

XII Results of crop protection trials in minor crops in 2019

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In 2019, the minor crops group at AU Flakkebjerg carried out 79 field and greenhouse trials. The group's activities are characterised by covering not only many different crops but also a variety of pests including weeds, diseases and insect pests as well as plant growth regulation. The research activities also involve many different stakeholders and the trials financed by various levy funds, GUDP, agrochemical companies and various private partners. The Swedish minor use project under LRF has also been a major contributor and collaborator in the past few years.

The range of traditional synthetic pesticides has for several years become less and less and this development is very evident in minor crops. Denmark belongs to the EU Northern Zone and the market for pesticides in this zone is small and the agrochemical companies show little interest in minor crops. Therefore, we often experience that if a pesticide does not have an authorisation for a major crop that ensures a certain sale, there is a risk that it will be withdrawn from the market. In other cases, it is often seen that products up for re-registration only apply for the authorisation in the major crop although it previously was used in both major and minor crops.

Because of this, the group's activities have become increasingly characterised by the growing interest in microbial products and other alternative products – an interest shared by the industry and certain companies. There is also a great interest in products which have an effect on pests but which are not registered as crop protection products. This includes products on the basic substance list but also, for instance, fertilisers, plant elicitors, enhancers or biostimulants. Within weed control there is an awareness that the times when chemistry could handle everything are over and that it is necessary to supplement with other forms of weed control.

However, the testing of chemical solutions is still the major activity in the group, and a summary of the most important activities is presented below.

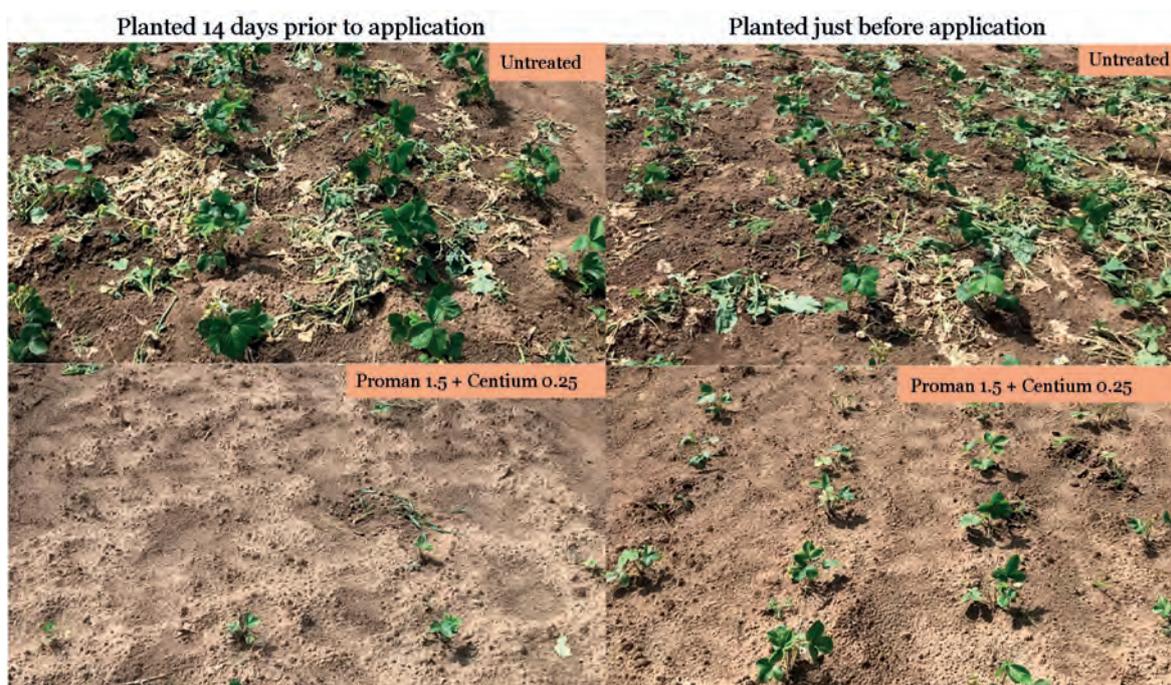
Weed control in vegetables and strawberries

Most of the trials on weed control in vegetables were a continuation of the trials from the previous year with minor changes compared to the previous study plans. The majority of the weed control trials in 2019 were once again carried out as part of the Swedish minor use project under LRF.

