Difficulties with mustard as a biofumigation possibility against *Verticillium*-Wilt

C. Steen[1], K. Dillmann[2], R. Ortlieb[3]

Abstract

The soil borne pathogen complex Verticillium-wilt (V. dahliae & V. albo-atrum) is not only able to cause damages between low fruit quality and complete plant loss in worst-case, it is also able to accumulate in soils where it can survive up to 10 years. Biofumigation can be used to reduce the amount of inoculum potential from Verticillium-wilt. Therefore mustard is highly recommended and in particular the variety ISCI-99, because of its high glucosinolates amounts. But as field trials showed, especially for strawberry farmers, who want to plant Frigo plants till the end of June, the time schedule is very tight. Because using mustard as a spring pre-crop it has a seeding date of the end of March until the beginning of April and it needs at least two month for biomass production and till flowering. Especially this stage of development is important because at this time the biomass contains the highest amounts of glucosinolates. Because of disadvantageous whether conditions the seeding date for mustard can be delayed which can cause less biomass than needed and therefore also less amounts of glucosinolates. If mustard is used the farmer has also to be aware that insects could attack the mustard and cause major damages which will result also in less amounts of glucosinolates. Especially in climate regions like Germany biofumigation right before planting Frigo strawberries seems to be quite difficult. Not only that the cultivation schedule for mustard and strawberries can be very tight. Furthermore the time from April to July is the time of the year with the highest work load for the farmer. So if biofumigation with the additional work and the crop itself doesn't fit into the farmers system another solution than biofumigation has to be found.

Keywords: *Verticillium*-Wilt, Biofumigation, Mustard, Strawberry

Introduction

After a few years of cultivation dicotyledonous plants like strawberries soil can be highly infested by *Verticillium-Wilt*, which is a pathogen complex of *V. dahliae and V. albo-atrum* (Babadoost, 2001). This soil borne pathogen is one of the most serious pathogens in strawberries because it is able to accumulate in soil and to survive there up to 10 years as microskelrotia (Neubauer, 2005) and lasting mycelia (Hoffmann & Schmutterer, 1999). And because in organic farming the possibilities to reduce pathogens like *Verticillium* are very limited the opportunity to plant mustard as a pre-crop as a biofumigation possibility gives farmers the chance to get back the fields they have already lost to *Verticillium*-wilt. But therefore a cultivation management has to be worked out which gives in this case especially strawberry farmers an overview about time and work schedules, which on-farm equipment is necessary and especially the extra workload at the busiest time for strawberry growers.

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Material and Methods

Frigo strawberry plants with brown mustard (ISCI-99) as a pre-crop for biofumigation:

Brassica like *B. juncea* (brown mustard) can be used for biofumigation to reduce soil borne pathogens like the microsklerotia from *Verticillium dahliae* on infested fields (Michel, 2008). As figure 1 shows, *B. juncea* has to be sown by the end of March until the beginning of April and has to be in the field for 6-8 weeks (Michel, 2008). This period of time is necessary for biomass production and to reach the development stage of right before flowering (Michel, 2008). At this point the mustard cells contains the highest level of glucosinolates and has to be broken down at the cellular level, incorporated in soil, back compacted and watered as soon as possible (Kirkegaard & Matthiessen, 2006; Michel, 2008) which is also shown in figure 1. Due to this treatment the released glucosinolates are transformed by enzymatic hydrolysis to isothio- and thiocyanates which are volatile and toxic (Michel, 2009; Matthiessen & Kirkegaard, 2006). Because of the lack of oxygen if lots of organic material has been incorporated there has to be at least one week in between before planting Frigo strawberries (Michel, 2008).

