CHAPTER 5

EDUCATION IN BIOLOGICAL CONTROL AT THE UNIVERSITY LEVEL AT KVL

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1. Competence

Why should we be concerned about education in biological control? It can be argued that most people working with this subject (scientists, extension officers etc.) do not need a particular education, but need solely a strong background in one discipline relevant for their particular approach. For example, scientists can have a background in applied entomology, plant pathology, microbial fermentation or legislation.

At many universities worldwide biological control is one among other elements to be taught at courses in applied entomology, plant pathology or weed control. Students are provided with an overview, for example by having a lecture or two on the subject. Such overview lectures are mostly closely related to the application of biological control and can be excellent introductions to the subject. Such introductory lectures will potentially stimulate students to learn much more in depth and thus to obtain real qualifications in biological control.

We believe that education at the university level in biological control has not yet reached its potential, but should be devoted much more attention as a subject in its own right. Students should get a chance not only to get a brief overview, but they should be able to understand fully the concept and practical possibilities. Also, we believe that the strict separation between biological control of pest insects, plant diseases and weeds is a hindrance for future scientists and other people involved in the protection of plants and husbandry, to develop a broad perspective on biological control. Therefore, we suggest that education in biological control should be based on a strong, broad view, and that this education should include as much as possible biological control of both pest insects (and other invertebrates), plant diseases and weeds. Education in biological control must be closely linked to the needs of the end-users, but should also include fundamental aspects.

At the Royal Veterinary and Agricultural University (KVL) in Denmark, overview lectures on biological control have been given for many years. Since 1988 our student have had the opportunity to choose courses devoted solely to biological control and thus to obtain defined competences in biological control. The first course was a laboratory course in biological control of insects, later a laboratory course in biological control of plant diseases and a theoretical lecture course in biological control of insect pests, plant diseases and weeds were added. The following describes the most important experience we have obtained over these years by having laboratory and lecture courses.

J. Eilenberg and H.M.T. Hokkanen (eds.),An Ecological and Societal Approach to Biological Control, 65–71.

Our aim is to develop an education scenario based on an analysis and description of the competences to be obtained by the participants. In other words: which kind of problems should the students be able to solve after participating in a KVL course in biological control?

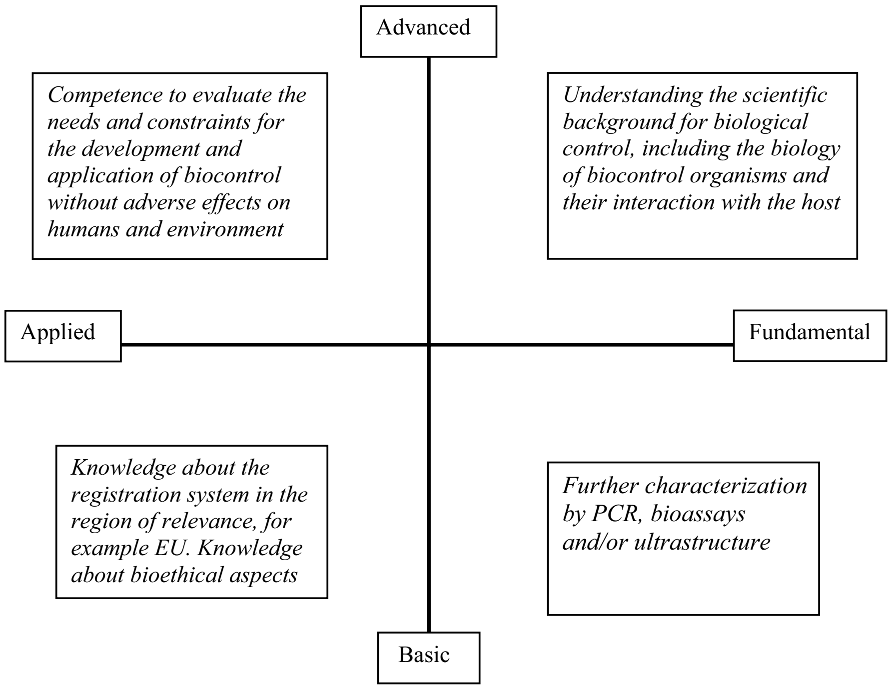

Figure 1: Competences obtained by participants in courses at KVL in biological control. See text for further explanation

