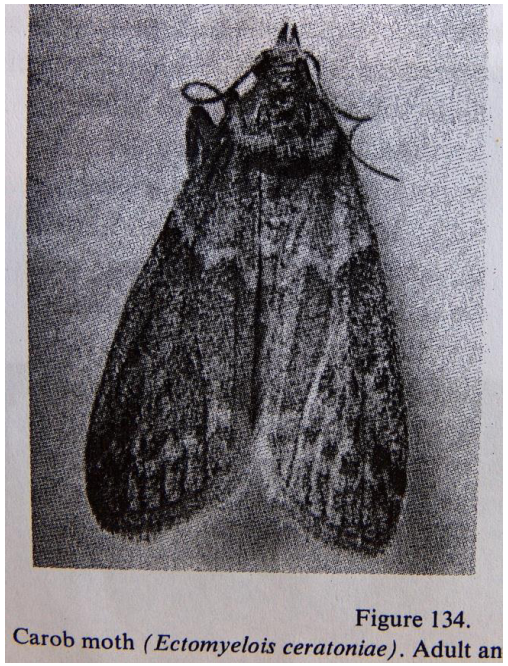
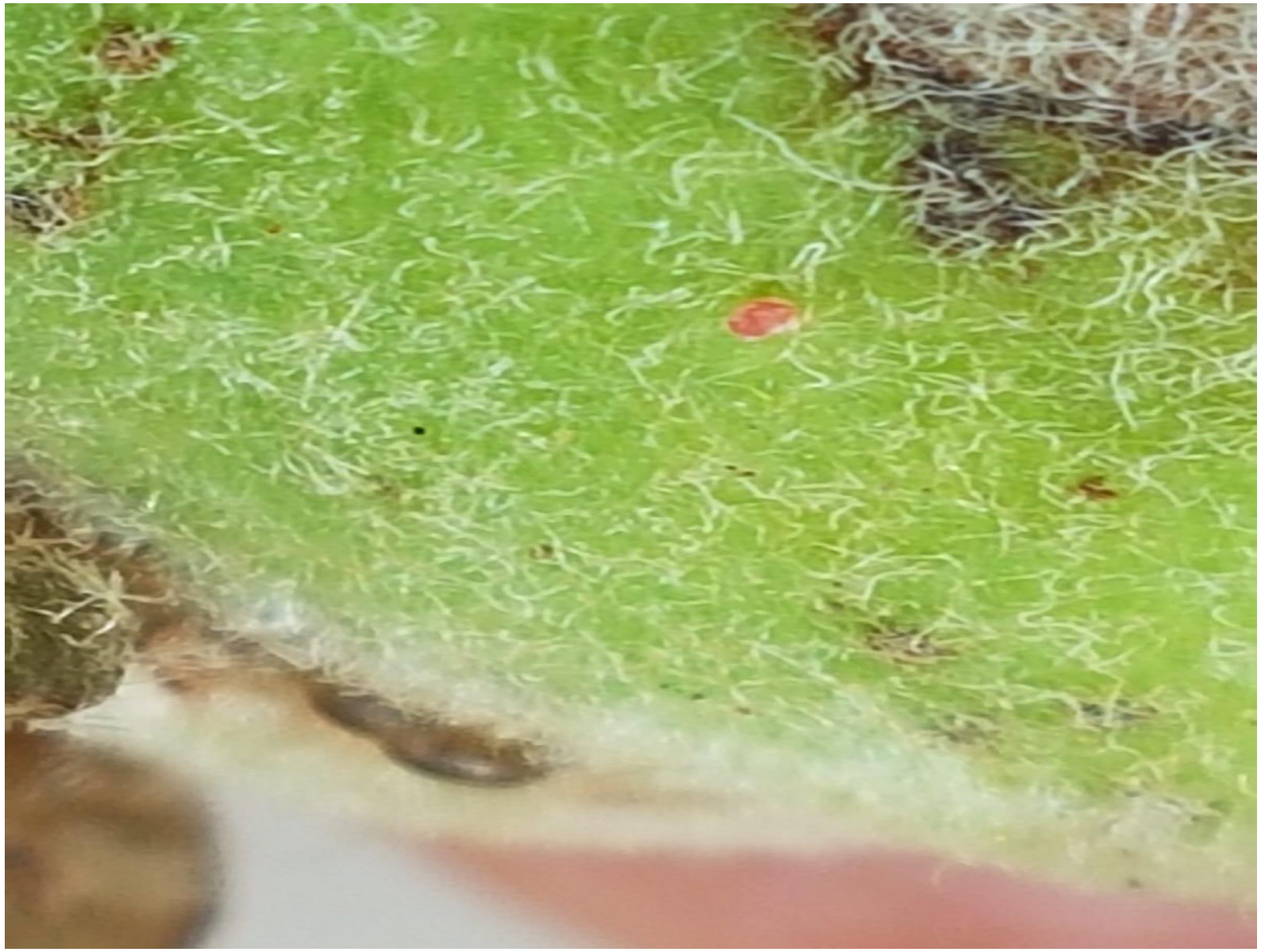


Figure 134.
Carob moth *(Ectomyelois ceratoniae)*. Adult an



Photography: Leah Sela

Carob moth in almonds

An egg on a green fruit

Photography: Leah Sela

Photography: Maayan Golani

Carob moth biology: important facts

A. The female can live for about two weeks to a month.

B. Egg laying starts a day after emergence.

C. A female can lay about 100 to 350 eggs during her lifetime.

D. According to reports, females lay eggs in cracks and wounds in the hull and in pathogen-affected areas.
Preliminary observations suggest that moth larvae can penetrate the hull even in the absence of an existing crack/wound.

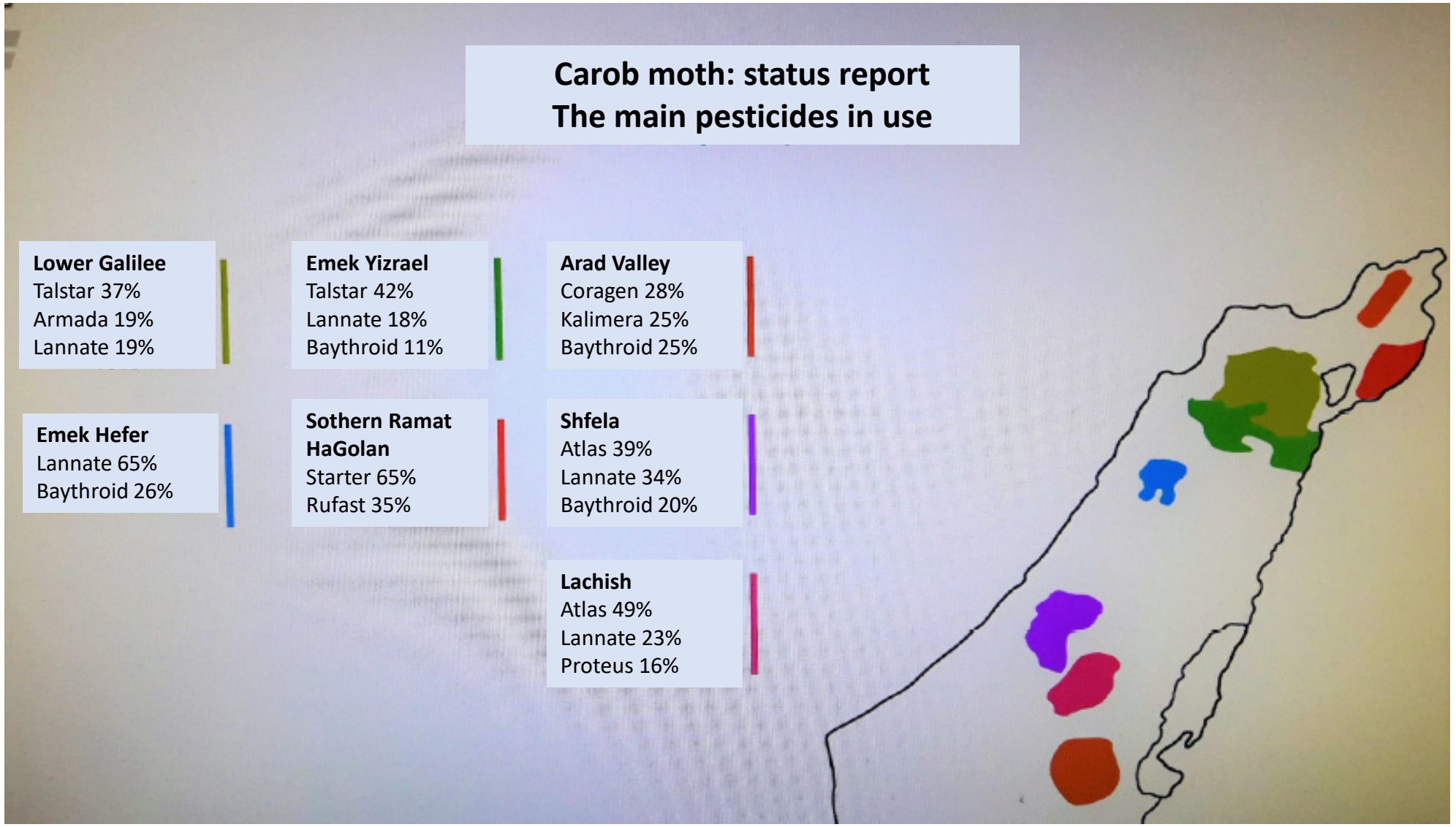
E. Larvae develop over six weeks to five months, depending on the season and the temperature.

