Growing Mustard for Biofumigation

Biofumigation is the suppression of soil born pests and diseases through the use of plants that produce inhibitory chemicals, also known as secondary metabolites. In most cases these biofumigant plants are chopped and incorporated into the soil so they can release their inhibitory chemicals. Mustard is a well understood biofumigant. Its biofumigation properties have been studied for a number of years and scientists have developed a method to fully use these properties. Mustard and most other plants from the brassica family produce chemicals called “glucosinolates”. When glucosinolates come in contact with water and a family of enzyme myrosinase, contained in plant cells, they are transformed in another group of compounds called “isothiocyanate”. It is these isothiocyanates that give mustard its biofumigation power. Isothiocyanates are also responsible for giving plants from the brassica family their bitter/hot/spicy taste. The isothiocyanate that is produced by mustard is called “Allyl isothiocyanate” (AITC). AITC is a compound that is very similar to the compound that is contained in the commercial fumigant Vapam®.

Picture provided by Cavendish Farms research division

Pest Control

When using mustard or any other crop as a biofumigant, it is important to know the targeted pest(s) and its life cycle. The biofumigant crop should be incorporated when the pest is present in the upper soil profile (15 to 20 cm). Seeding date should be planned accordingly in order for the crop to have reached maximum biomass and secondary metabolite production at time of incorporation. Mustard has been shown to control a variety of soil born pests. These include *Verticillium spp*., *Rhizoctonia spp*., *Fusarium spp*., *Pythium spp*., *Sclerotinia spp*., common scab and a range of nematodes. The use of mustard as a biofumigant has also shown a decrease in damage caused by wireworm.

Varieties

Mustard comes in many varieties but not all are equally as effective when it comes to biofumigation. Some mustard varieties produce more glucosinolates compared to others. In fact, some varieties have been bred for the sole purpose of biofumigation, for example, the “Caliente” group of varieties. Generally speaking, mustard varieties that were bred from “oriental mustard” (*Brassica juncea*) tend to have higher levels of glucosinolates.

Mustard variety	Seeding rate	Description
Caliente 199	10-12.3kg/ha (9-11lbs/ac)	Grows quickly and is typically used in spring or late summer, bred specifically for biofumigation as it contains very high levels of glucosinolates.
Caliente 61	5.6-7.8kg/ha (5-7lbs/ac)	Tolerant to drought and heat. It will not bloom prematurely when stressed; lower glucosinolate than Caliente 199; can produce more biomass under a long photoperiod summer.
Caliente 119	10-12.3kg/ha (9-11lbs/ac)	Used in Maine trials; one of the first “Caliente” varieties.
Nemat/Caliente	5.6-7.8kg/ha (5-7lbs/ac)	Can be planted in the spring; intended for improved nematode suppression; root exudates from *Eruca sativa* attracts nematodes to the upper soil profile; *E. sativa* is also an indicator plant of nematodes.

Table 1: Description of Caliente varieties with their suggested seeding rates.

Seeding Date

Mustard can be sown, either drilled or broadcast, at any time starting in spring to fall as long as there is sufficient moisture for quick germination. Mid to late summer sowing tends to produce poor and uneven stand due to dry conditions. If seeds are broadcast, it is important to roll the field in order to have good seed to soil contact to ensure quick and vigorous germination. Seeding date should be based on the pest you are targeting. Mustard should be seeded about 60 days before pest will be present in the field as mustard should be incorporated into the soil before seed

production begins. Depending on variety and growing conditions, it takes about 60 to 70 days to attain maximum biomass production.

Fertilization

In order to obtain the best results, the pH of the soil should be above 5.5. If the field has a pH lower than 5.5 the biofumigation process might not be successful. For optimal results, the pH of soil should be as close to 7 as possible. Biomass and glucosinolates are factors that are fundamental to the success of biofumigation. It is paramount to add fertilizer when growing mustard because nitrogen is important to the production of biomass and sulfur is crucial for the production of glucosinolates. Fertilizers should be broadcast prior to sowing mustard. Nitrogen should be applied at a rate of 84kg/ha (75lbs/ac) to 140kg/ha (125lbs/ac) depending on the field's history. The rate of sulfur should be adjusted in relation to the chosen nitrogen rate in a 6:1 ratio. For example, if 112kg/ha (100lbs/ac) of nitrogen is applied then the suggested amount of sulfur to be applied would be 19kg/ha (17lbs/ac).

Soil Incorporation

As the growing season unfolds mustard should be monitored for flowering. Mustard has to be incorporated into the soil before full bloom and before it starts to produce seeds for the following reasons; 1) If mustard is left to produce viable seeds there is the potential for mustard to become a weed problem the following season; 2) Glucosinolate levels quickly decline once mustard plants begin to produce seeds. Ideally, mustard should be soil incorporated before full bloom (about 2 weeks after flowering has started). In order to be successful with biofumigation the following procedure must be followed **rigorously**.

1. Soil incorporation should be done before the mustard crop has reached full bloom.
2. Soil incorporation should be done in the morning or evening. Avoiding hot sunny days.
3. Soil incorporation should be done when soil has a good level of moisture. Do not incorporate mustard when the soil is dry.
4. Prior to the actual incorporation, it is critical to chop and crushed as much plant material as possible to release the fumigant from plant cells. This can be done with a flail mower.
5. Mustard must be incorporated **IMMEDIATELY** after mowing, 80% of the fumigant gas will be released in the first 20 minutes after mowing.
6. For ideal incorporation, choose a tool that will place as much plant material as possible into the top 15 to 20 centimeters. Do not use a plow.
7. If possible, after incorporation the field should be rolled and packed to trap the fumigant gas in the soil. For small scale production systems and when possible, cover the area with a tarps to trap the gas in the soil. This will enhance the biofumigation effect.
8. Finally, once the incorporation process is complete, leave the field undisturbed for 14 days to ensure that all the plant material can break down. Attempting to plant another crop before the 14 day period has passed will cause significant crop injury and hinder germination. If soil temperature is less than 10°C, a longer post incorporation period may be required for plant material to break down

Conclusion

When managed properly mustard offers another tool to help growers control soil born pests and diseases. The use of mustard as a biofumigant is particularly interesting for organic producers. It is important to strictly follow the outlined cultural practices if you want to have any chance of success using mustard as a biofumigant. Proper chopping of plant material and soil incorporation is of utmost importance. Although mustard is a remarkable biofumigant, it has similar benefits that is expected from any other cover crop such as; prevention of soil erosion, recycling of soil nutrients, improved soil structure and maintaining soil organic matter. Mustard can also acts as a deterrent to many insects (wireworm) and pests therefore it may prevent many problems from occurring in your field. Interestingly, there are other crops that show possible biofumigation effect such as but not limited to; buckwheat, pearl millet, Sorghum-Sudan grass, rape seed and oil seed radish.