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REVIEW ARTICLE

Soil health and their effect on Disease management-A review

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ABSTRACT
Soil health is the ability of soil to perform as important living system, with ecosystem and land use threshold to sustain biological activity, maintain environmental quality, and also to promote plant, animal, and human health. The soil health assessment includes soil quality test kit, soil quality score cards, soil conditioning index, and soil management assessment framework which is affected and determined by recent crop and soil management practices. It is determined by physical, chemical, and biological index and the most commonly used and accepted index include physical index. Management techniques that boost soil health, including the use of crop rotations, cover crops and green manures, organic amendments, minimum tillage and soil solarization also have good effects on the management of soil borne diseases through a number of probable mechanisms. All of the important soil health-building management practices contribute to make active, diverse, disease-suppressive soil microbial communities should be used correctly for an effective and sustainable disease management. But there will always be a need for additional control methods as well as the need to respond quickly to an emerging risk, whether it is coming through pesticides, natural products, cultural practices, or biological control, in order to provide an efficient and economic disease management for optimal crop production.
Keywords: *Soil health, soil quality, soil-borne, sustainable disease management, disease-suppressive soil*

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INTRODUCTION

Soil health is the capacity of soil to function as a necessary living system, with ecosystem and land use threshold to maintain biological productivity, quality of environment, and also to promote plant, animal, and human health [9]. The healthy soil should have high levels of organic matter, high tilth (loose and friable soil structure), increased water-holding capacity and drainage, adequate and excessive supply of nutrients, sufficient depth for root growth, large and diverse populations of soil micro-organism, resistant to degradation and flexible in their ability to retrieve from unfavorable weather conditions and environmental stresses [15].

ASSESSMENT AND INDEX

Soil quality test kit- outlined techniques for 12 on-farm tests, an explanatory section on each test, data recording sheets and also a section on how to develop your own kit. **Soil quality score cards**- used to evaluate the current status of soil health, show soil health indicators and related explanatory terms. **Soil conditioning index (SCI) -** It is a device that can estimate the results of cropping systems and tillage methods on soil organic matter. **Soil management assessment framework (SMAF) -** developed by [4] which provides site-specific interpretations for indicator results. **Agro-ecosystem performance assessment Tool (AEPAT) -** developed by [13].It is computer based program designed to assess agronomic and environmental performance of soil and crop management practices. **Mridaparikshak** – [22] 2015 from Indian Institute of Soil Science, Bhopal (2015).It is digital, mobile, quantitative mini soil laboratory. It can evaluate 10 important soil parameters, viz., pH, organic carbon, available nitrogen, phosphorus, potassium, sulphur, boron, and iron. Soil health is determined by physical, chemical, and biological indexes and the most commonly used and accepted indexes include physical attributes such as aggregate and structure, surface sealing, compaction, porosity, water movement and availability. The chemical attributes such as pH, soluble salts, sodium, nutrient holding capacity and biological indexes of soil health, including factors such as micro-flora, macro-fauna, biological activity and organic matter [16].

SOIL HEALTH MANAGEMENT METHODS

Crop rotation- It is defined as practice in which ground is kept fixed and crop is being rotated year after year. It provide many uses to crop production and soil quality, and helps in diverse functioning such as increased soil fertility, soil tilth, decreased soil erosion, improved soil water relations and increased microbial activity [5].

A study was set up at KARI Tigoni station between April 2007 and May 2010 to evaluate the effect of crop rotation on soil pH and macro nutrient levels. Rotations include maize, potatoes and cabbages. Results revealed that, soils at KARI Tigoni station are generally acidic with pH ranging from 4.3 (extreme acidity) to 5.59 (medium acidity). Cultivation minimizes the pH due to increased organic matter decomposition. Percent organic carbon was decreased and was significantly (P = 0.05) high by the rotation of crop [18].

Cover crops and green manures - A cover crop is described as a crop which is chiefly grown to cover the soil surface in order to safeguard it from soil erosion and nutrient leaching between the periods of crop production. Advantages and uses of cover crops are reduction of water run-off, reduction of soil erosion, improved soil structure, improved soil tilth, addition, recycling of nutrients, greater soil productivity, weed, pest, and disease control [26]. Both oat and rye cover crops decreased inter-rill and rill erosion. The decrease in soil erosion in this system to a less water flow rate across the soil surface, fixing of residues, and more binding of soil by roots. In plots without cover crops, water flowing across the soil surface replaced and moved residue, which uncover the surface and made it more prone to erosion. Cover crops can predominately reduce erosion even in cropping systems with increased levels of residue cover[11] Green manuring is defined as integration of fresh crop material for the cause of soil improvement. It has many uses such as increased organic matter, enhance soil fertility and structure, addition of C and N to soil, large microbial populations with increased activity [14]. The significantly highest soil moisture content was found in G_1 (*S. aculeata*) followed by G_2 (*M. invisa*) and G_3 (*V. radiata*). The lowest moisture content was observed in the control. The soil moisture increased in G1, which might be due to incorporation of more organic matter to the soil by *S. aculeata* that enriches water holding capacity. Soil moisture was reduced gradually from sowing to 80 DAS and the highest moisture (14.7%) was found in April 2012 due to high rainfall (141 mm) [24].