F. In Israel, the carob moth develops four generations a year (mid-April to the end of June, June to the end of August, August to the end of October, end of October to full development in the next spring).

Apricot moth—Anarsia, another pest in almond orchards

Photography:
Leah Sela

Data from ‘Field-In’ presentation (2018)



The Initiative aims

1. To develop environmentally friendly pest management in almond orchards, emphasising the carob moth, as an alternative to the harsh pesticide spraying currently in use.
2. To examine innovative and environmentally friendly pest management preparations for the control of carob moth in almond and citrus orchards.

The alternative management is based on the use of selective, environmentally friendly preparations as the main control strategy of carob moth in almond.

1. Mating disruption by the innovative preparation “Carob moth SPLAT”.
2. Complementary spraying of biological preparations such as “Bio T Plus”.
3. Additional products, such as Coragen and others, will be integrated in the future.

Carob moth SPLAT

A novel technology for applying pheromones within an inert substance containing non-toxic disposable materials

Carob moth SPLAT contains an analogue of the female pheromone that “confuses” the males.

The preparation is active for approximately eight weeks.

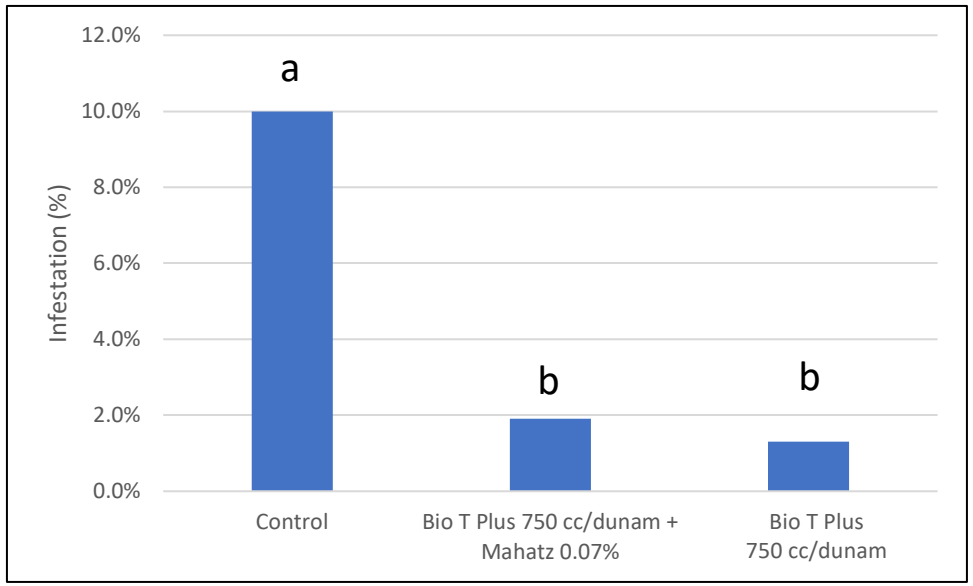
Application by ALTA company drones, or by a purpose-build applicator.

Bio T Plus

Biological SC containing *Bacillus thuringiensis* Var. *Kurstaki (*16,000 ITU)

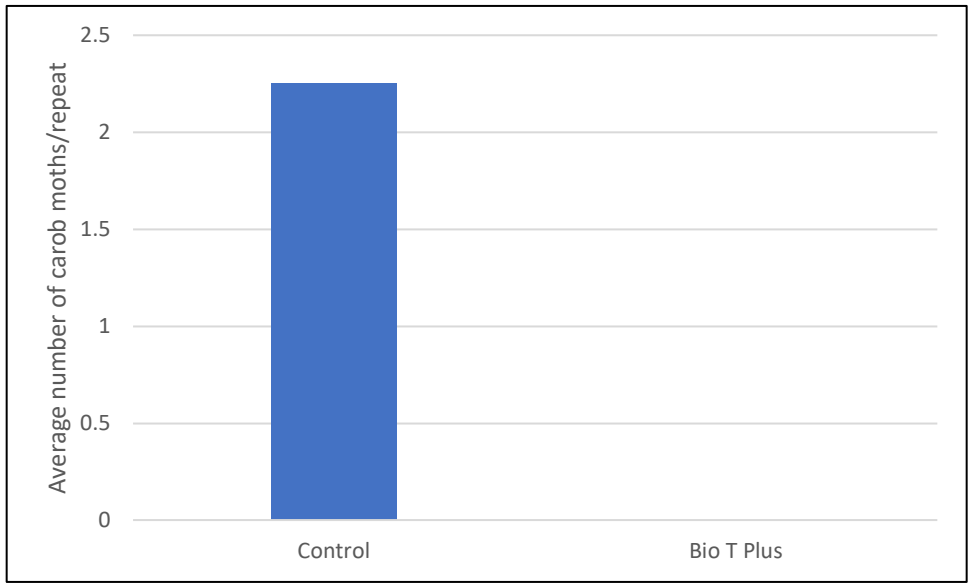
Previous experiments have shown that B.t preparations are effective in controlling carob moth in almond and citrus orchards (A. Lyn, M. Broza, Bar Zakai and Gross, Visotzki and Harpaz, Ben Yehuda et al.)

An experiment testing the effectiveness of Bio T Plus in controlling carob moth in pomelit, Glil Yam 2018



Different letters indicate significant difference between values (P<0.05)

An experiment testing the effectiveness of Bio T Plus in controlling carob moth in the Orr variety, Yifat 2018



Methods and Materials

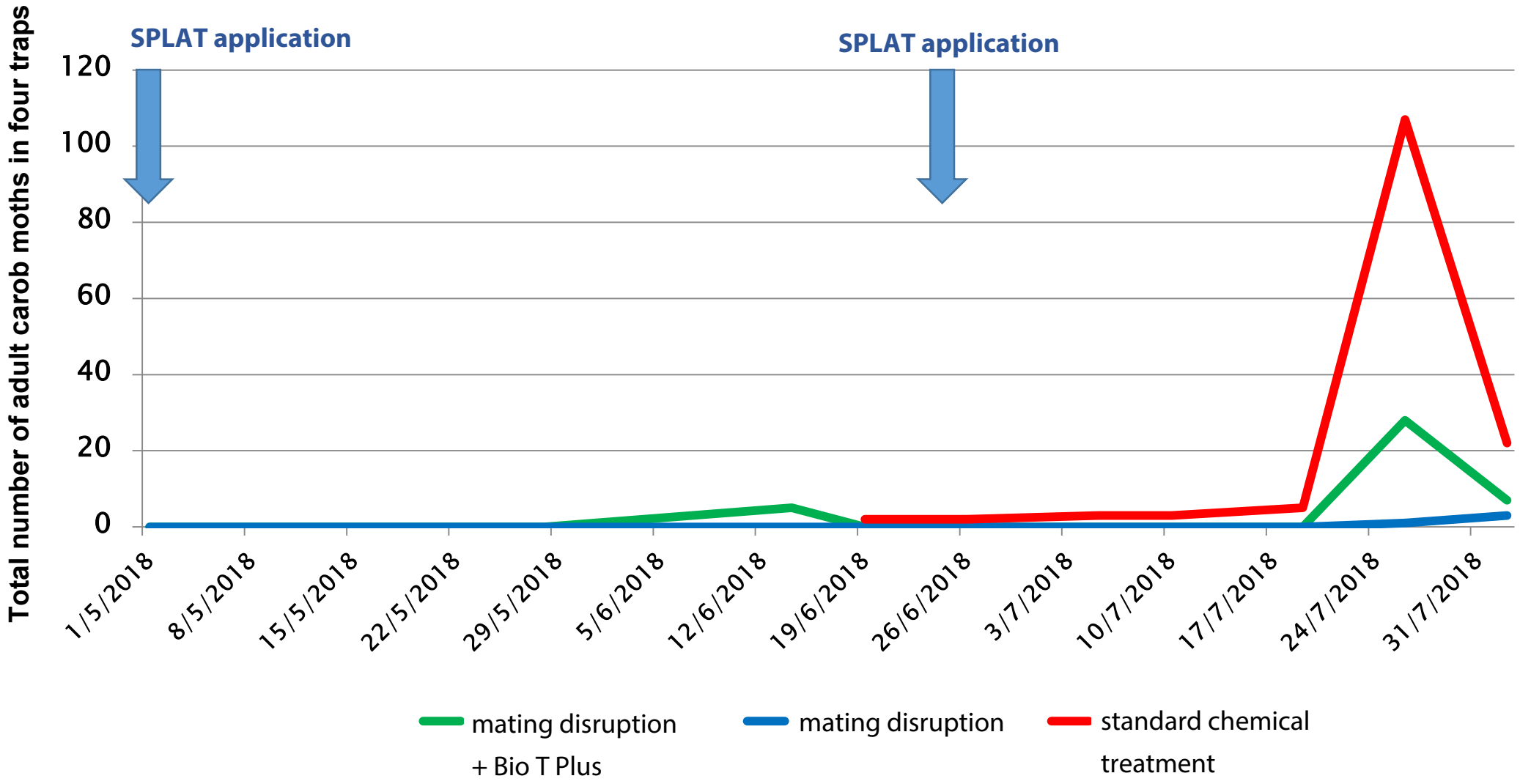
2018

- Four almond orchards: Malkia, Lavi, Yizrael, Kfar Menachem
- Treatments: 1. Standard commercial management, 2. Alternative friendly management, 3. Mating disruption management only.
- Each treatment was applied to a plot of 30–50 dunam, apart from the mating disruption that included several rows that have not been sprayed at all (approximately 8 dunam).
- Weekly monitoring in pheromone traps.
- Fruit infestation examined every two weeks.

