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Biofumigants and Green Manures for Field-Grown Nursery Stock©

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INTRODUCTION

This paper considers the general benefits of green manures, cover crops, and biofumigants for the nursery industry and reviews the three green manure/biofumigant crops currently of interest to growers in Great Britain and Ireland.

It is important to understand the distinction between a green manure, a cover crop, and a biofumigant crop:

Green Manure. The soil incorporation of any crop (green or soon after flowering) for the purpose of soil improvement.

Cover Crop. Any crop grown to provide soil cover, regardless of whether it is later incorporated. The crops are primarily grown to prevent soil erosion by wind or water.

Biofumigation. Growing and incorporating a crop in a way that exploits its defensive enzymatic systems or biocidal activity, as a strategy to control weeds or soil-borne pests or pathogens.

General Benefits of Green Manures and Biofumigant Crops. These crops can help improve soil structure and moisture retention and provide a supply of organic nutrients to the following cash crops. They also help improve the diversity of populations of beneficial microorganisms.

Used as part of an integrated pest management (IPM) programme they offer: reduced risk of development of pesticide/fungicide resistance; reduction in pesticide costs; reduction in staff exposure to chemical applications; an energy source for beneficial microorganisms; an opportunity to break the pest or disease life-cycle; and direct suppression of weeds, pests, and diseases.

BIOFUMIGANTS

Mustard.

Benefits.

- Attracts naturally occurring beneficial insects during flowering.
- Root penetration aids soil structure.
- Soft seeded.
- Some types are fairly frost tolerant.
- Easy to grow.
- Produces biofumigant iosthiocyanates (ITCs) when tissues dam -aged, for example by chopping, which control a range of pests and diseases.

Mode of Action. Isothiocyanates were discovered in mustard seeds in 1840 and play a role in the plant's defence system against insects and microorganisms. They are produced in the green tissues of many members of the brassica family. When the tissue is mechanically damaged, stored glucosinolates are exposed to degrada-

tive enzymes, which break them down to produce ITCs. Synthetic ITCs include pesticide products such as metam-sodium.

Fertiliser applications can have a direct effect on glucosinolate concentrations.

Research in the U.S.A. and U.K. has shown that mustards used as biofumigants can help control pests and diseases of a range of crops including verticillium wilt, fusarium, pythium, sclerotinia, replant disease, nematodes, and slugs as well as weeds.

Caliente is a mustard variety with a particularly high glucosinate content.

Factors to Consider When Using Mustard. Mustard is best grown as a summer crop so may need irrigation during dry periods. It requires a moist soil before and after sowing. The crop can be vulnerable to brassica pests and diseases. Average seed rate for use as a biofumigant is 15 kg ha^{-1}; rising to 18 kg ha^{-1} for fixed bed crops.

The highest concentration of ITCs is in the flowers so timing of chopping and incorporation is crucial — the plants should be allowed to flower but not seed.

The green material needs to be incorporated immediately after chopping — 80% of the volatile ITCs are lost in first 20 min. After incorporation, the field must be left for 21 days before planting young crops.

French Marigold.

Benefits.

- Wide range of nematodes removed/suppressed.
- Associated rhizobacteria/fungi likely to increase and reduce nema-
- tode numbers through competitive exclusion and predation.
- Produces naturally occurring broad-spectrum biocides.
- Inter-row planting capability.
- Can be grown prior to a susceptible crop.
- Potential for diversification into flower/seed sales.
- Attracts naturally occurring beneficial insects during flowering.
- Easy to grow.

Mode of Action. Root cells react to damage by producing terthiophenes which block nematode metabolism, inhibits egg hatching and development of juveniles, and reduces nematode root penetration.

Factors to Consider When Using French Marigold. Certain species of nematode may only be controlled by a certain species of marigold. The nematicidal compound is only effective if the crop is grown in the soil requiring treatment and control ends after incorporation.

French marigolds are not frost tolerant. They require a moist soil before and after sowing. Bulk seed may not be readily available. Seed rate for use in nematode suppression is 3 to 4 kg ha^{-1}.

A combination of *Tagetes erecta* (African) and *T. patula* (French) gives the most effective nematode suppression. Other marigold species used have been shown to be too vulnerable to nematodes.

Sudan Grass.

Benefits.

- Tolerant to drought and heat.
- Deep penetrating root system can loosen subsoil.
- Significantly reduces nematode populations.
- Significantly reduces verticillium wilt levels.

- Attracts predators during flowering and beneficial microorganisms during decomposition.
- Is not vulnerable to any significant pest and diseases.
- Rapid establishment and growth is ideal for short growing windows.

Mode of Action. The growing crop releases sorgoleone, a root exudate that suppresses weed growth while tissue damage on chopping and incorporation releases of hydrocyanic acid and glucosinates.

Factors to Consider When Using Sudan Grass. Sudan grass is still used mainly as a game-cover crop in the U.K., so there has been little research into its biofumigant activity, including varietal glucosinolate levels. It is not frost tolerant and should not be grown where cattle or sheep will graze. The seed rate is high — 45–60 kg ha to improve its ability to smother weeds. Levels of glucosinolates are higher in young tissue so it should be cut twice during the growing season. Sow at higher rates to increase weed smother ability.

Pre-Planting Recommendations for All Three Crops.

1) Test soil prior to sowing to check nutrient levels — the amount of fertiliser has a direct effect on the amount and quality of organic matter produced for any green manure effect required.
2) Sow from mid-May onwards.
3) Control any early weed seed at crop seedling stage.

Approximate Costs of Seed 2006 (u.k.).

- Caliente mustard: £100 per ha (£ 6.67 per kg).
- French marigold: £456 per ha (£114 per kg) with tails or £536 per ha (£134 per kg) without tails.

Seed Suppliers (u.k.).

- Marigold: Thompson and Morgan (wholesale), Suffolk, U.K.; Sahin BV, The Netherlands.
- Sudan grass: Church's of Bures, Suffolk, U.K.; Oliver Seeds, Lincoln, U.K.; King's Seeds, Colchester, Essex, U.K.
- Caliente mustard: Plant Solutions Ltd, Surrey, U.K.