Organic amendments- The direct addition of organic matter to soil through organic amendments, such as composts, animal manures, or organic mulches, has various practical uses and benefit such as-decreased erosion, increased water retention, high soil organisms [29]. A compost amendment helps to increase microbial populations and activity, change in community structure and composition, and increases specific groups of organisms (7). Manure applications helps to increased the organic matter, aggregation, organic carbon, soil respiration, and infiltration (6) while, mulching enhances soil moisture content and organic matter in the soil, support the soil structure [21].

Minimum tillage- The cultivation practices that allows at least 30% of the soil surface covered by residue between crop harvests and planting. It has consequences on soil properties, including enhancements in various physical soil properties, such as available water capacity, infiltration, porosity and bulk density. Alterations to chemical properties include decreases in pH, cation exchange capacity (CEC), and increased in nutrient availability, and effects on biological properties may include increases in organic matter and soil organic carbon, microbial populations and activity [19]. Higher soil moisture contents were found in case of deep tillage (16.1%) and minimum in conventional tillage (15.2%). It is because of the development of proper environment for root penetration in case of deep tillage and it is due to deep tillage prevails the difficulties of soil compaction, enhances rooting depth which ultimately raise the soil tilth [21].

Soil solarization- A non-chemical method for controlling soil-borne insects and pathogens using high temperatures produced by catching radiant energy from the sun. It has many benefits such as it increases the breakdown of organic matter in the soil, increased parts of useful soil biota, enhanced weed control and increase in soluble nutrients. There was a remarkable increase in electrical conductivity (0.13 dSm^{-1}), organic carbon (0.21%), nitrogen (166.70 kg ha^{-1}) and potassium (48.77 kg ha^{-1}) in solarized soil as compared to pre-solarized soil; however, a non-significant increase in pH (0.25), phosphorus (5.87 kg ha^{-1}), calcium (0.50 me l^{-1}) and magnesium (1.1 me l^{-1}) was reported. This transformation can be allocated to an increase in the rate of decay of organic matter at high temperatures and as the mesophilic organisms are eliminated and decomposition during solarization, thereby releasing soluble materials into the soil [27].

Soil health and their effect on disease management

Organic amendments- Composting materials helps to decrease the soil-borne diseases in a broad variety of many crops and for different patho-types, including diseases. Ex: damping-off and root rots (*Pythium ultimum, Rhizoctonia solani, Rosellinia necatrix, Phytophthora* spp.etc), wilts (*Fusarium oxysporum, Verticillium dahliae),* and others (*Sclerotinia* spp*., Streptomyces* spp*.,* etc.) [17]. They have evaluated the effect of different concentrations of composts, the various composts brought down wilting from 89% in the control plants to 4-50 (mean 38%), 6-61 (48%), 61-72 (66%) in the treated plants while, decreases disease index by 67-74 (71%),51- 64 (58%), 44-54 (50%) and mortality by 100 (100%), 88-100 (98%) and 75-100 (85%) at 2.0, 1.0 and 0.5% concentration, respectively. Thus, higher dose (2%) of composts shows excellent disease controlling potential followed by 1.0 and 0.5% concentrations, in that order and it is due to higher doses increases non-parasitic micro-organisms providing antagonism to tomato wilt fungus or decay of compost products unfit for proliferation of fungus inoculums [23]. All the manuring studies remarkably decreased root rot disease. No root rot disease was reported in the non-inoculated and non-amended negative check, whereas disease incidence and crop mortality was 85 and 22.2%, respectively in positive check. Poultry manure followed by cattle manure was the best treatments for reducing disease incidence, plant mortality and disease severity. In the poultry manure treatment, disease incidence was reduced to 16%, and plant mortality to 6%. Cattle manure repressed the disease incidence and crop mortality and disease to 19 and 6%, and it is because of the fact that on decay, compost release nitrogenous substances and allele-chemicals which leads to disease prevention [2].

Rotation of crop- Crop-rotation can reduce soil-borne diseases by general mechanisms are: By serving to break the host-pathogen cycle of inoculum production, growth, or survival, by changing the soil's physical, chemical, or biological properties, making the soil environment less favorable for pathogen development, by direct inhibition of pathogens, either through production of inhibitory compounds in the roots or plant residues or by enhancing specific microbial antagonists may directly inhibit pathogen inoculums. In a recent study, a 2-year crop-rotation of beans (2 consecutive years of sweet corn or 1 year of table beet and 1 year of sweet corn) highly boost bean yield (pod yield by 25%) and slightly reduced root rot severity ratings, as compared to a monoculture of bean production [1].