2019

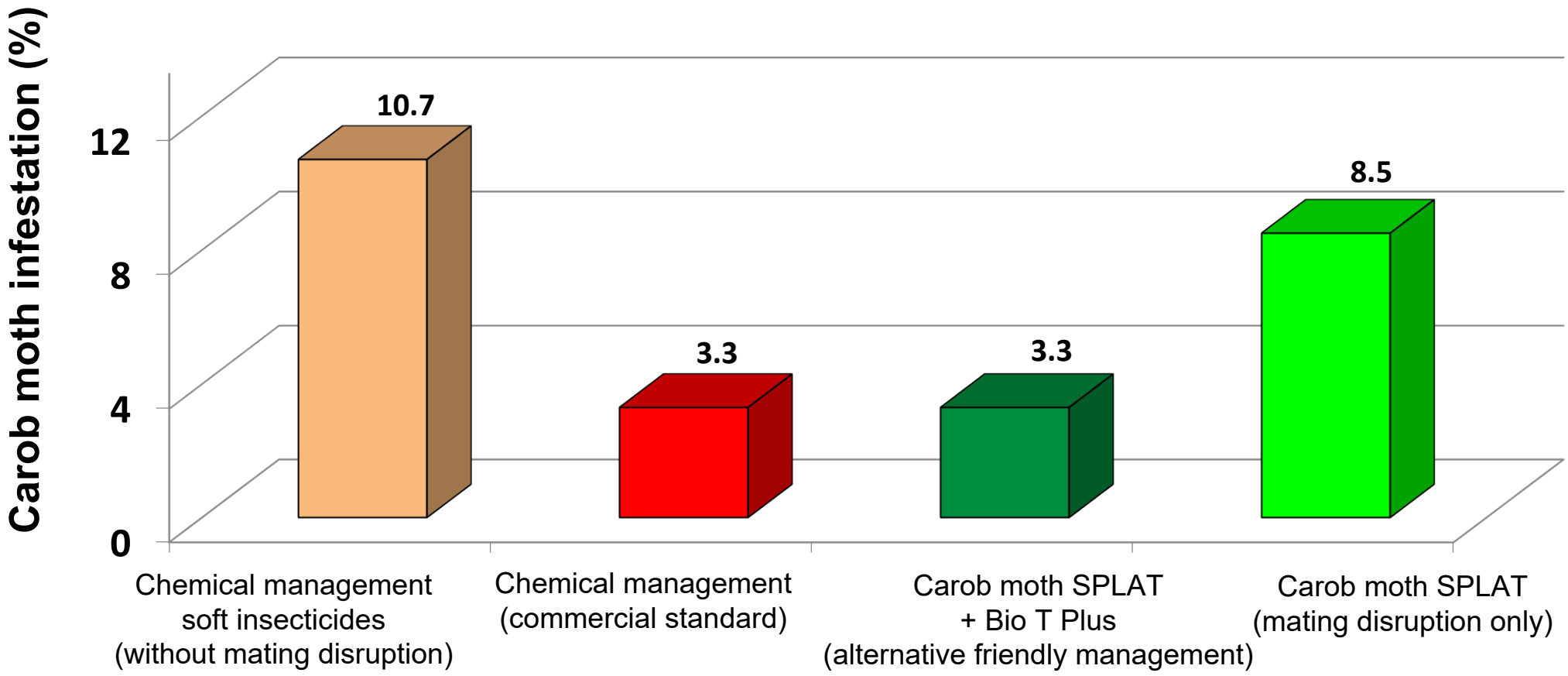
- Five almond orchards: Malkia, Lavi, Mishmar HaEmek, Magal, Kfar Menachem
- Methods were similar to those used in 2018, with an emphasis on **monitoring and inspection and a focus on controlling only the carob moth.**

