Effectiveness of biological pest control (BPC) in Icelandic greenhouses

Yi Xi Kang

UCL Department of Geography

Background

BPC is defined as an "ecologically based pest management that uses one kind of organism (the 'natural enemies') to control another (the pest species)" (Hoddle and Van Driesche 2009). This method is often used as it reduces the reliance on pesticides and herbicides, which are known to be largely detrimental to human health, the ecosystem, and the crops themselves (Heimpel and Mills 2017). In Iceland, greenhouses are often used to extend the short growing season. In 2012, the total surface area of all the greenhouses in Iceland was 194,000m^2, and half of this was used to grow edible plants (Ragnarsson 2015). The potential for BPC is especially high in greenhouses due to the fewer number of highly specialised greenhouse pests that cannot survive outdoors in the harsh climate of Iceland.

Aim of the research

While BPC is a common practice across Icelandic greenhouses, there has yet to be a comprehensive study of the effectiveness of BPC specific to Iceland. One significant obstacle is the large number of factors that have to be considered. Even within a controlled environment like a greenhouse, the ecosystem is complex and can be affected by many factors: the type of growing medium (e.g. soil vs hydroponics), the type of crop grown, other pests present (Messelink 2012) and the usage of synthetic or organic fertilisers. The present study constitutes the first highly detailed analysis of the relationships between such factors and the effectiveness of BPC employed within Icelandic greenhouses.

Methods

Five greenhouse farms were visited from 18 June 2022 to 30 June 2022. Their locations are shown in the map below. In each greenhouse twenty plants were randomly selected, and the number of leaves, pests, natural enemies and other observations of plant damage (including those caused by fungi or viruses) were noted. Interviews were also conducted with the greenhouse owners to find out growing techniques and common pests within the greenhouses.

Results

The number of pests and natural enemies were recorded using the following symbols:

- 0: indicates absence of pest or natural enemies
- x: indicates one to five insects observed
- xx: indicates five to ten insects observed
- xxx: indicates more than ten insects observed

GH1 (Tomatoes only)

Plant height	Median no. of leaves	Population of whiteflies	Population of *Macrolophus pygmaeus*	Population of spider mites	Population of *Phytoseiulus persimilis*
0-30cm	32	0	x	xxx	0
30-60cm	61.5	x	x	x	0
60-90cm	77	0	x	x	0

Macrolophus pygmaeus is an omnivorous natural enemy of whiteflies, but there were more of the former observed than the latter. This corroborates with the information given by the owners of GH1, who observed that *Macrolophus pygmaeus* tends to overbreed and cause more damage to the tomato plants through sap feeding. While the growers have stopped using *Macrolophus pygmaeus*, the insects still find their way into the greenhouses. Another interesting observation relates to the spider mites being all found on one plant, especially at the lower parts of the plant. *Phytoseiulus persimilis* was not observed, possibly due to the small size of the mite and difficulty observing with a hand lens.

GH2 (ornamental flowers: roses, lilies, statices)

	Roses	Lilies	Statices
Aphids	xxx	xxx	xxx
Spider mites	xx	xx	xxx
Thrips	xx	x	x
White flies	x	x	xx
BPC species (colour coded to match target pest)			
Amblyseius swirskii	xx	x	BPC not used
Transeius montdorensis	xx	x	x
Orius laevigatus(thrips only)	x	BPC not used	x
Phytoseiulus persimilis	x	BPC not used	x
Aphidius colemani	x	x	x
Aphidius ervi	0	0	BPC not used
Aphelinus abdominalis	0	0	BPC not used
Praon volucre	0	0	BPC not used
Ephedrus cerasicola	0	0	BPC not used
Aphidoletes aphidimyza	BPC not used	x	x

Aphids were the biggest pest in GH2, despite the use of 5 species of predatory wasps and a predatory midge. As a result, the staff of GH2 must spray insecticides occasionally in the event of an aphid infestation, which occur often throughout the year. It is possible that the use of pesticides have led to the development of some pesticide resistance within the aphid populations. Other factors such as the lack of double-door systems could have exacerbated the problem of aphid infestation.

Whiteflies and thrips were well controlled by the 2 generalist natural enemies *Amblyseius swirskii* and *Transeius mondorensis*, suggesting high effectiveness of these BPC species.

Spider mites are still present throughout the plants, but are not as serious of a problem as aphids, with the natural enemy *Phytoseiulus persimilis* being more effective on roses than statices.

BPC is generally less effective in GH2 than GH1, although this can be attributed to a large number of factors. The usage of soil in GH2 is commonly known to be a conducive environment for thrips, while GH1 uses only peat. Furthermore, the plants in GH2 are much denser than those in GH1, allowing for the easier spread and movement of pests between plants.

GH3, 4 and 5 (edibles, flowers, tree seedlings)

These 3 greenhouses will be discussed together as they all grow a much wider range of crops than GH1 and GH2 and exhibit much smaller pest populations. The plants observed were: Sitka spruce (*Picea sitchensis*) for GH3; Roses (*Rosa* genus) for GH4; and tea-leaved willow (*Salix phylicifolia*) for GH5.

Similar among all 3 greenhouses is the limited use of BPC (only GH5 uses soil nematodes against fungus knats while GH3 and GH4 do not use any), and the prevalence of spiders, which are generalist predators. The presence of spiders indicate a large number of insects (possibly pests and natural enemies as well) which are the main food source for spiders. Despite this, pesticides still have to be used occasionally in all 3 greenhouses, as there are cases of mass infestations from invasive species. *Phratora vitellinae* is found in all 3 greenhouses despite their geographical distance and causes severe damage to tree seedlings especially *Populus* and *Salix* species. There is also no commercial BPC species to target *Phratora vitellinae* as these tree species are less economically valuable than tomatoes or ornamental flowers. As a result, less research has also been conducted in this area.

Polyculture (having many different species of plants) as compared to monoculture might be an effective way of reducing pest populations too, as GH3, 4 and 5 all plant multiple species within their greenhouses. The presence of multiple species of plants confuses the pests and attracts natural enemies to the greenhouse which will can on native and non-native pests.

Conclusion

The current BPC species are highly oriented towards edible crops and ornamental flowers of high value, rather than lower value crops such as tree seedlings. Further commercialisation and diversification of the BPC market could also benefit growers who adopt polyculture growing methods which are more ecologically-friendly. Increasing plant diversity around the greenhouse could also serve to attract more native natural enemies, which can suppress populations of native and non-native pests, as seen in GH4 (Messelink *et al.* 2021). There exists a large potential for further research into the use of BPC for tree seedlings, as seen from the case studies of GH3, GH4, and GH5.

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