Especially the Swedish onion and carrot growers have been severely affected by the limitations in the range of herbicides. The loss of Stomp and Totril has been a theme in the trials for some years. But whereas we in Denmark still have access to Stomp, and Totril has been replaced by Xince (bromoxynil), the situation in Sweden is different as Stomp and bromoxynil products are banned, and no emergency uses for these products are permitted anymore. Furthermore, the dose rate of Fenix has been significantly reduced to a maximum rate of 0.9 litres per hectare, which is considerably less than the dose rate previously permitted for use in crops like carrot and parsnip. In 2019, the herbicide strategies in onion without Stomp and bromoxynil proved to be quite efficient, although phytotoxic effects on the crops were observed.

The Danish activities on weed control in vegetables and berries have mainly been carried out as part of the GUDP project HORTPROTECT including work with direct sowing and strip tillage in celeriac and strawberries. Another element in the project is testing of 'row-differentiated' weed control, that is to say different weed control within the row (intra-row) and in the space between the rows (inter-row). The testing includes a dual band sprayer allowing intra-row spraying with a selective herbicide and at the same time making a shielded inter-row spraying.

The Swedish strawberry growers are also affected by the very limited availability of strawberry herbicides. Based on earlier experience, a demo trial with two soil-applied herbicides that are authorised in potatoes and oilseed rape – Centium and Proman – was established in order to demonstrate herbicide selectivity in strawberries. The results suggest that the two soil-applied herbicides can be used up to approximately 7 days after transplanting, but if the application is carried out later, there is a risk of severe damage to newly established strawberries.



Photos were taken 13 June (36 days after application) of a strawberry demo trial with soil-applied herbicides. A tank mix of Proman and Centium caused very severe damage to strawberries planted 14 days before application, but the same treatment was safe when applied just after transplanting of frigo strawberries, while they were still relatively dormant. The photos were taken two days after hand-weeding, and weed debris on the soil surface in the untreated plots gives an indication of the weed pressure and it is very clear that a tank mix of Proman and Centium can be considered a very effective weed control when applied just after transplanting. Field trial at Löderup, Sweden 2019.

Weed control in horticultural seed crops

Denmark's status as the world's largest producer and exporter of spinach seeds is the background why the industry is continuously on the lookout for new herbicides or novel ways of controlling weeds. An urgent issue is the ongoing search for a replacement for Asulox, which is a key herbicide in spinach cultivation. The future of phenmedipham – the active ingredient in Betanal – is also uncertain as it is up for renewal of its authorisation, and this has also influenced the herbicide trials in spinach. In 2019, a fairly large matrix trial was carried out in spinach where different herbicide treatments were applied across spinach rows sown at different timings, thus allowing us to evaluate the selectivity of the different herbicide treatments at different growth stages. Apart from spinach, different weed species were sown in rows in for assessment of the efficacy of the treatments. Besides a number of other trials in spinach, weed trials in 2019 were also carried out in pak choi and cress for seed production.

Herbicide screening trials using a ‘small plot’ sprayer in onions, carrots and strawberries

A specially designed sprayer for ‘small plots’ allows us to screen a large number of different herbicides in a relatively small area. The area of each plot is usually 1 m², and it is a very efficient way of screening herbicides before including them in future large-plot field trials. A few candidate herbicides were identified in the onion and carrot trials that will most likely be tested in the larger scale field trials in the future. The small plot sprayer was also used to mimic an inter-row application in newly established strawberry bed systems with plastic in order to screen a number of known soil-applied herbicides. The need for these trials in strawberries is due to the ban of diquat that has been used for inter-row weed control in strawberry (for more about alternatives to diquat, please see the next paragraph).



