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A Review: Organic Amendments of Soil for Management of Soil Borne Pathogens

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ABSTRACT: The harmful effect of chemical on living organisms and loss of chemical fungicides towards plant pathogens which attracted the attention towards organic amendments of soil for management of soil borne pathogens. Application of different organic amendments like animal waste, bone meal, blood meal, vermicompost and antagonists etc suppress the soil borne pathogens (*Rhizoctonia* spp., *Sclerotinia* spp. and *Pythium* spp. etc) as well as increase soil heath too. There are various methods like soil suppression, soil solarization, bio solarization, anaerobic disinfectants and bio fumigation several and more methods in organic amendments. This review mainly focuses on application of organic amendments of soil for management of soil borne pathogens. By using of soil amendments to control soil borne pathogens is very effective in result then chemical control. While organic amendments reduce plant pathogen populations, they result in a 1000-fold increase in soil microorganism populations after implementation. As a result, pathogen displacement is selective and can last for many years in fields after a single application. we can learn more about the possible benefits of organic amendments, there's a chance they'll make a comeback as a useful tool in Integrated disease management.

Keywords: Organic amendments, soil borne pathogens, soil fertility, soil solarization, anaerobic disinfestation, bio-fumigation, soil suppression.

INTRODUCTION

In field there are several pathogens like fungus, bacteria and nematodes which causes damage at different stages of crops and also causes loss of yield every year (Liu *et al.,* 2012). Using of chemicals for control pathogen attack on crops is very famous throughout the world. But now a days the banning of pesticides uses on crops start by many countries due to their adverse effect on human health and ecosystem. These chemicals causing diseases like cancer, brain problem, heart related problem etc. So biologically controls have been taken under alternative option to chemical for control pathogens (George, 2001).

The main disease-causing pathogens are soil borne and seed borne with indicate an unbalanced soil microecosystem in soil (Avis *et al.,* 2008). Pathogens may be obligate and facultative saprophytic or parasitic which survives in favourable condition and cause diseases in the crops. If there is an unfavourable condition, they are used to convert themselves into rest stages in soil, seed and plant debris. They can survive for many years in host plant debris, seed and soil as resistant structure like sclerotia etc (Åström, *et al.,* 1988). There are many methods to control pathogens which maybe eco-friendly in nature (crop rotation, soil solarization and organic amendment in soil etc) and non-eco-friendly in nature (use of chemicals, fungicides, bactericides and nematicides etc) (Baysal-Gurel, *et al.,* 2019).

Soil borne pathogen such as *Rhizoctonia* spp., *Fusarium* spp., *Verticillium* spp., *Sclerotinia* spp., *Pythium* spp. and *Phytophthora* spp. can cause 50%–75% yield loss in crop such as wheat, cotton, maize, vegetables, fruit etc (Mihajlovi´c, *et al.,* 2017). Soil borne pathogen is responsible for around 90% of the 2000 major diseases in the crops are grown throughout the world (Mokhtar and El-Mougy (2014)). Soil borne diseases have a vast range of devasting pathogens which can cause diseases over 150 economically important crops. Due to bad effect of chemicals use in crop protection, now people start thinking about their health condition and ground water table as well as soil health condition which indirectly or directly affected by the chemicals. Now a day's people moving towards alternative method of chemicals, start using biological control methods, which control pathogens efficiently then chemicals under field condition (George, 2001).

There was not any sign of chemicals in the begin of agriculture era. At that time agriculture totally depend upon culture practices (crop rotation, deep ploughing etc) and organic manure. During 19th century, using of inorganic chemicals, fertilizers, pesticides and fungicides start applying in agriculture to control pest, disease, soil fertility etc. these activities replace the culture practices with inorganic chemicals (Hoitink and Boehm (1999); van Diepeningen *et al.,* (2006); Willer *et al.,* 2010). There are vast range of biofertilizers have been used to control disease causing pathogens mostly soil borne seed borne pathogens as well as nematodes (Ansari *et al.*, 2017b; Khan *et al.*, 2014; Akhtar and Malik 2000). Organic matter is used as soil amendments in order to maintain good health of soil. Also, incorporation of organicinputs into soil with or without any beneficial microorganisms offers pollution-free environments. Using of soil amendments to control soil borne pathogens is very effective in result then chemical control. It manipulates varies bulk microbial colonies (Lazarovits *et al.*, 2000). Organic amendments like animal manures and composts are common in agriculture. Using organic amendments control pathogens, as well as improve health condition of soil (Waksman and Starkey 1931). Composts use against various pathogens such as *Phytophthora* and rhizoctonia root rot etc is very effectiveness (Hoitink & Boehm 1999).