Time course of adult carob moth capture in Malkia, 2018

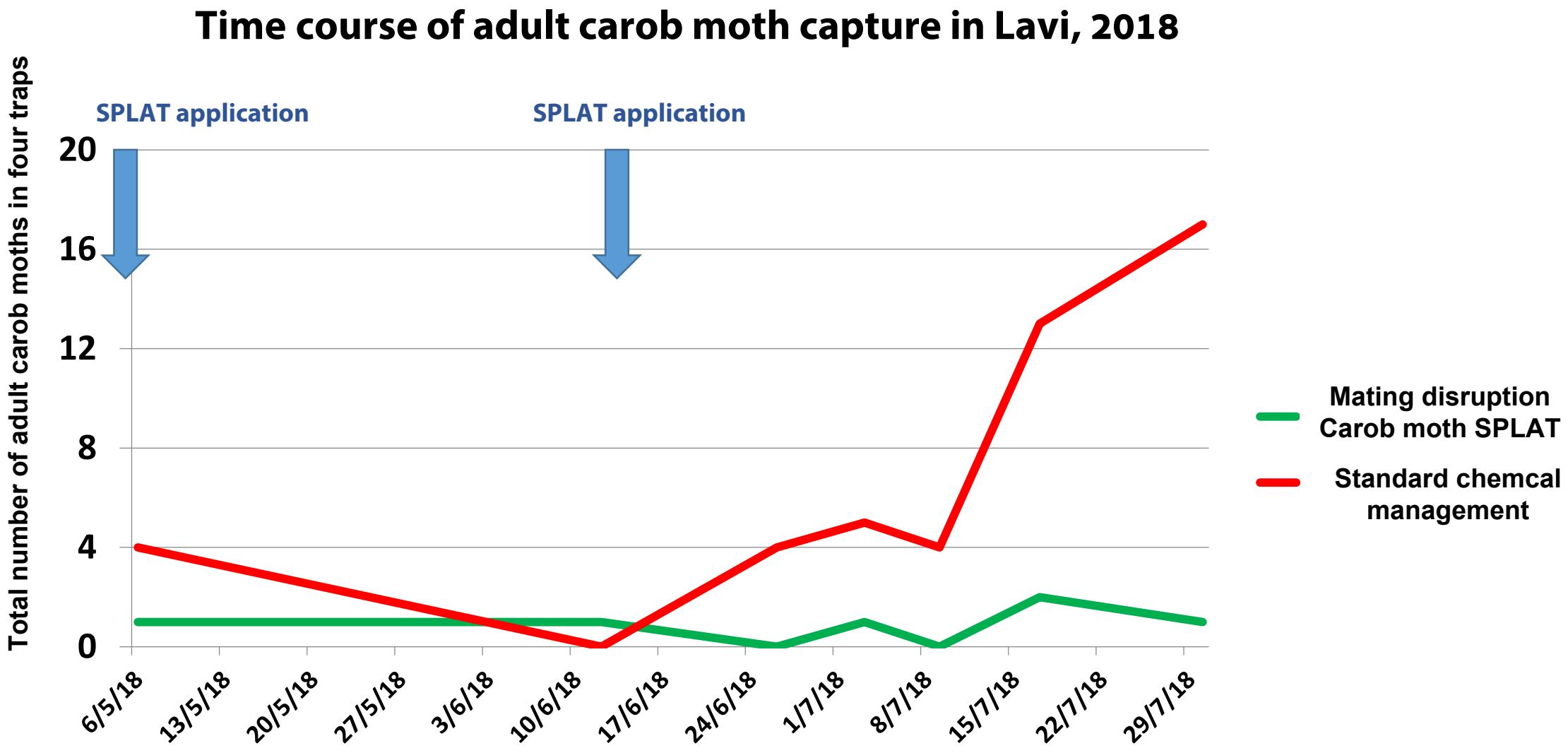


Malkia, 2018 Results

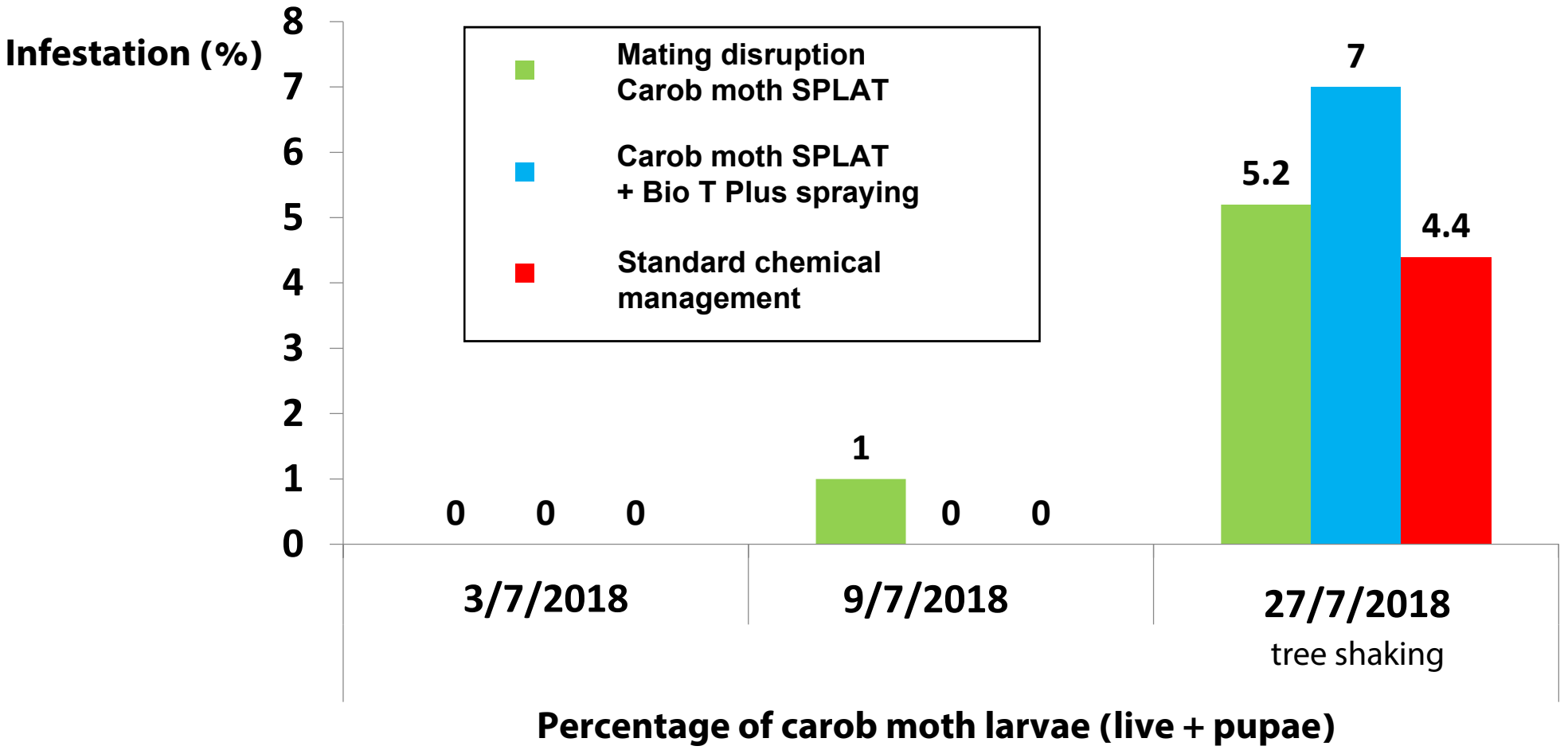
Percentage of carob moth infestation at the time of tree shaking