On figure 1 is shown the main competences to be expected from a student who has passed our biocontrol courses. The figure is an example on the KVL implementation of the ideas of the sociologists Pierre Bourdieu and Emile Durkheim (Høyen, 2003). All course responsibles at KVL must nowadays describe the competences obtained by participants. Based on the diagram teachers are able to implement lectures, exercises, discussion and other activities, which together ensure that the competences are actually obtained.

The upper left corner on fig. 1 gives information about the most significant competences obtained in our courses in biological control. The competences are acquired at an advanced level and with the focus on applied aspects, since biological control should relate to applied problems of real significance to man. Our aim is thus to ensure that students can analyse the needs and constraints for the development of biological control. Further, students should be able to do this with sufficient ecological care and without adverse effects on man (producers, end users, and consumers). These qualifications must be obtained by advanced lectures detailing scientific problems, student analysis of primary scientific literature, in both cases with discussions among the participants and teachers. Also, students should on their own seek information about practical experiences with selected biocontrol agents.

The competences should also be based on experimental work in the laboratory. Such laboratory work should at the best be a progression of a project rather than a series of prefabricated exercises. Students should develop their own experimental approach using their supervisor as consultant.

The upper right corner gives information about competences at a high level, although more fundamental. Students must understand the basic biological interactions between for example target insect and predator or plant disease and antagonist. They must acquire the elementary glossary on population ecology, infection processes and other subjects of particular relevance for biological control. In our courses in biological control, these elements are integral parts of lectures and student group discussions.

In the lower left corner are shown elements, which are parts of the education in biological control, but at lower levels. Students are expected to have some level of knowledge about these elements but not sufficient to analyse complex situations. For example, a lecture will provide students with information about the registration system for microbial control agents. Students will learn about the status in EU (or elsewhere), but are not expected to have a competence in EU legislation.

Finally the lower right shows some additional benefits for students attending our courses in biological control. They learn at a fundamental level about biological characters of some major taxonomic groups of biocontrol agents, and they get experience about the correct behaviour in a laboratory when performing scientific studies. The latter element can be regarded as general and can of course be obtained in other courses not related to biological control. Yet, experimental work in biological control will add to the total student competence in laboratory work and how to progress.

2. The student's background

Our courses are held in English and are attended by students from all parts of the world. This gives some additional challenges. First, it can be hard, if not impossible, to check the level of each applicant student. We normally recommend that a student should have passed courses in applied entomology, plant pathology and/or microbiology. In reality, however, students from foreign universities have various backgrounds with more or less emphasis on elements we regard as important. This is not necessarily a problem and we have experienced that it can sometimes be regarded as an advantage that students have complementary skills when starting.

Depending on the region of origin for a student, they know specific insect pests and plant diseases. Since our courses aim to cover general aspects and not region-specific problems, we advise often the students to pay attention to the general aspects and not species-specific aspects. Biological control of aphids, for example, has something in common worldwide, irrespective of the specific aphid species in focus.

Cultural differences among students do also exist. Some students are already familiar with group discussions and mutual analysis of problems (in general or for example through specific methods like '*problem based learning*') while others have no such experience. To challenge the cultural differences the teachers are active and often decisive in the formation of student teams to ensure a sufficient mixture in each case.

3. The conceptual framework

Many textbooks on biological control do not provide the reader with a conceptual framework. This is urgently needed before starting any course in biological control. We need to define, how we understand biological control and which elements are parts of or are not parts of biological control. We need as much as possible to homogenize terms and to understand discipline specific terms, for example terms used in plant pathology while not in entomology.