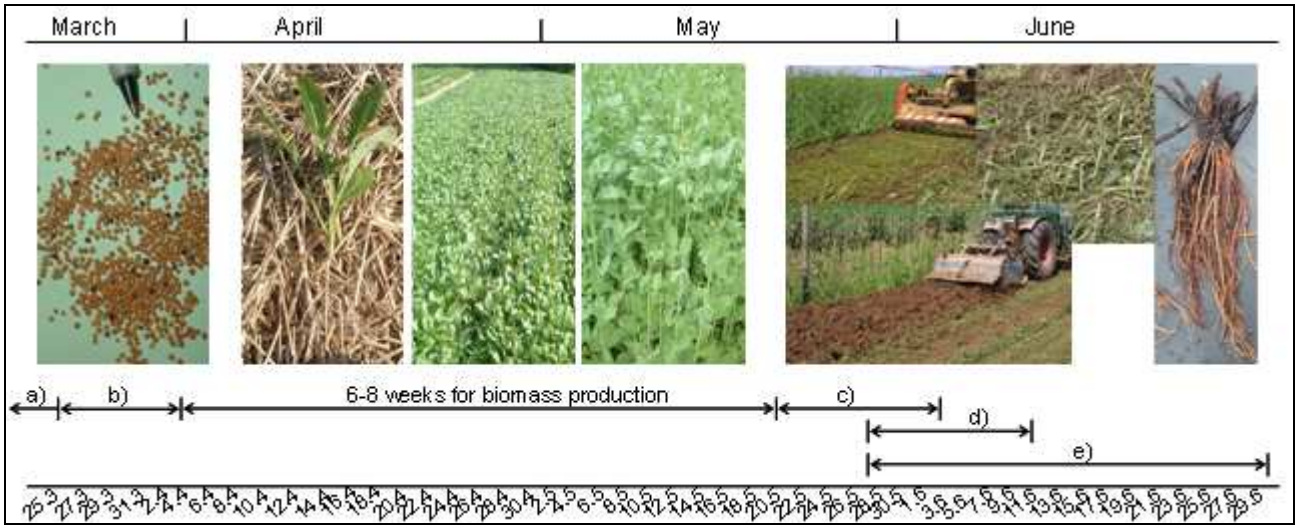

Figure 1: Time and work schedule for planting Frigo strawberry plants with the biofumigation option *Brassica juncea* (brown mustard) used as a spring pre-crop. **a**: seedbed preparation, **b**: sowing mustard, **c**: cutting, chopping, incorporation, back compaction mustard at stage of right before flowering, **d**: at least 1 week between incorporation and planting strawberries, **e**: planting Frigos till the end of June (pictures by C.Steen & K. Dillmann).

Results

Integrating biofumigation in the farming system as figure 1 for mustard in combination with Frigo plants shows has not just to meet several requirements. Because of the tight time and working schedule, which is also shown in figure 1, biofumigation can be quite difficult to realize for the farmer. Figure 2 gives an example from a practical field study which started in spring 2009 what kind of disruptions can happen during mustard cultivation. As figure 2 shows, the date for sowing brown mustard can be affected by several disadvantageous weather conditions. These can be long frost periods, too much rain or periods of dryness. Factors like these can cause a delay in sowing or germination so that a) the mustard needs more time for reaching the stage of flowering or b) it must be chopped down before the mustard reaches flowering. More time for the mustard can cause a delayed strawberry planting date which is not acceptable because it will negatively influence the upcoming yield amount. The other possibility, chopping down the mustard

much earlier than recommended will cause a lower amount of glucosinolates which means a lower isothiocyanat concentration compared to the concentration which is needed to kill and reduce microsklerotia of *V. dahliae* in the soil.