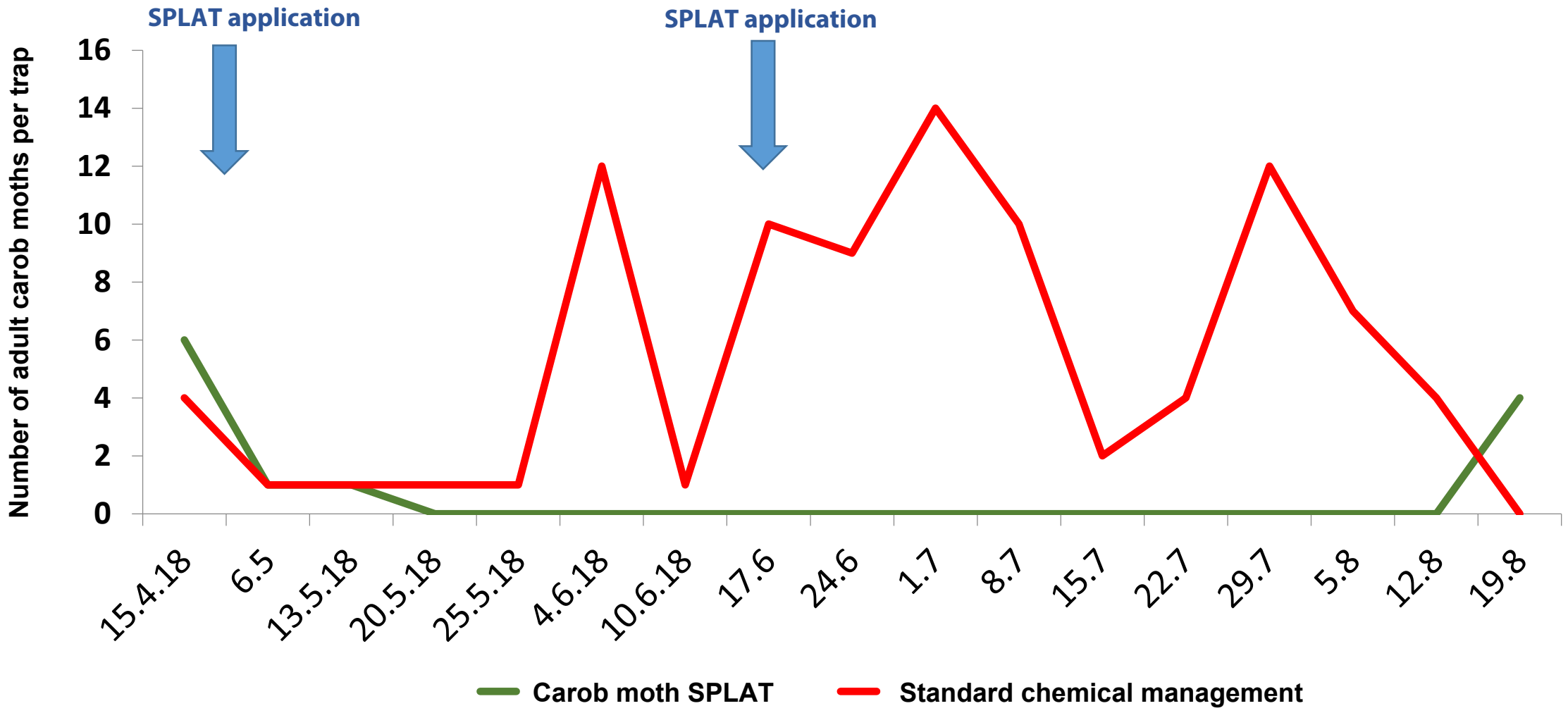
Lavi, 2018 Results



Carob moth infestation, Lavi 2018 results



Time course of adult carob moth capture in Yizrael, 2018

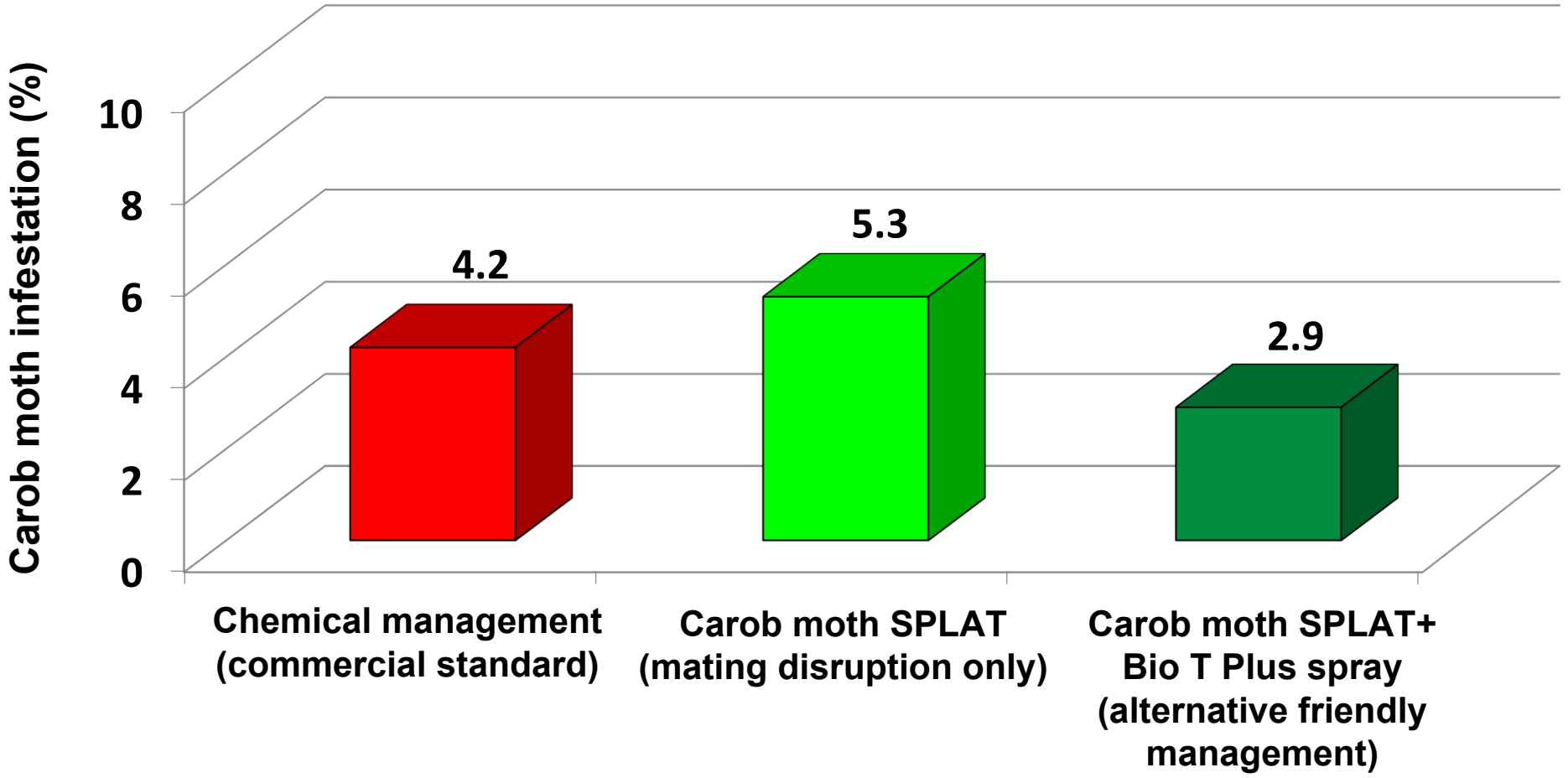


Yizrael: pest control spraying, 2018

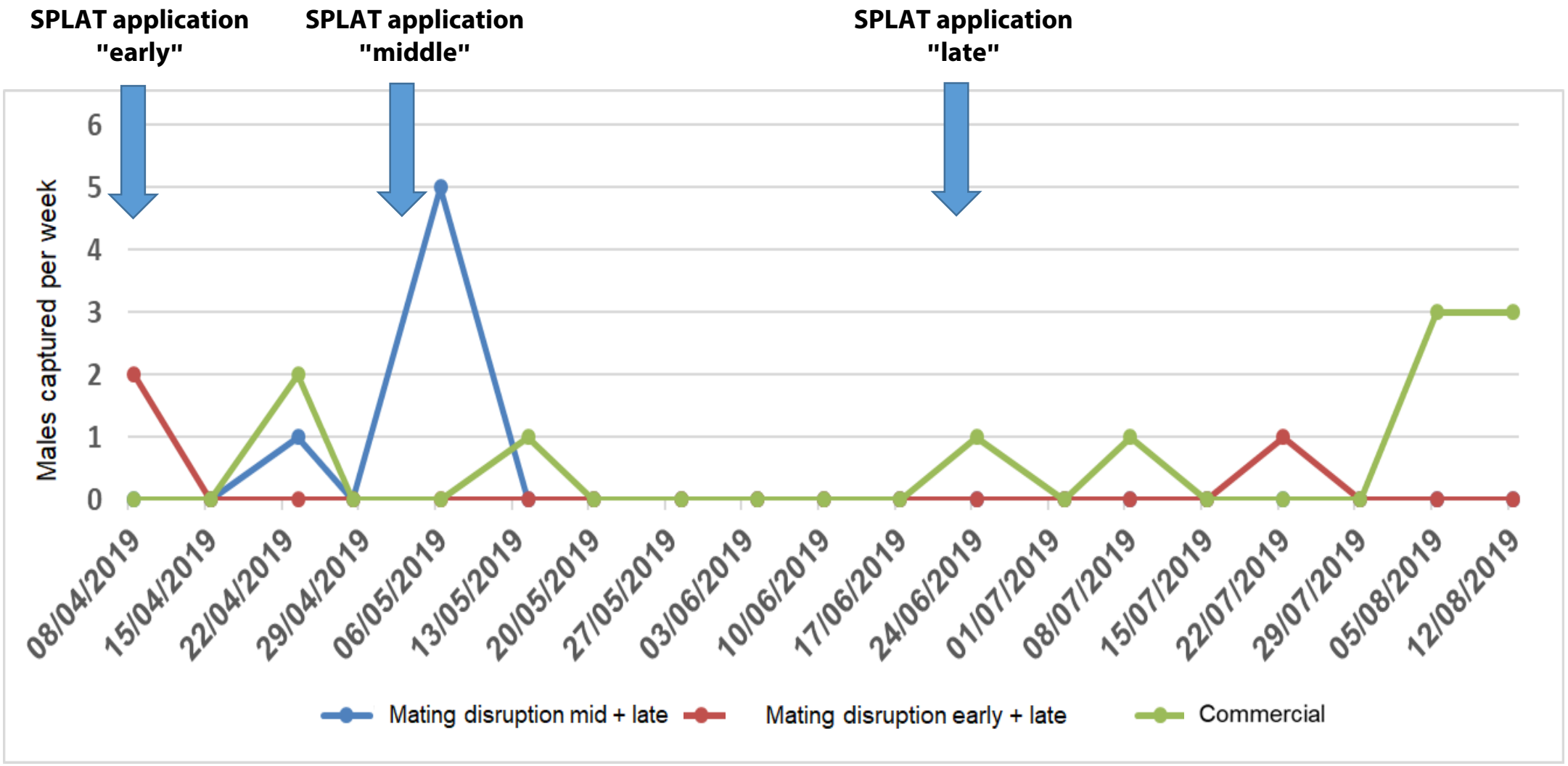
Date	Alternative management (mating disruption + Bio T Plus)	Standard chemical management
11/3/18	Talstar 0.3%	
15/4/18	Baythroid + Envidor	
24/5/18	Teppeki	Rogor
11/6/18	Plictran	KarateMaxx + Plictran
3/7/18	Bio T Plus + Plictran	Runner + Lannate + Plictran
10/7/18	Bio T Plus	Talstar + Lannate
26/7/18	Bio T Plus	Talstar

Yizrael, 2018 Results

Percentage of carob moth infestation before shaking (31.7.18) and on shaking date (2.8.18), weighted average of 600 fruit per sample



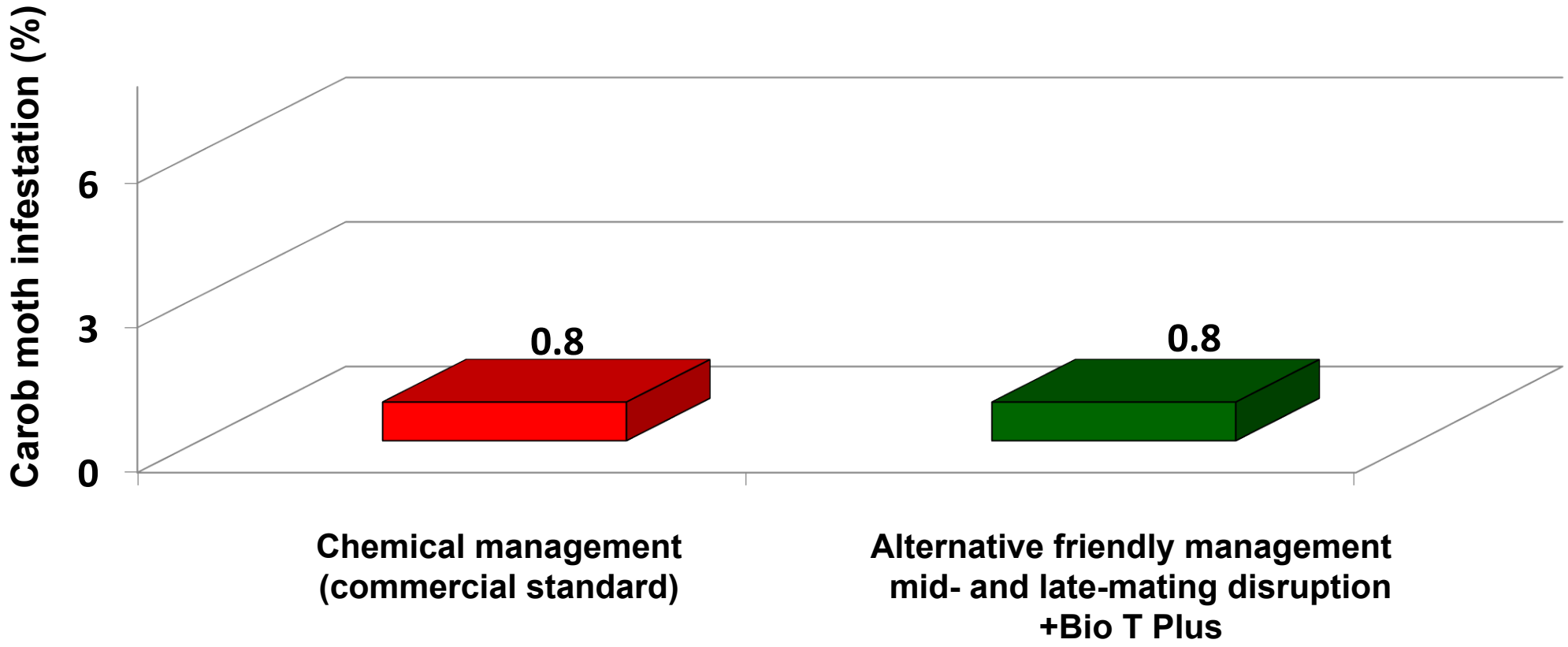
Malkia—time course of capture in the observation plots—2019 results