For this purpose we use the first session in our theoretical course to discuss the conceptual framework with the students. They need all to understand exactly what is biological control and what is not. Table 1 is a list of terms we give the students. In groups of four to six the students are asked to organize these terms by cutting and pasting (by paper and tape or by computer). First, they should define what *biological control* is part of, namely *integrated control*. They should learn that biological control and *biocontrol* are synonymous. Then, they should find the core elements included in biological control, for example organisms like *parasitoids* (used in entomology) or terms like *suppressive soils* (used in plant pathology). Then, they should discuss and define how biological control is related to terms like *organic farming* and *risk assessment*. Last, but not least, they should learn which terms are not at all defined in relation to biological control but merely reflects a vision, for example the term *environmentally friendly control*. It is on purpose that one or more squares are left blank. Some students may find that some terms are missing and can suggest these to be added. Student put up their solutions on cardboard posters or they upload files on the Internet. Each team presents their solutions to the other teams and to the teachers, the suggestions are discussed, and a consensus is decided.

Table 1:

Students exercise to learn about terms of relevance for biological control. The students get an unorganised list of the terms. Groups of students must then organise the terms in order to clarify the definitions and their relationships

Biological control	Biocontrol	Environmentally friendly control	Genetically modified organisms
Induced resistance	Microbial inoculants	Antagonists	Non chemical control
Bacteria	Virus	*Bacillus thuringiensis*	Predators
Fusarium	Protozoa	*Pseudomonas*	Integrated control
Parasitoids	Antibiosis		*Trichoderma*
Sterile males	Crop rotation	Suppressive soils	Fungi
Natural control	Organic farming	Nematodes	Risk assessment

We find this exercise extremely useful. Each year, lively discussions take place. For example, we spend time to discuss, why biological control is not always environmentally friendly. We also spend time to clarify, that biological control is *per se* not a subset of organic farming but can be used in all types of farming systems. Finally it is challenging to discuss with the student that biological control is not at all excluding the use of GMOs. Based on these discussions all students understand the necessary conceptual framework, they use the terms the same way, and they can analyse primary literature much better.

4. Student progression in experimental work

As mentioned our aim is to allow each team of students to obtain qualifications in the progression of experimental work. The process is illustrated on fig 2, using insect pathogenic fungi (the genera *Beauveria*, *Metarhizium* or *Paecilomyces* as an example. The principle is that a group of students starts with field sampling in order to obtain some novel isolates of these fungi. The students thus learn about sampling and diagnostics of insect pathogens. Selected fungi are isolates *in vitro* and used for experimental work. The students characterize the fungi by classical morphological methods, using microscopes. The group then decides with their supervisor how to progress. Should they go for PCR characterization? Should they perform infection experiments like dose response relationships? Should they study the behaviour of the target host in relation to the fungus? Should they study autodissemination? Should they perform one replicate of several types of experiments, or should they focus on very few types of experiments, but with more replicates?

The students must throughout the course perform experiments, evaluate, analyse and take decisions about the next experiments to be done. This is often not easy, and students need guidance and support, yet still allowing the progress to be decided by the students, the supervisor rather being a consultant. The final report should include an analysis of own work and the perspective of the tested fungal isolates. The fact that the fungi used by the team are 'their own' isolates never studied before is of major benefit. The students learn really how to work with biological control from nature (or cropping system) to laboratory and back to nature (or cropping system) again.

The example on fig 2 is related to insect pathogenic fungi and the ecological cycle of such organisms. The subjects of student teams have, however, covered a very broad range of organisms: Bacteria (*Bacillus thuringiensis*), predators (*Orius*, *Anthochoris* etc), parasitoids, and nematodes (*Steinernema*). The approaches have also different: student teams have focussed on behavioural aspects, morphology, bio-assays or genetically characterization. Some student teams have been involved in quality control experiments in co-operation with biocontrol companies. Concerning student groups involved with experimental work in biological control of plant diseases they will focus on selected problems, for example the efficacy of *Clonostachys* to control leaf spot.