A. Suppressive soils

Soil is playing a major role in agriculture. Soil consists of various organic matters, inorganic matters, minerals and biodiversity of micro-organisms and macro-organisms (Fierer, 2017). Soil contains mass microbial communities which can be non-infected and infected to the crops. Microbial which are infected in nature cause huge loss in agriculture economic. But there are non-infected microbes which do not cause any types of loss or harm to crop they help in various physiological activity of plant and soil. They can also suppress disease causing microorganisms (Kariuki *et al.*, 2015). In soil there are many soils borne pathogens and microbials populations. There are some soils which is suppressive in nature towards some diseases causing pathogens and microorganisms etc (Hoitink & Boehm 1999).

Menzies was the first person who gave concept of suppressive soils. He states that the soil of Central Washington is inhibited for *Streptomyces scabies* which is pathogenic to potato and cause potato scab (Baker and Cook 1974, Menzies, 1959). Soil is a medium for various microbial population which present at rhizosphere region near to plant roots. There are some antagonistic microbial populations which control soil borne pathogens by suppressive them (Kariuki *et al.*, 2015) such as *Rhizoctonia* sp. (Ogoshi 1987), *Fusarium* sp. (Alabouvette, 1986) And *Phytophthora* sp.(Andrivon, 1994).

B. Organic amendments and disease suppression

From many yearsOrganic materials or methodsare playing an important role in agriculture. Organic material like compost, which is used frequently as a suppressive amendment agent in soil. Compost like crop residues and animal waste are effectively used against disease for suppressive up to 45% to control (Boehm *et al.*, 1997). Organic amendments affected pathogenic fungi and bacteria in different ways. Suppression may have various methods of biotic and abiotic on pathogenic microorganisms;

- Increase the amount of organic material insoil leads to decrease microbial population by releasing chemical substances.
- Organic amendments show indirect suppression by showing antagonist action toward pathogenic organisms in soil.
- Indirect suppression by balancing nutrient ability in soil, by inducing pathogen inhibitor toxic, by showing dominate competition in area, reproduction etc (Rosskopf, *et al.*, 2020).

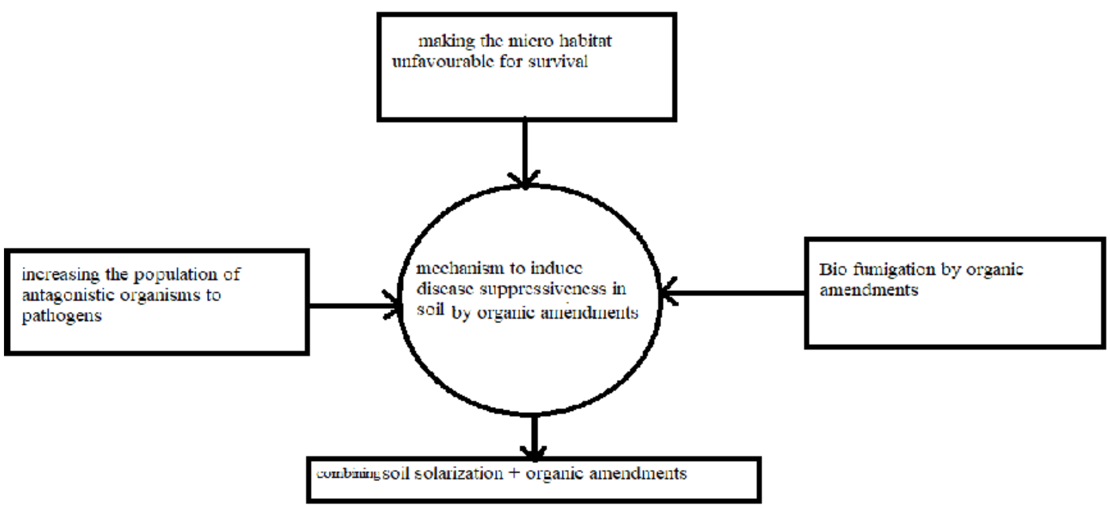


Fig. 1. Mechanism of organic amendments in soil.