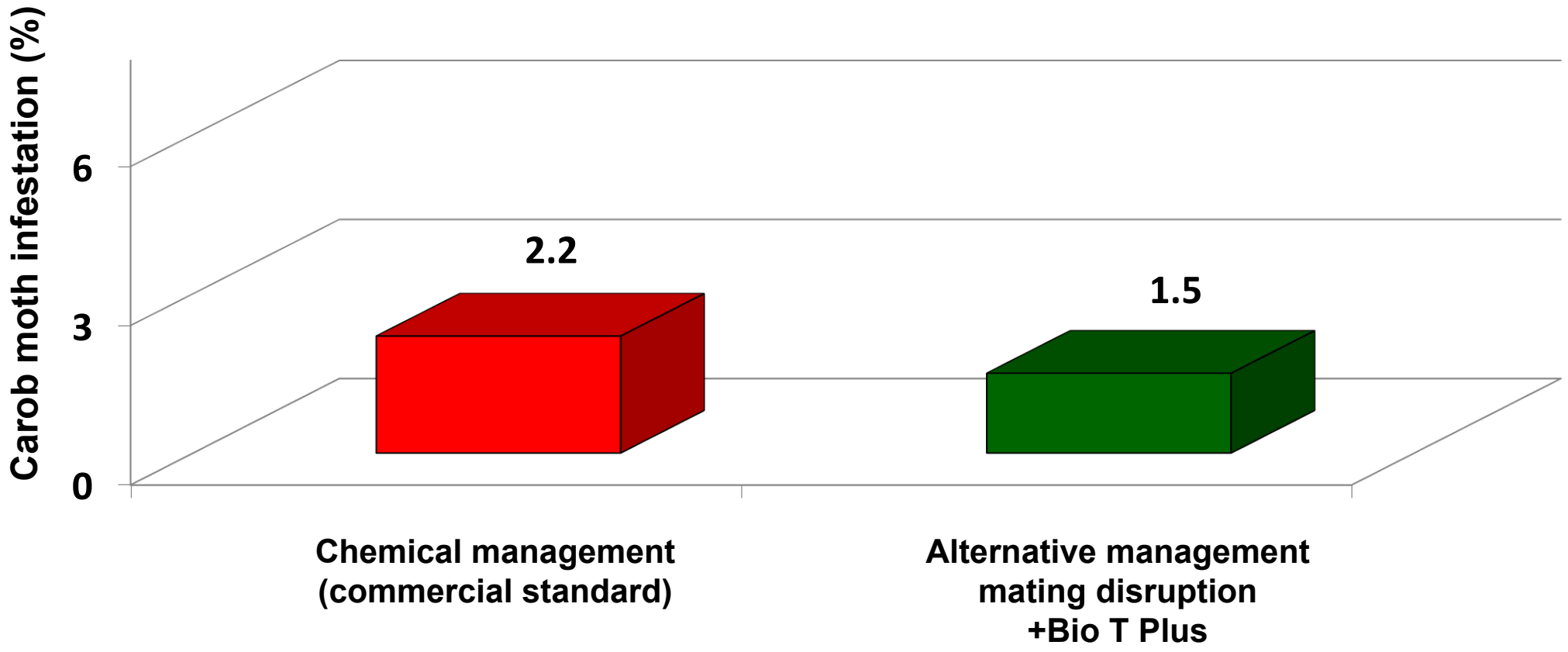
Malkia: pest control spraying, 2019

Standard chemical management				Alternative management (mating disruption + Bio T Plus)		
Date	**Preparation**	**MOA**		**Date**	**Preparation**	**MOA**
23/03/19	Clutch	neonicotinoid		23/03/19	Clutch	neonicotinoid
28/03/19	Aceta Star	pyrethroid+ neonicotinoid		03/05/19	Durivo	diamide+ neonicotinoid
03/05/19	Coragen	diamide		29/05/19	Ampligo	diamide+ pyrethroid
29/05/19	Tarsip	pyrethroid		29/05/19	Bio T Plus	B.T
02/06/19	Envidor	tetronic acids		02/06/19	Bio T Plus	B.T
18/06/19	Mephisto + Atlas	neonicotinoid+ pyrethroid		18/06/19	Bio T Plus	B.T
11/07/19	Decis	pyrethroid		11/07/19	Bio T Plus	B.T