The balance between elements planned by the teachers beforehand and decisions taken by the students as part of their progression is crucial. Obviously, some elements must be ready before the course starts: some insects, some plants, some biocontrol agents, some petri dishes, and some description of methods. The students should, however, be encouraged to be innovative and develop their own ideas and ask for additional support by the teachers. For example, we can add electron microscopy if wished by a group, but the students must define first why they want this element added. For example SEM can be a nice tool to study the mandibles of predators and by this students obtain a deeper understanding about attack and handling rates of the organism studied.

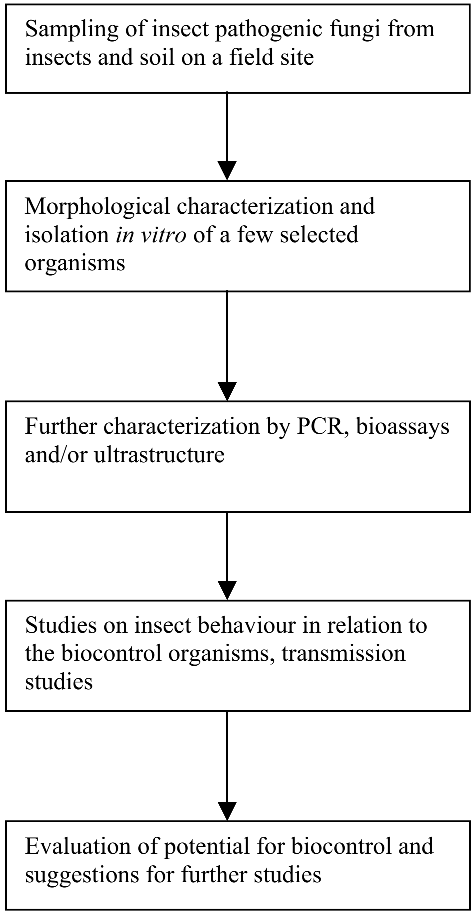

Figure 2:

An example of progression of a group of students performing experimental work in biological control

All in all, the student work tends to be as scientific as possible under the circumstances given. The examination reflects this. Students present their findings in a short and concise report (Student reports 1988-2004), a proceeding manus similar to the style used in IOBC, or as a poster. In all cases they present and discuss their results with the other teams and the supervisors.

Obviously this sort of student work in the laboratory has some drawbacks. Each team of students will only get the chance to work with a very limited number of organisms and with a limited number of methods. We feel, however, that student can easily extrapolate and learn species-specific methods afterwards, when needed. It is more important that they have obtained qualification in biological experimental work related to biological control and have a realistic idea how such progression takes place. Based on this they have competence to analyze realistically the potential of new biocontrol agents.

5. The future: internet based teaching or 'hands on'?

In 2004, we tried for the first time to incorporate elements in our lecture course as e-learning. The Internet gives new challenges to education in biological control. We see e-learning as particularly useful for education in biological control.

First, biological control is not solely a biological discipline but includes political and ethical aspects. Such aspects can be presented and discussed on Internet conferences among student from different parts of the world, since such principles are universal. An example from autumn 2004 was an exercise devoted to *visions and limitations* of biological control. The activity was set up as a web-conference for students and teachers. The students were located home or at computers at KVL and were asked to suggest visions and limitations on a special set up designed for this purpose. The suggestions were grouped and discussed, by use of the web.

These novel possibilities will be incorporated in our courses in the future. These new aspects are obviously needed in the future world of seeking information on the web and communicating by use of the web as well. We feel although that 'hands on' in the laboratory, will still be essential for obtaining competences of high value. Also, we feel that face-to-face discussions are important and will stay important.

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