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Biofumigation : A new concept for management of soil-borne plant pathogens in organic farming

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Soil-borne plant diseases cause enormous yield losses in almost every agricultural, plantation and vegetable crops because of the wide host range of soil-borne plant pathogens. Conversely, the occurrence of soil-borne diseases is very rare in natural or undisturbed ecosystem but they are very destructive for conventional production system. Traditionally, management of soil-borne diseases was often based on the application of chemical soil fumigants like methyl bromide, metham sodium, chloropicrin etc. which was successful in managing the problem. With the realization of ill-effects of these chemicals on the environment, humans as well as animals, efforts were started to find out some alternatives to them. Soil-borne plant pathogens flourish well in unhealthy soil which is deprived of nutrition and beneficial microflora and fauna. Therefore, the key for their management resides in keeping the soil healthy with the incorporation of green manures, mulches, organic amendments and composts etc. Other alternatives to chemical fumigants are soil solarisation, crop rotations, bio-control agents and a new concept of bio-fumigation.

Bio-fumigation is a popular concept for the management of soil-borne plant pathogens in the developed countries. The term "Biofumigation" was coined by J.A. Kirkegaard for suppressive effects of different plant species on noxious soil-borne organisms that arose quite specifically through liberation of isothiocyanates from hydrolysis of the glucosinolates. It is an agronomical technique exploiting the allelopathic effect of some plants like Brassicas, sorghum, and marigold etc. These plants have some volatile defensive chemicals which are released during mechanical damage and herbivores attack (chewing) or decomposition of plant parts. In *Brassicas*, biofumigation is based on its most important enzymatic defensive systems the myrosinase-glucosinolate system. In *Brassica* plant cells, glucosinolates and hydrolysing enzyme myrosinase lies separately in vacuoles and myrosin cells, respectively. Once attacked by pests or due to mechanical damage glucosinolates from vacuoles come in contact with the enzyme. After which, glucosinolates (GSLs) are hydrolyzed by the endogenous enzyme *Thioglucosidase hydrolase (myrosinase)* at neutral pH, to release isothiocyanates (ITCs). Till now researchers have identified over 100 Isothiocyanates, 20 of which are commonly produced by *Brassicas* and known to have a biocidal effect. *Alike Brassicas,* Sorghum spp. and Sudangrass showed biofumigation effect due to the production of a cyanogenic glucoside, *p*-hydroxy-(*S*)-mandelonitrile-β-D-glucoside compound called Dhurrin. It is a substrate of its secondary defensive system that breaks down to release toxic cyanide when plant tissue is damaged. Plants of Solanaceae family *viz.,* chili and marigold etc. also produce terthiophenes during biotic attack which blocks the development and metabolism of plant pathogens.

Some fungi *viz., Muscodor albus* and *Ceratocystis fimbriata* also showed biofumigation ability and used for the management of post-harvest diseases of fruits and vegetable*. M.albus,* an endophytic ascomycetes fungus, produces 28 organic volatile compounds which together inhibited and killed various species of fungi, oomycetes, and bacteria. *Recently, C. fimbriata* has been *found to* produce a variety of volatile organic compounds (VOCs). These VOCs have strong bioactivity against a wide range of plant pathogens.

Biofumigation is an eco-friendly process and important strategy of disease management in organic production system in Europe and Australia. But biofumigation is not a familiar and popular practice among Indian farmers. In India, *Brassicas* are grown intercropped traditionally with wheat and legumes; main crops always perform better in the presence of *Brassica*. Indian farmers also follow various cultural methods like intercropping with sorghum to control wilt, crop rotations, mulching, mustard as catch crop etc. Biofumigation has good scope in Indian agriculture. Only a few studies were done in Indian condition on biofumigation and *Brassicas* like cauliflower and cabbage were found most effective in reducing the incidence of carnation stem rot to 22.28%. By incorporation of radish leaf stalks in soil 60.6 % reduction in root-knot nematode, *Meloidogyne hapla* population and 41.9% increase in celery green leaf and stalk yield has been reported. Because there`s barely literature available about the usability of biofumigation in organic vegetable cultivation in the country, this method should be researched and tested in field trials. Keeping in view the soaring rise in the cost of chemicals and other inputs year by year biofumigation could be considered as an alternative disease management strategy but more research is needed under Indian conditions to find out its usefulness to the farmers. It could be used for the management of soil-borne diseases under protected cultivation and potentially may also have a future in organic agriculture sector in India.

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