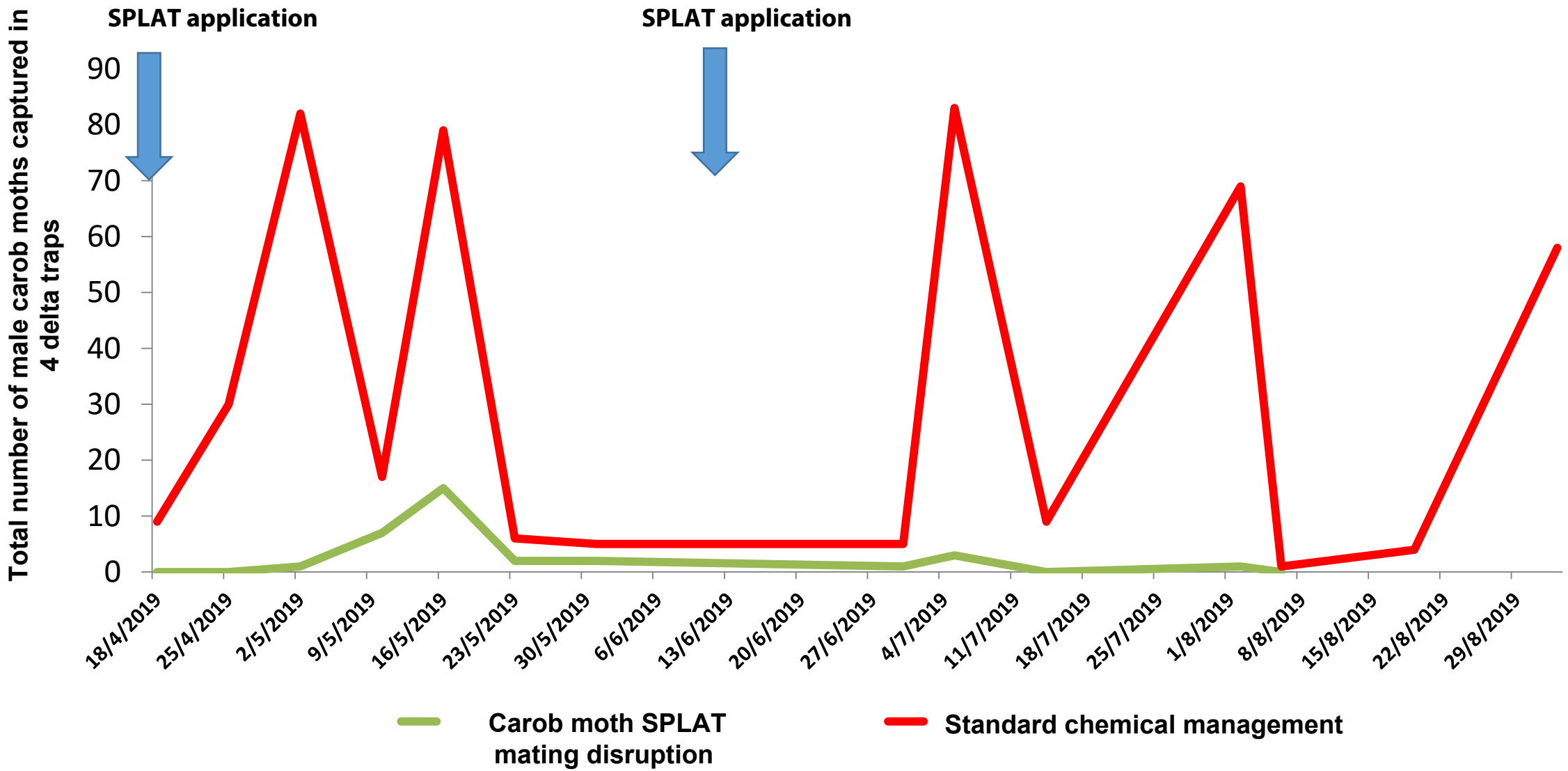
Malkia—2019 results



Lavi—2019 results



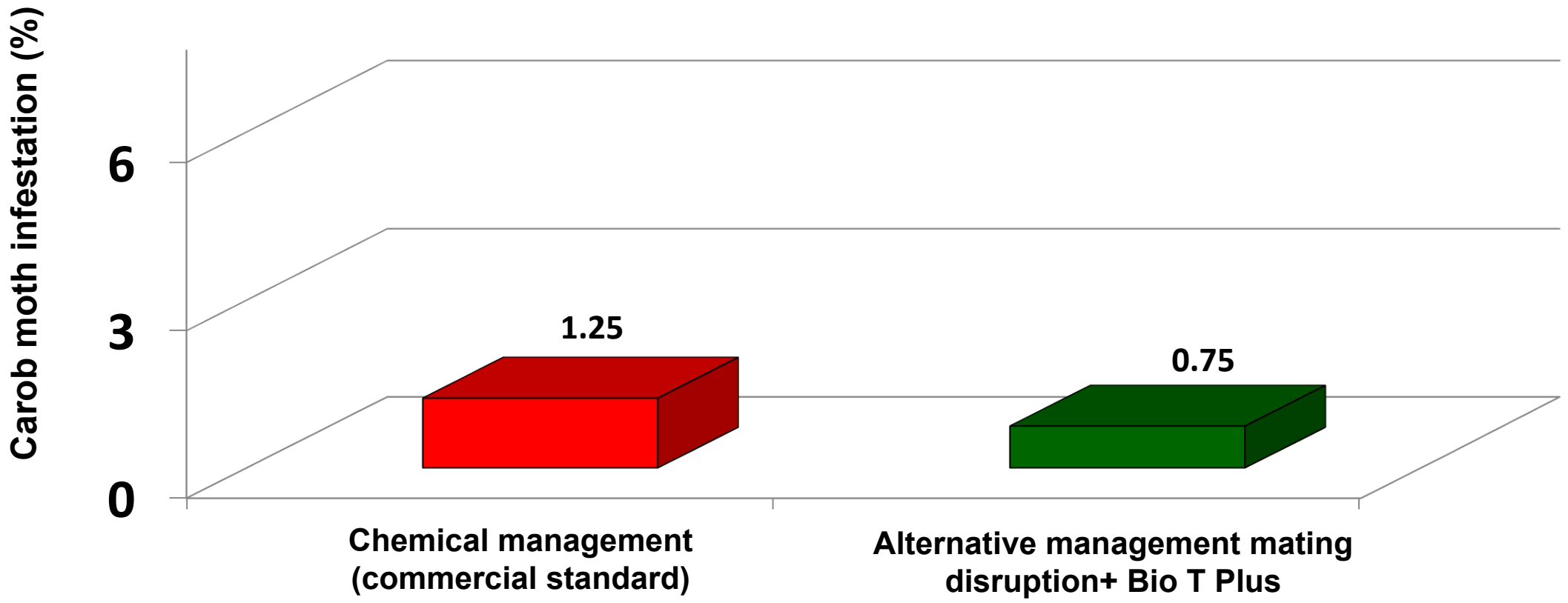
Magal—capture time course—2019 results



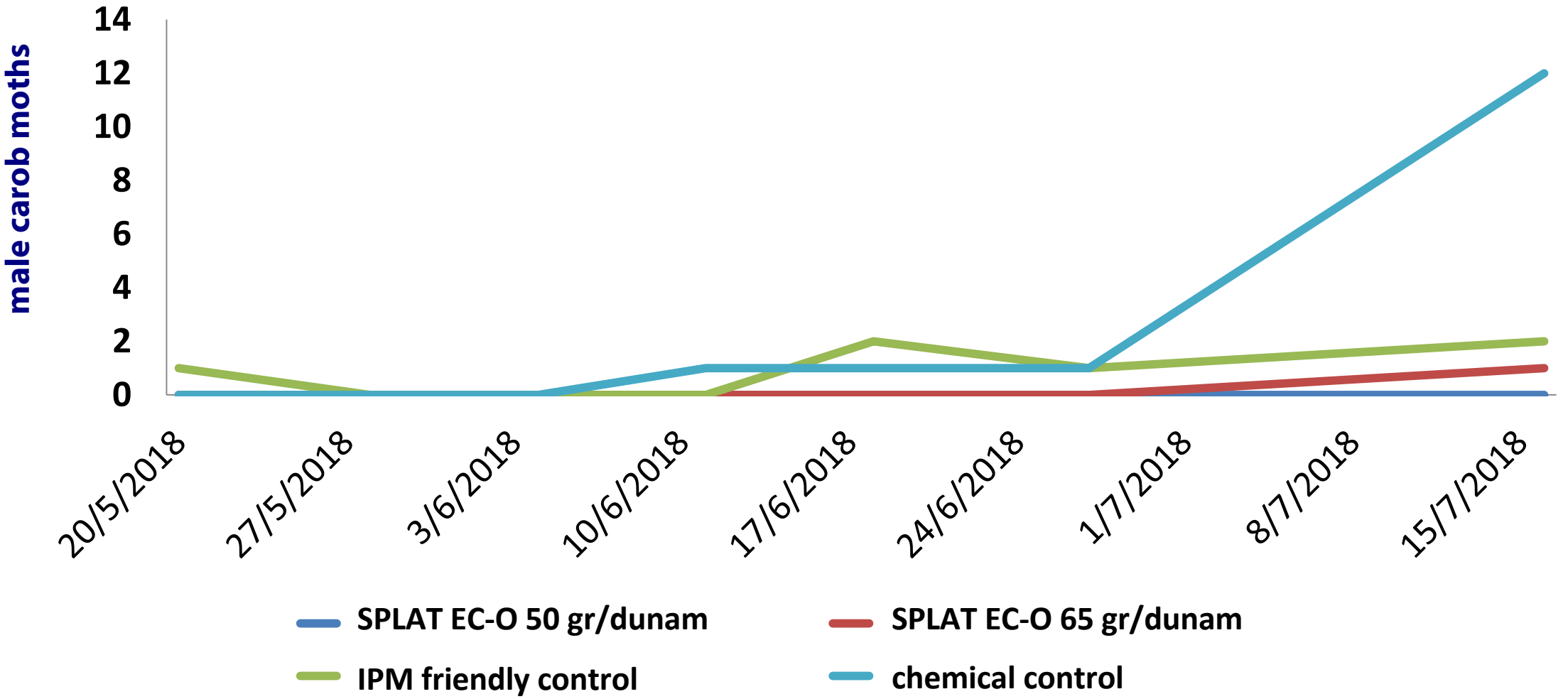
Magal: pest control spraying, 2019

Standard chemical management				Alternative management (mating disruption + Bio T Plus)		
Date	Preparation	MOA		Date	Preparation	MOA
16/5/19	Rufast (0.06%)	pyrethroid		13/5/19	Ampligo (0.02%)	diamide+ pyrethroid
6/6/19	Ippon (0.05%)	neonicotinoid		17/6/19	Imidan (0.2%)	organic phosphate
5/719	Ippon (0.05%) + Lannate (0.1%)	neonicotinoid + carbamate		7/7/19	Bio T Plus (0.4%)	B.T
12/7/19	Runner (0.04%) +Imidan (0.3%)	MAC+ organic phosphate		18/7/19	Bio T Plus	B.T
24/7/19	Lannate (0.1%) +Baythroid (0.15%)	carbamate +pyrethroid		29/8/19	Bio T Plus	B.T
				8/8/19	Bio T Plus	B.T

