

The Science of Bio-fumigation by *Brassicaceae*

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Introduction

Interaction has been a key aspect of living systems. Whether this system is of plants, animals, bacteria, fungi and to the viruses, there is always the flow of chemicals which makes the living system dynamic. We don't see what is the language spoken of in-between, but when we actually decode it through molecular mechanism illustrations we reach at a point of conclusion that what all is living, it is chemically dynamic. To add to this dynamism there is a concept which describes itself in the term of bio-fumigation which utilizes organic matter addition to soil. The sure short definition of bio-fumigation relies on the fact of incorporating the essential release of volatile compounds with potential of nullifying the pathogen associated changes displayed by plant from the biochemically derived interaction among the bio-fumigants and the plant thus benefitted. The source of bio-fumigants dates back to plants themselves and speaking of their potential targets are bacteria to viruses which are *en core* materials of plants. So the life-to-life communication is yet another variable which is dependent on all the environmental situations present in and around. To this point the image of Brassicaceae family species is all clear about how devastating their phyto-chemicals could be to the so called obstacles of plant growth- the pathogens.

The Evolutionary Change

A pathogenic fungus when entered into an optimally active living system is hard to ward off. To tackle this while travelling through the evolutionary journey the Brassicaceae members harnessed and developed the catalytic proteins (enzymes) in-specific action to the functional group boundaries of glucosinolates (glucobrassicin) generating isothiocyanates (-allyl, -butyl, -propyl, -phenyl) which were later proven to be toxic to survival of not only fungal pathogens but also retarding the growth of almost all the living (protozoa, bacteria, insects and nematodes) and other half-alive (virus) pathogens. While possessing the chromosomal variations and point-to-different gene actions genus *Raphanus*, *Sinapis*, *Eruca*



and Brassica are important sources of bio-fumigants. Like a sound requires a medium to travel to, the path comprising the release of bio-fumigant chemicals and arrival at their targets requires the keen presence of organic matter and the kind of soil structure which supports this beautiful yet complex biochemical process.

The Human Growth

From noticing the bio-fumigant approaches to developing certain prior technologies for their generation, a large heap of researches have been considered so far in a time span of 200 years by the race of humans dedicated to Brassica. The outstanding outcomes of certain brilliant human minds have established their socially and scientific 'Intellectual Property Rights' in form of 'Patents' where they have analyzed feasible compatible biochemical interaction through technological products like pellets as well as liquid formulations.

A keen component of human survival is to meet the daily demand of food along with water and air. To get this food from plant based sources, one has to pay a price or technically grow and process it. What if one day humans cannot grow crop plants, then other ones will not be having the capacity to purchase the plant based products, technically the 'Food'. The other case scenario which is even more probable under the current circumstances of agricultural produce is the hampering of productivity, in which one grows but can't harness it or harnesses it to a level which is not desirable. Food security mission of agricultural minds has been deeply involved in enhancing food productivity by either incorporation of quantitative (yield) and qualitative (bio-fortification) parameters, or by reducing the factors which are hampering agents of food productivity.

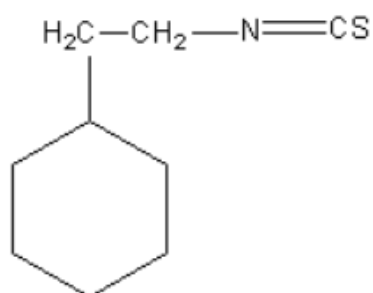
The Soil and its Inhabitants

Ultimately crop has to be produced on a soil, which gives life overall to plant but hides within certain other living creatures whose presence is meant to be avoidable by humans for better productivity. Known by name of, 'Soil born pathogens' poses a challenge in productivity of agricultural produce. So to keep plant productivity high it is the soil with which we have to deal with. In one case where one thinks of sterilizing the soil one has also to consider the depletion of organic matter content associated with the kind of soil sterilizing technique involved. The other case of improving the soil quality is that where one can provide it with additional organic matter. The presence of additional organic matter will be an ensured stimulant of microbial growth, but there is nothing less worse one can imagine if the

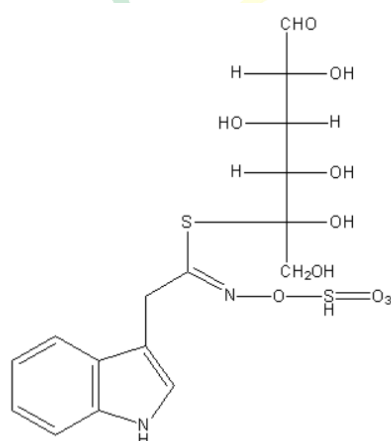
organic matter added becomes a feed and food for pathogenic microbes. Then how to justify the employment of bio-fumigation, which is in all addition of organic matter to the soil? It seems that nature beholds itself within the layers of benefit and harmful effects, one beneath the other. What nature has gifted to humans can be understood by the revealing the science behind man-made incorporation of organic matter to soil derived from plant based structures in governance of bio-fumigants thus formed. The organic matter thus provided when harnessed by machinery of microbes in soil leads to release of an array of toxic compounds and due to prolonged microbial metabolism decrease in microbial respiration oxygen level takes place which ultimately leads to death of aerobic microbes themselves.

Chemical Structures

a. Phenylisothiocyanate



b. Glucobrassicin



All of this, story revolves around pathogenic microbes whether they are protozoan, bacteria, fungi and viruses. First, they enjoy the feast of organic matter nutrients. Then due to bio-fumigants (in form of various isothiocyanates) released upon the enzymatic cleavage of

glucosinolates through myrosinase (an enzyme present in Brassicaceae species), they (pathogens) lead to their inevitable loss of life, for which a tabulated presentation has been given below:

S.No.	Host Plant	Target Pathogen	Biofumigant Source	Strategy Employed	Remarks
1.	Tomato	<i>Rhizoctoniasolani</i>	Brassica oleracea	Use of fresh residues	Reduced symptoms and increased yield
2.	Wheat	<i>Sclerotinia sclerotiorum</i>	<i>Brassica napus</i> , <i>B. juncea</i> , <i>B. campestris</i>	Macerated and dry tissues	Growth reduction and sclerotia formation
3.	Rice, Wheat	<i>V. dahlia</i>	<i>B. carinata</i>	Pellets (DSM), liquid formulation	67% efficiency using the liquid formulation
4.	Grass	<i>Sclerotinia homoeocarpa</i>	<i>B. juncea</i>	Pellets (DSM)	Reduced mycelial growth and incidence

Conclusion

Basically, utilizing the molecular machinery of them, the plants seem to have developed a war like strategy against those that harm them – the microbial and non-microbial pathogens. The glucosinolates and myrosinase are both present in cell of Brassicaceae plants but are compartmentalized, meaning they don't mix up while present in a miniature invisible naked-to-eye cell. But as soon as the plant material is ruptured through its different compartments of cell, the enzyme and its substrate (glucosinolates) gets mixed up and the isothiocyanates are produced leading to warding-off effects on plant pathogens. It is like first pathogens as invaders intruded the safety boundary of once a healthy to be plant, then made it sick by their chemical effects and then in turn the revenge was celebrated upon by the detached-dead once lively parts having bio-fumigation potential by further encountering the



elimination of same intruders which once were pathogenic to a large community of plants. Although human efforts are essential for bio-fumigation prospects to be covered, but it is all in the essence of mother-nature in whose vicinity the bio-chemical interactions of bio-fumigation seem lively.