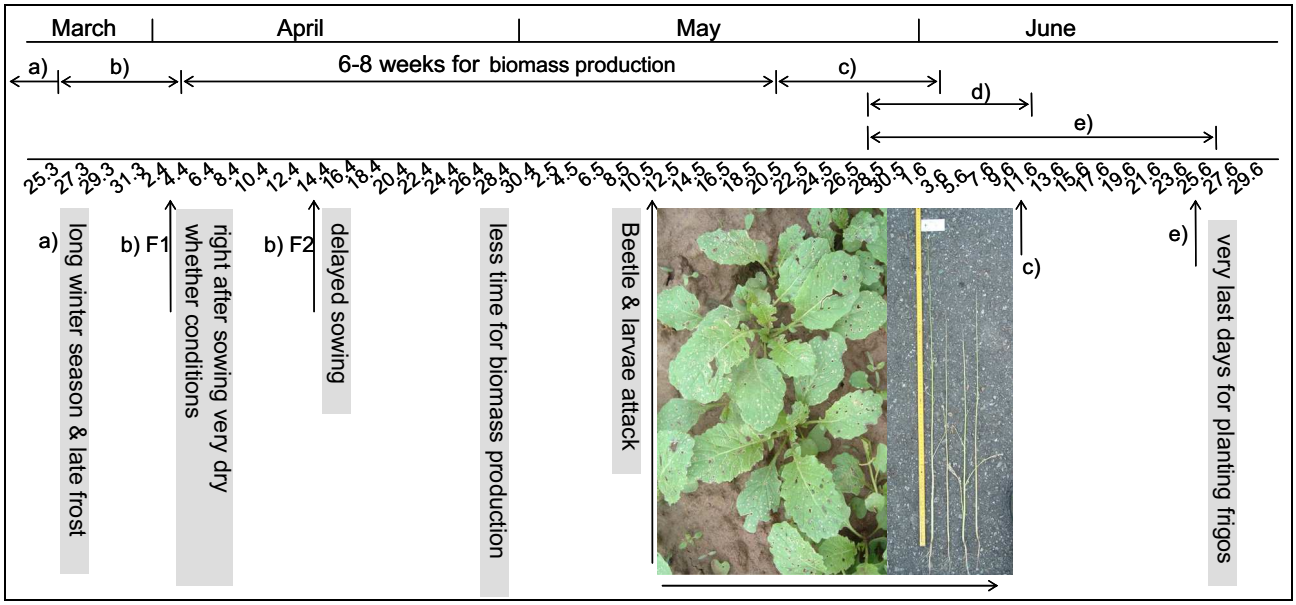

Figure 2: Time and work schedule in combination with some disruption possibilities using mustard for biofumigation as a spring pre-crop for Frigo strawberry plants (**F1**: Field 1, **F2**: Field 2, **a**: seedbed preparation, **b**: sowing mustard, **c**: cutting, chopping, incorporation, back compaction mustard at stage of right before flowering, **d**: at least 1 week between incorporation and planting strawberries, **e**: planting Frigos till the end of June) (pictures: C. Steen & K. Dillmann).

Another effect which reduces the required amount of biomass and therefore the glucosinolate amount can be caused by insect attack. Typical rape and mustard insects like *Psylliodes chrysocephala* (stem flea beetle) or *Meligethes aeneus* (canola beetle) can cause high damages and loss of biomass.

Furthermore there is the extra workload which could not fit into the present time & work schedule which could cause an insufficient crop management like:

- chopped biomass lays for hours on the field before it is incorporated which causes the loss of isothiocyanates because of its volatile characteristics.
- at strawberry harvest season, when time is the limited factor, the farmer could easily miss the development stage of right before flowering and misses the ideal incorporation point.

These quite important examples in case of mustard in combination with Frigo strawberries have to be considered by the farmer before money and time will be spend in biofumigation.

Discussion

As Michel (2008) showed, biofumigation brings a lot of advantages like structure improvements, nitrogen fixation and decreasing germination ability of different weed seeds. But to get all these advantages the biofumigation has to fit right into the farming system (Matthiessen & Kirkegaard, 2006) otherwise the expected efficiency can not be reached. Sometimes biofumigation can fit easily just by replacing an existing green manure (Matthiessen & Kirkegaard, 2006) but in case of Frigo strawberries many difficulties can occur like field trials placed in Germany showed. The time schedule which is very tight for Frigo strawberry cultivation (figure 1) is one of the biggest obstacles. One possibility to up tighten the time schedule between sowing mustard and planting Frigos could be offered by the wide variety of phonological and morphological diversity within the

Brassicaceae (Matthiessen & Kirkegaard, 2006). Indeed *B. juncea* is highly recommended (Michel, 2008) but this variety is more adapted to the climate of the middle and south of Europe and is maybe not able to produce the same amount of biomass in Germany which is needed for a successful biofumigation. Which shows that climate is a very important point of interest which has to be considered. However for biofumigation in Germany other mustard varieties have to be chosen. But these varieties have to produce at least the same amount of biomass than the recommended varieties just in a shorter period of time for up tighten the time schedule. In addition the variety has to produce enough toxic substances like glucosinolates to kill the microsklerotia. Another way to up tighten the time schedule could be the change from Frigos strawberry plants to green plants or potted plants which can be planted by the end of June until mid August instead of until the end of June (Schmid, 2003). Unfortunately as far as the situation in Germany is at the present time, it is quite difficult to get these from organic propagation and often times with a very limited choice of varieties. Additionally there are the facts that especially potted plants are more expensive than Frigos and growers often times just prefer Frigos. Furthermore there is the difficulty with the susceptibility of mustard to several insects in Germany (Böhm, 2009). If the insect pressure is too high the farmer should consider other possibilities than biofumigation because using pest control would not be just unacceptable expensive (Matthiessen & Kirkegaard, 2006) it would take again the farmer's time and money.

These points are just the most important difficulties for strawberry growers. More work for moderate climate regions like Germany has to be done to get results and robust work schedules which will convince growers to invest into the biofumigation system and to avoid the up build of soil borne pathogens like *Verticillium*-Wilt in their fields.

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