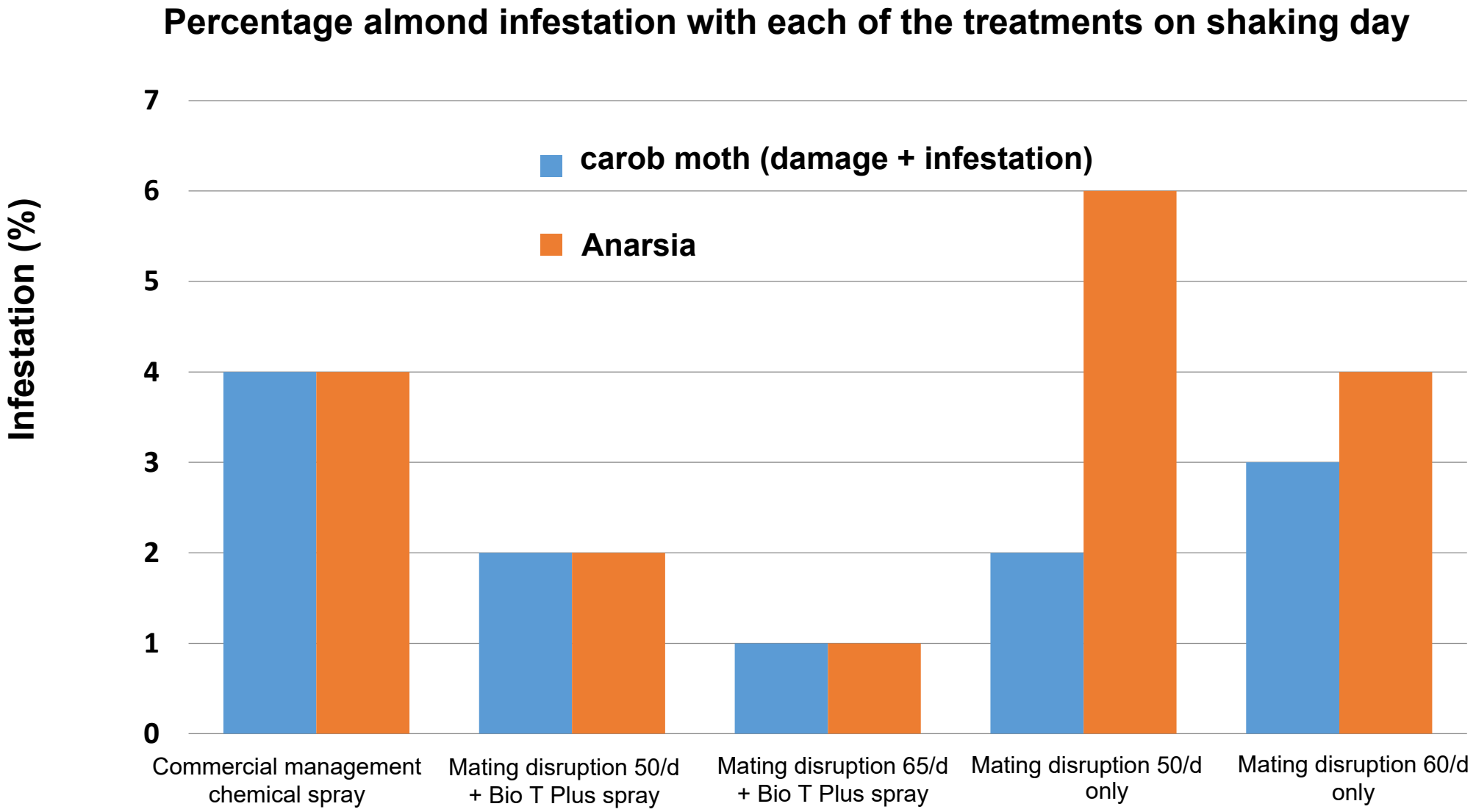
Magal—infestation results, 2019



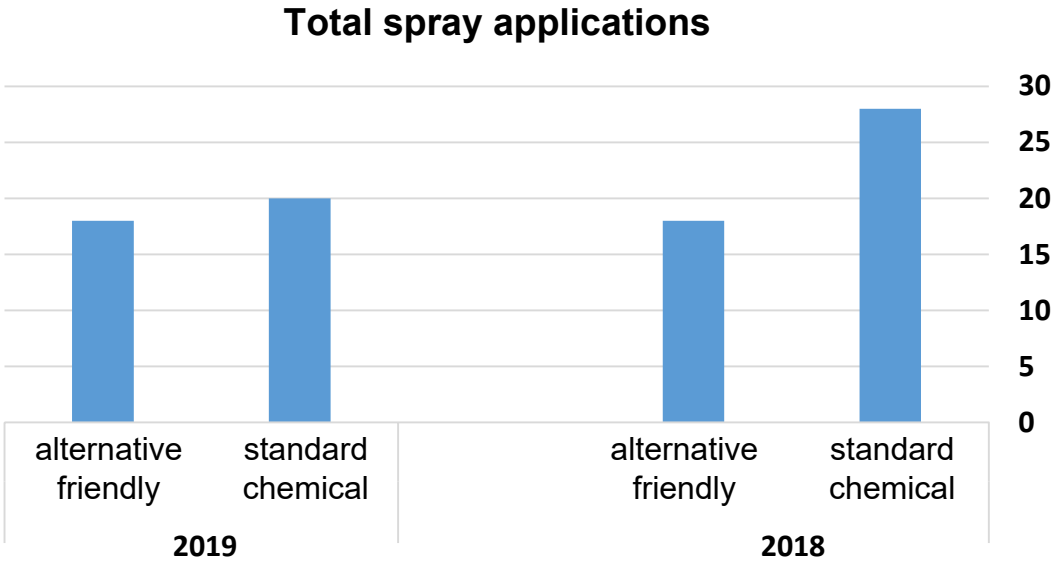
Kfar Menachem, 2019 results

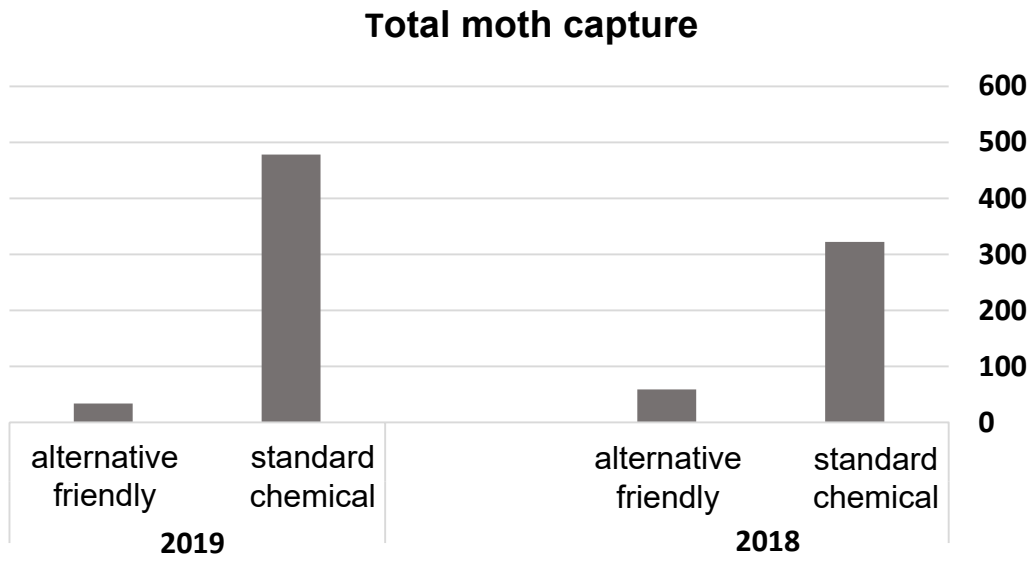


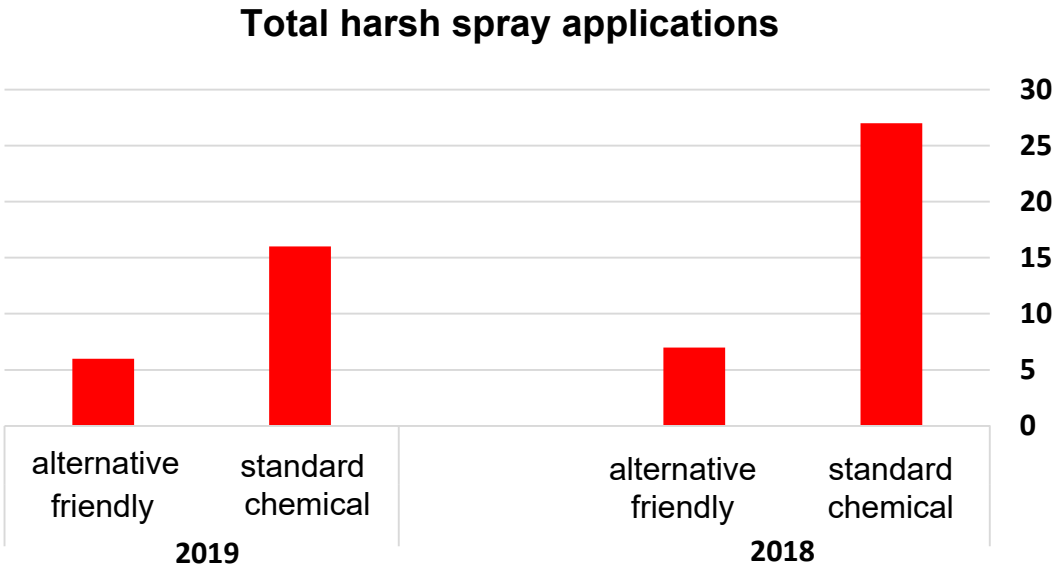
Kfar Menachem, 2019

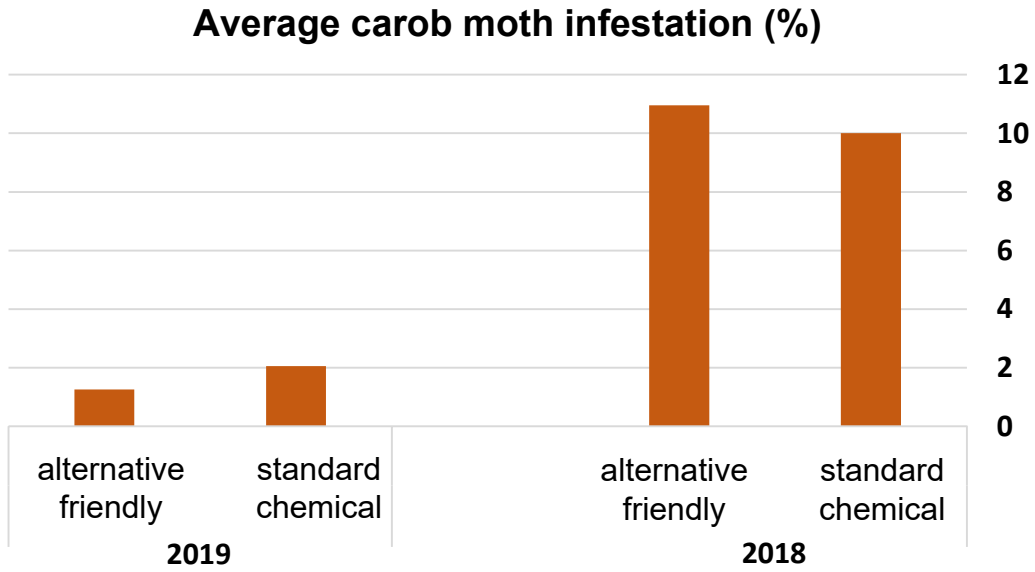


Summary of the main results: developing an alternative management programme for the control of carob moth 2018—2019









Summary and conclusions

1. The results indicate that the effectiveness of controlling the carob moth is generally similar between the standard chemical management and the alternative, friendly management, which is mainly based on mating disruption and spraying with complementary “soft” preparations, such as Bio T Plus.
2. The alternative management, based on two mating disruption treatments by carob moth SPLAT and three spray applications of Bio T Plus shortly before the hull split, allows the harvest of almonds that are free of pesticides.
3. In summary, the results from our two-year research project show that:

a. The mating disruption caused a sharp decline in the number of carob moths captured in the monitoring traps.

b. The alternative management required fewer spray applications in the orchard overall.

c. The alternative management required substantially fewer harsh spray applications than the standard chemical management.

d. The level of carob moth infestations was similar in the two management strategies.

Summary and conclusions

4. We recommend further development and integration of the alternative management presented here.
5. Other important aspects of the alternative management should be examined. These include improving the monitoring, optimising the timing of treatments, evaluating other complementary and environmentally friendly preparations, expanding the pest control options in response to unusual pest population outbreaks in the orchards and their surroundings, etc.
6. The alternative management presented in the current study can serve as a model for future studies on the application of mating disruption methods in Anarsia and the use of environmentally friendly preparations.
7. Implementing an alternative, environmentally friendly management programme may allow the export of almonds from Israel in the near future.
8. We recommend implementing alternative, environmentally friendly management in all almond orchards through a controlled and gradual process that will start on a small scale and expand progressively.
9. Similar to the management of key pests in other crops, effectiveness is expected to increase with the implantation of large-scale spatial control programmes, and with a multi-year application of mating disruption preparations and integration with complementary sanitation schemes.

Acknowledgments

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Thank you for your attention!