Biofumigants

Plants in the genus Brassica are commonly researched as biofumigant crops due to their production of secondary compounds from glucosinolate hydrolysis, sometimes referred to as allelochemicals, which can control or suppress soil-borne pests and diseases. Brassicas produce between 30 to 40 different glucosinolates which when combined with the enzyme myrosinase, form breakdown products with nematode suppressive effects. These compounds work through interference with nematode reproductive cycles, growth inhibition, or feeding deterrence, and direct toxicity. The bioactivity of glucosinolates and their hydrolytic derivatives has been shown in several nematode species. It should be emphasized that at this time the current research on biofumigant crops has resulted in suppressive and not eradicative effects on nematodes.

The breakdown products of glucosinolates when exposed to myrosinase, include isothiocyanates, nitriles, epithionitriles, and thiocyanates. Glucosinolates and myrosinase come in contact when plant tissue is damaged leading to formation of glucosinolate hydrolysis products. Myrosinase is not just a single enzyme but is a family or group of enzymes. The most common and predominant glucosinolate hydrolysis products are isothiocyanates (ITCs) which are the main compounds demonstrating effects on nematodes. The ITCs are highly toxic with varying volatility, can remain in soil from a few days to a few weeks, and are considered general biocides.

Brassicas are used as biofumigants most commonly through the use of green manures. Crops are typically grown in rotation with the nematode host crop and plowed into the soil at different times in the season depending on the Brassica crop and its intended target. Rotational plantings and incorporating green manures have been used to suppress populations of *Pratylenchus penetrans,* and to reduce populations of *Meloidogyne chitwoodi*. Oilseed mustard and white radish have been tested as green manure crops planted in early spring or late summer and allowed to grow for at least 8 weeks before incorporating. To maximize a more even distribution and effect of the glucosinolate byproducts, the crop should be chopped or mowed first before plowing under. Maceration of green tissues is necessary to maximize ITC release. Root-type glucosinolates may be more potent than leaf-type glucosinolates in biofumigation mainly due to the byproduct phenethylisothiocyanate, however a higher root biomass may be necessary to achieve sufficient levels after incorporation. It has been suggested that Brassica crops could be grown in association with potatoes (inter-cropping) during the first growth stages of the nematode in order to manage PCN. In Portugal, incorporation of glucosinolate containing plant extracts simultaneously to potato cultivation has been shown to suppress PCN populations.

In laboratory experiments, potato root exudates and exudates from Brassicas were tested on single cysts of *Globodera rostochiensis*. Black mustard exudates had the highest suppression of emergence (8.6% emergence). Similar effects were found when the experiments were conducted with the mustard oil allyl isothiocyanate. Exudates of black mustard, white mustard, and cress all reduced *G. rostochiensis* emergence. In a separate experiment it was again shown that decreased hatch of *G. rostochiensis* eggs occurred in mustard root diffusate when followed by exposure to potato root diffusate. Petri dish tests conducted with 2nd stage *G. rostochiensis* juveniles found that the addition of myrosinase to 2-propenyl glucosinolate released 2-propenyl isothiocyanate resulting in the mortality of nematodes after 24 hours. 100% mortality of 2nd stage *G. rostochiensis* juveniles was achieved in Petri dish tests at concentrations of 1.0mg/ml, corresponding to 6mM, with phenethylisothiocyanate, benzylisothiocyanate, and prop-2-enylglucosinolate at 16hrs, 16hrs, and 40hrs respectively.

Spacing of the biofumigant crop, moisture regime, and how nutrient availability can affect glucosinolate concentration are important considerations in properly utilizing a crop with the intent of biofumigation to suppress nematodes. Environmental conditions during glucosinolate hydrolysis may also affect the release of byproducts. Areas which require further study for biofumigation are understanding the processes and fates of the allelochemicals in soil, sensitivity of nematode species to specific ITCs, application technologies, and determination of ITC lethal concentration values for specific nematodes. The use of biofumigant crops is an option for the organic grower to suppress nematode populations if used correctly.

Research has shown that myrosinase activity and glucosinolates are preserved in cold-pressed seed meal of Brassicas. The addition of water to the seed meal results in the production of hydrolysis products including isothiocyanate. Mustard meals with high glucosinolate concentrations of 250 umol/g tissue need to be researched further for utilization as a 1% meal amendment to soil resulting in an estimated release of 500 nmol ITC/g soil based on a 20% release. This would be levels similar to commercially available ITC fumigants (517-1294 nmol/g soil).

Jack Brown a plant breeder at the University of Idaho has developed two biofumigant Brassica varieties, Humus rapeseed and IdaGold mustard, with elevated levels of glucosinolates. Agraquest of Davis, California is marketing the product Arabesque, derived from the fungi *Muscodor albus*, as a biofumigant for use on nematodes.

Factors which may affect Biofumigation for PCN are: *Globodera pallida* spends very little time during its life cycle when it is vulnerable moving within the soil, it only has one generation per season not multiple generations such as root knot, and PCN is very persistent and host specific.

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