1. Direct effect of organic amendments

Impacts of soil borne pathogens. In plants, cell wall is consisting of various component in which chitin is main component of cell wall. Ammoniacal nitrogen generated through decomposition of chitin (Bailey and Lazarovits 2003). Application of high-volume nitrogen containing composts are use as amendments such as vermi-compost, poultry manure and bone meal etc released nitrous acid and ammonia, respectively at low pH and high pH of soil, both of these chemical components are associated with the death of soil borne pathogens (Tenuta, *et al.,* 2002).

Effects of Organic Amendments on Soil Chemical Properties. Hao and Chang (2003) found that after 25 years of high rates of cattle manure application, the soluble ions and adsorption ratios of Na+ and K+ increased, especially under non-irrigated conditions. Another study found that, even in an area with plenty of rain, there was a chance of secondary soil salinization from successive chicken and pigeon manure applications. As a result, proper organic fertilizer selection as nutrient sources, timing, and method of application to soil can all be considered equally essential. In terms of application process, Khaled and Fawy (2011) discovered that the interaction between salt and soil humus application was statistically important, indicating that under salt stress, both soil and foliar application of humic substances increased nutrient uptake in corn fields. The uptake of N was increased by soil application of humus, while the uptake of other macro- and micronutrients was increased by foliar application.

2. Indirect effect of organic amendments

rganic amendments effect on microbial communities and plant pathogen impacts. Organic amendments are a method of organic agriculture in which soil borne pathogens cause diseases in plants or crops are suppressive by organic amendments (Bonanomi *et al.,* 2018). Organic amendments application suppresses the soil borne pathogen by increase microbial population in soil with respect to phytopathogens in soil, by created competition for nutrients, areas for inoculum, water and air etcalso released toxic substances with increase mortality rate of pathogens in soil (Van Bruggen and Semenov 2000). Such as soil borne pathogens *Fusarium sp., Pseudomonas sp* etc are effectively suppressive by organic amendments (Jambhulkar *et al.*, 2015).

Enhancements of plant resistance. On application of organic amendments in soil leads to secretion of some chemical which are toxic to soil pathogens. On the reaction of chemicals with pathogens leads to death and also make unfavourable environment for survival of pathogens. These chemicals also make crop or plant resistance toward soil pathogens because of their extreme concentration near root zone (Chitwood, 2002). Plant extracts mainly secreted by root hairs in rhizosphere which induce resistance against soil borne pathogens. Example such as root extraction of cucumber resistance to *P. ultimum* (Lievens *et al.,* 2001). Chemical extracts released by organic amendments induce resistance or suppression to soil borne pathogens, including *Trichoderma* spp. And *Pseudomonas spp*. (Cohen *et al.,* 2005), and free-living bacteria (Ali & Xie 2020) example – plant resistance to *Streptomyces spp*. (Cohen *et al.,* 2005), *Rhizoctonia spp.* (A. Wolfgang, *et al.*, 2020), Bacterial wilt disease (Qi *et al.*, 2020) and clubroot disease of *Brassicaceae* family (Castro-Moretti *et al.*, 2020).

3. Organic amendments and soil disinfestation

There are various advantages of application of organic amendments in soil which suppress soil borne pathogens by secretion of extracts in rhizosphere region of plant and it also improve fertility of soil by increasing microbial population in soil but still there are some problems in application organic amendments in cropping systems. It is more effective with culture practices like soil solarization etc. (Bonanomi *et al.*, 2010).

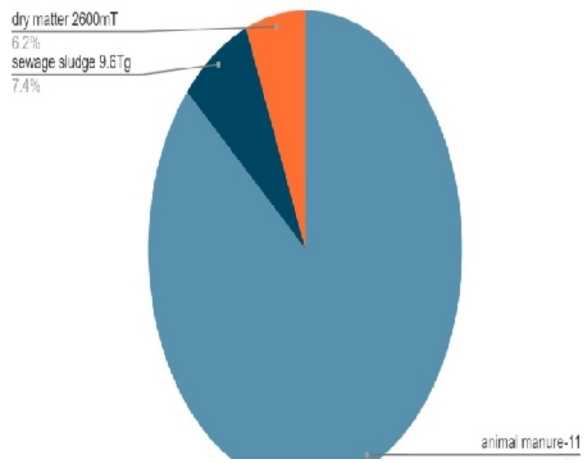


Fig. 2. Different types of organic amendments application worldwide. (Wirsenius *et al.,* 2010, Epstein, 2003).