Cover crops and green manuring - It increases the crop diversity, trigger and modify soil microbial populations which results in disease suppression. Ex: Brassicas reduced take-all in wheat, *Sclerotinia* (white mould) in lettuce and *Verticillium* wilt in cauliflower. The number of apothecial count was decreased in case of rye grass as compared to other cover crops study and can be used for the management of *Sclerotinia sclerotiorum* and it is because of the release of toxic substance which are not glycosinolates origin or to suppressing of processes in main crop host plant producing disease resistance [17]. Greater possibility for reducing soil-borne diseases than cover crops because of the much higher levels of fresh organic matter incorporation as well as their greater effects on soil microbiology [10]. Green manures of peas, Sudangrass, rapeseed, oats or rye was reported to reduce *Verticillium wilt* in potato crop. They have taken five study as Fallow, Austrian winter pea, Sudan grass, Dwarf Essex rape, Bridger rape and reported that sudan grass gives less fungal count (3.27 log cfu/g soil) and found that sudan grass can be used as green manure crop for the management of *Verticillium wilt* of potato and it is because of high non-pathogenic *Fusarium spp* (*F. equiseti*) [8].

Conservation tillage-

It has many effects on soil-borne pathogens and diseases. Increase or decrease was found due to the pathogen-type and availing conditions. Some soil-borne diseases are expected to decrease- Ex: some root rots and *Rhizoctonia* diseases **(20)**. On the basis of mean fungal count (*F. moniliforme*) was more in case of deep tillage which is 2.1×10^2/g dry soil as compare to zero tillage is 0.5×10^2/g dry soil and it is due to the fact that in zero tillage, soil is left undisturbed and fungus could not grow well because of lack of aeration by continuous ploughing and turning activities of soil [25].

Solarization of soil-

Solarization during the warm summer months can increase soil temperature to levels that kill many pathogen propagules, nematodes, and weed seeds and seedlings. Populations of these pathogens were very high at initiation, following the spring potato crop. An initial infestation of around 3,000 propagules g^{-1} of soil of *Fusarium* spp. was obtained in the top 30 cm of soil. Solarization reduced by 96% and 76% the inoculum density of *Fs* at the upper and lower 15 cm layers, respectively. At the end of summer, population densities of *Fs* remained high in bare soils, and no notable difference between the irrigated and the non-irrigated bare soils was reported. Although the inoculum density of *Fs* was little higher in the bare irrigated soil in the top 15 cm, it was not higher 15-30 cm deep, therefore irrigation without mulching did not increase pathogenic propagule densities by means of spore germination. The reduction of viable propagules at the depth 15-30 cm where temperatures are less indicates that a time temperature relationship might exist for the thermal killing of this fungus and/or bio-control mechanisms might occur in solarized soils incase of *Fusarium* spp **(30)**.

Conjunctions and interactions among diverse management methods-

Greatest results on soil health and sustainability can be obtained when all the soil health management methods should be used together to some extent. Care must be taken so that the combined methods should be compatible, complementary with each other and they do not disturb with each other. The combined action of using a canola or rapeseed rotation in combination with a winter rye cover crop decreased common scab of potato severity to 30% as compared to continuous potato or by 25 to 26% relative to a barley/clover rotation [12].

Implication of soil health management practices for plant disease management-

Soil health and soil health management methods have an excellent effect on management of soil-borne diseases. Biological control agents (*Trichoderma harzianum* and *Pseudomonas flourescence*) induced systemic resistance in Cucumber and *Arabidopsis thaliana* against the *Fusarium* stem and root rot [3]. They have taken two strains namely *T. harzianum* Tr6 (TR) and *Pseudomonas* spp Ps14 (Ps).When these two strain taken individually they do not show any remarkable reduction in the disease incidence but when these both strains are mixed together they greatly reduce the disease incidence and it is due to the fact that induction of various signaling pathways which confers the disease resistance [3]**.** They have evaluated the effect of organic amendments on soil borne fungus i.e. cucumber damping off in field condition for two year of study (2001 and 2002) and foliar disease i.e. snap bean anthracnose in glass house condition for one year (1999)**.** Three treatments are taken namely Paper mill residuals (PMR), raw; paper mill residuals composted (PMRC) and paper mill residuals bark compost (PMRBC); and a non-amended soil control while, composted amendments were applied to soil at rates of 38.1 (L) and 78.4 (H) dry t/ha and raw amendment was added at 22.4 (L) and 33.6 (H) dry t/ha and reported that in case of cucumber *damping-off*, PMR H gives the best result having less disease severity (1.33%) followed by PMRC H (1.65%), while in snap bean anthracnose PMRC H gives the excellent outcome having less disease severity (0.80%) [28].

CONCLUSIONS

All the management practices should be integrated with one another to provide an effective disease management. But care and attention must be taken while, combining the management practices is that they are compatible, complementary with each other and they do not interfere with each other.

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