Herbicide screening trials using ‘small plots’ – an efficient way of screening herbicides before including them in traditional large-plot field trials. This photo was taken just before pre-planting application of soil-applied herbicides in strawberries in newly established bed systems with plastic. The idea behind the use of soil-applied herbicides is that it will reduce the need for weed control once the strawberries are planted. Field trial at Osted 2018-2019.

Alternatives to diquat

Diquat is banned in the EU from 4 February 2020 due to concerns related to the exposure of bystanders, residents and birds. Diquat is widely used in minor crops for weed control and as a desiccant before harvest. Diquat is used pre-emergence in a number of seeded vegetables and as a shielded band (inter-row) application in plant nurseries, Christmas trees, pome fruit and berry bushes. Diquat is also widely used as a desiccant in vegetable seed production.

Growers of horticultural seed crops and certain horticultural crops will be greatly affected by the loss of diquat. A few grower organisations have initiated activities both to look for alternatives to diquat and to gather the necessary knowledge and data required for an application for an emergency use of diquat.

The minor crops group participated in a field experiment that provided important data about spray drift when using diquat with boom and shielded sprayers. These data will be used to support applications for an emergency use of diquat where no alternatives are available to diquat.

In 2019 the minor crops group also carried out a few trials with alternatives to diquat in pre-emergence of seeded onions, carrots, parsnips and a seeded nursery crop – oak. A trial with alternatives to diquat as a desiccant in spinach for seeds was also carried out. A few products were identified as having similar properties as diquat, but the alternative products cannot exactly replace diquat. Currently, there are unfortunately no alternative products that can act as quickly and as efficiently as diquat.

Christmas trees – glyphosate free weed control

Denmark is the leading exporter of Christmas trees in Europe. Germany and France are the two largest export markets accounting for more than 50% of the Danish Christmas tree export. Some importers in both countries are requesting ‘glyphosate-free’ Christmas trees, and as the future of glyphosate in the EU is uncertain, there is also among the growers an increasing interest in Christmas tree production without glyphosate. Currently, glyphosate is a very important herbicide in Christmas tree production and 5 different uses are authorised in Christmas trees including spring and autumn applications (over the trees before and after bud burst, respectively) and as shielded application after bud burst.

The Danish Christmas tree Association’s research fund has granted a two-year project to look for alternatives to glyphosate where a number of herbicides used in cereals, maize, potatoes and vegetables were tested in 2019 for efficacy and selectivity to the Christmas trees. The project was initiated in 2018 and a lot of valuable data were collected in 2018-2019. Many of the tested herbicides provided very good weed control. However, most of the products control a far narrower range of weeds than glyphosate, and in some cases it is necessary to use a combination of different products in order to achieve the required level of weed control.

Surprisingly, there were very few occasions in the growing season 2019 when phytotoxic damages were observed on the Christmas trees. After evaluation of the efficacy and selectivity data and the costs of herbicide treatment, new trial plans have been designed for the growing season 2020 where different weed control strategies without the use of glyphosate will be tested.

Control of fungal diseases in vegetables

Apart from the number of trials carried out for agrochemical companies, the trial portfolio of 2019, in line with previous years, included a number of trials conducted for growers’ organisations focusing on current challenges and topics. One issue that had been on top of the agenda of both the Danish and Swedish onion growers for some years now is finding alternatives to Acrobat (dimethomorph + mancozeb) for control of downy mildew of onion. The extraordinary warm and dry weather in 2018 created very unfavourable conditions for fungal diseases and in many fungicide trials no or only very minor attacks developed. This includes trials where it was attempted to establish disease through artificial inoculation. Several of these trials were therefore repeated in 2019. This also applied to the trials with the objective of finding alternatives to Acrobat. With some delay, when warm and dry weather in July was replaced by more favourable conditions in August, and after transplanting diseased plants into the trials, a high level of downy mildew developed in the trials. The high disease pressure put the alternatives to a hard test, and only a few strategies came close to matching the Acrobat-based strategies.