As show in above pie chart different types of organic amendments application worldwide represent animal manure is used at high percentage followed by sewage sludge and dry matter that is 86.4%, 7.4% and 6.2% respectively (Wirsenius *et al.*, 2010) (Epstein, 2003).

As show in above chart, usage percentage of sewage sludge as organic amendment is utilized by five countries in the world that are France (which is at top at usage), Spain, U.K, Germany andItaly (Epstein, 2003).

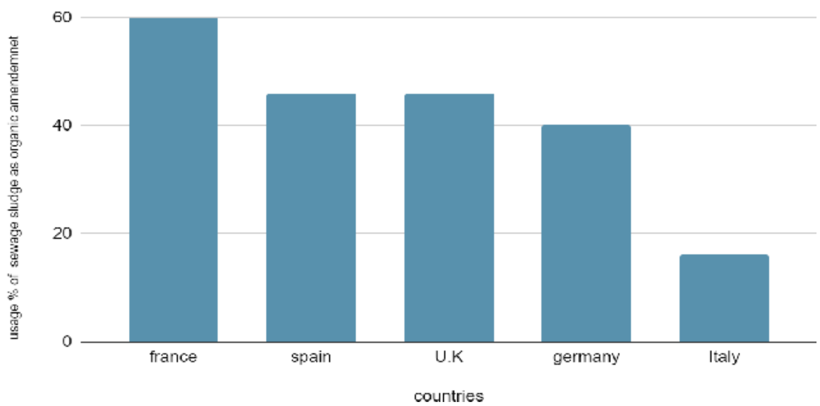
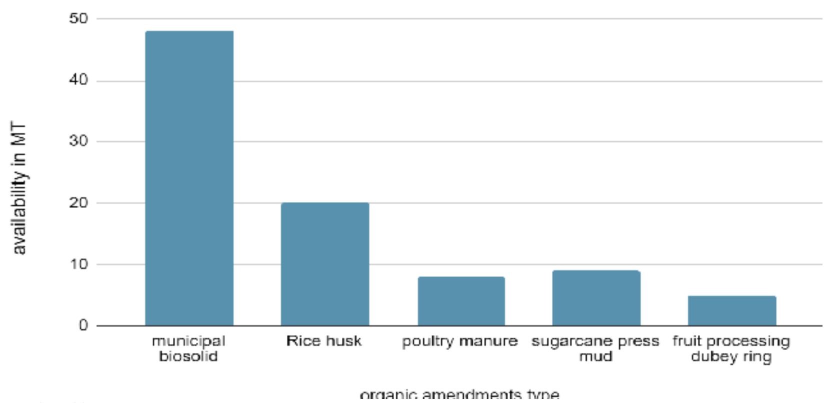


Fig. 3.



Y-axis: availability of different organic amendments in million tons
X-axis: Different types of organic amendment.

Fig. 4.

Fig. 3 representing of different types of organic amendments sources which are available for use in world as organic amendments (Bhattacharya. *et al.,* 2001). Fig. 4 representing different types of organic amendments application worldwide.

4. Bio fumigation

The term biofumigation was coined by Kirkegarrd (Kirkegaard *et al.,* 1993). In biofumigation application of bio pathogen and organic amendments directly in soil like *Trichoderma* spp., for control various soil borne pathogens like *Pythium* spp., (Mazzola *et al.,* 2015) and seed meal of *Brassica juncea* for control of *Macrophomina phaseolina* and *Prarylenchus penetrans*, (Mazzola *et al.,* 2017) respectively.

5. Soil bio solarization

Soil solarization is mostly used method of cultural practices, which is used for disinfection of soil and seeds (Stapleton *et al.,* 1985). Solarization of soil is done with the help transparent polyethylene mulch sheets. It helps in rising the temperature of soil more than environment temperature. Increasing of temperature level induce suppress of soil borne pathogens, weeds and nematodes (Gamliel and Katan 1993). Practices or application of organic amendments with soil solarization is termed as Bio-solarization (Katan, 1981). Soil solarization at the time of application organic amendments like animal manure, crop residues. On increasing in the level of heat under the polyethylene mulch which enhance rate of breakdown of compound, volatilization of compound and accumulation of compounds which suppress the soil borne pathogens (Gamliel and Stapleton 1993) such as *Phytophthora capsica* and Phytophthoranicotianae in pepper crop (Lacasa *et al.,* 2015), *Fusarium oxysporum* (Haung *et al.,* 2015), *R. solani* (Panth *et al.,* 2020).