Severe attack of downy mildew in onion (*Peronospora destructor*). Field trial at Flakkebjerg 2019.

Control of fungal diseases in spinach for seed production

Fungal diseases can have a great impact on both quality and yield of spinach for seed production. In the growing season 2019, the area of spinach for seed production approached 12,000 hectares and being a high value crop, proper control of fungal diseases can be of major economic importance. Since 2016 work has been going on to develop strategies including other active substances than the few currently authorised fungicides for spinach. Current practice consists of strategies with a relatively high input of pyraclostrobin and boscalid, two fungicides with a high inherent risk of evolution of fungal resistance. The work was carried out in collaboration with Frøafgiftsfonden and started in 2016 with one trial followed up by three trials each year in 2017 and 2018. Due to the warm and dry summer 2018, no data were collected and the trials were repeated in 2019 with the continued focus on finding other effective fungicides with the view to improve resistance management. The main target diseases developed in two of the three trials; however, symptoms were at a very early stage suppressed by wilting prompted by an unknown cause, which challenged the conduction and conclusions of the trials. The results did not provide a clear answer regarding alternative fungicides; however, some new products could be relevant to be studied further.

Plant protection trials in greenhouse cultures

At the request of the Swedish minor use project, the work to find alternatives to Cycocel as a plant growth regulator in greenhouse cultures continued with three trials in 2019. The trials were carried out in *Osteospermum*, white marguerite and zonal pelargonium. Compared to the initial phase of the project with screening of a wide range of products, the plans for 2019 included a few promising candidates selected on the basis of results and experiences from the previous years. The objective of the trials was to optimise efficacy and minimise phytotoxicity. The latter is of significant importance, as ornamentals are subject to restrictions with close to zero tolerance regarding phytotoxicity.

Alternative plant protection products for disease and insect control in pot plants

One of the activities of the GUDP project HORTPROTECT focuses on improving the use of microbial-based plant protection products greenhouse and vegetable production. In 2019, six greenhouse trials covering control of insects and fungal diseases were conducted. The trials on control of insects included green peach aphids in bell pepper, spider mites in pot roses, western flower trips in *Chrysanthemum* and glasshouse whiteflies in common poinsettia. Overall, the results did not clearly identify alternatives to the currently used chemical fungicides. A characteristic of the alternatives is a lower effect and less robustness. Furthermore, the environmental conditions and the method of application have typically more influence on the efficacy compared to synthetic pesticides, as the mode of action for these products is contact related. However, when these parameters are taken into consideration, several of the alternatives are suitable for preventative use and as part of an Integrated Pest Management strategy.



Pepper plants infested by green peach aphids (*Myzus persicae*). Glasshouse trial 2019.

Two other greenhouse trials were set up with a focus on alternative products for control of *Fusarium* in *Cyclamen* and powdery mildew in potted roses. *Fusarium* is a soil-borne disease, which is difficult to control once the plants are infected and it is considered a severe problem in ornamentals. The trial included a range of biofungicides based on different beneficial fungi or bacteria, which are acting by colonising the roots and outcompeting the fungal disease. In these trials, it was not possible to identify effective solutions for the control of *Fusarium*.

The trial on control of powdery mildew in potted roses was a repetition of a trial conducted in 2018. The trial plan was modified based on the 2018 results and updated regarding new relevant products. In contrast to the severe disease pressure seen in 2018, it was not possible to achieve a successful infestation of powdery mildew despite several attempts with artificial inoculation. The trial is scheduled to be repeated in 2020.