6. Anaerobic soil disinfestations

In this method application of organic amendments leads to labile carbon with irrigated soil up to saturation point of soil which lead to oxygen impermeable trap that will affect the soil borne pathogens etc (Rosskopf *et al.* 2015). Effectiveness of anaerobic soil disinfection completely depends upon the selection of "C" source, Application of C source (t per ha), Pathogen suppression, time of application etc. It shows that "C" source is dependency of anaerobic soil disinfestation (Priyashantha & Attanayake 2021). For example, "C" Source like: Grass or potato haulms, Wheat bran, Cereal rye (Secale cereale), Mustard, Rice bran and Radish roots. Application of C source (t per ha):30, 2, 0.134, 4.9, 20 and 100. Pathogen suppressed: Ralstonia solanacearum, Meloidogyne incognita, Rhizoctonia solani, Pythium ultimum, and Fusarium oxysporum, Verticillium dahliae and Fusarium oxysporum. Treatment period (weeks): 6, 24, 4, 2, 4 and 3. (Messiha *et al.,* 2007), (Katase *et al.,* 2009), (McCarty *et al.,* 2014), (Hewavitharana *et al.,* 2014) and (Mowlick *et al.,* 2013) respectively.

7. Plant pathogen management using anaerobic soil disinfection

Anaerobic soil disinfection with organic amendments shows effective control on soil borne pathogens such as *Fusarium* spp. and *Rhizoctonia* spp. etc (Goud *et al.*, 2004). Various studies in Florida on control of *M. phaseolina* in strawberry crop is effectively control by application organic amendments followed by irrigation than drip applied fumigation (Rosskopf *et al.*, 2020).

8. Metabolites produced during anaerobic soil disinfestation and disease suppression

In metabolism, various compounds like nucleotides, enzymes, proteins etc show important role in diseases suppression with application of organic amendments and anaerobic soil disinfection with either irrigation or soil solarization which lead to breakdown of amendments in soil (Wang *et al.*, 2004). Increasing organic amendments lead to increase organic acids such as acetic acid and lactic acid which indicate occurrence of anaerobic condition in soil, which suppress the soil borne pathogens like *Fusarium* sp. Etc (Okazaki and Nose 1986)

II. SUMMARY AND CONCLUSIONS

Organic amendments application in field control soil borne disease effectively as well as increase fertility of soil by increasing organic compound in soil. From many years chemical compound is using in field increased. Which effect soil fertility, ground water, animals and human health. There are many studies which focus on organic amendments application and culture methods like solarization, anaerobic soil disinfestation which reduce the soil borne pathogens in field by culture methods. Total dependency on chemicals will lead to resistance in pathogens but application of organic amendments doesn't lead resistance in pathogen because of their board spectrum control of soil borne pathogens by increasing microbial colonies in soil, secretion of extracts, create resistance in plant toward pathogens, increase organic acid in soil which led to develop anaerobic condition in soil and creating competition with causal organisms etc. As we learn more about their potential benefits that organic amendments can reduce plant pathogen populations, but they also result in a 1000-fold increase in soil microorganism populations. When soil and biological conditions are favourable to the activation of processes that minimize pathogen survival, disease prevention with organic amendment is possible. Organic amendments can make an appearance as a valuable tool in integrated disease management.

III. FUTURE ASPECTS

Organic amendments' cost–benefit ratio needs to be explained. Understanding the mechanism of action could allow for the use of lower product prices and more sustainable disease controls that last for years. If this happens, there is a bright future with the use of amendments. Synthetic fertilizer costs are expected to rise, making their use more cost effective. They achieve ample increases in marketable yield to cover the costs of transportation, handling, and application. One issue that has come to light is a lack of manure supply. The second, less obvious drawback is that growers often overlook the fact that manures can vary greatly in composition and that manures must be checked to ensure that their C:N ratio is suitable for usage. We noticed that poultry manure that had been composted for a few days had lost both its nitrogen content and its disease-suppressive activity.

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