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GOOD AGRONOMIC PRACTICES (GAP) - AN EFFICIENT AND ECO-FRIENDLY TOOL FOR SUSTAINABLE MANAGEMENT OF PLANT DISEASES UNDER CHANGING CLIMATE SCENARIO

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ABSTRACT

IPCC projected minimum 1.8 °C increase in temperature by 2100 above 1990 level and confirms that the global average temperature increased by 0.74°C over the last century, is about poses a potential threat to agricultural production and productivity and affects the crop yields due to incidence of plant diseases and weeds, pests as well. There is a 5 per cent decrease in rice yield for every °C rise in temperature above 32 °C. The costs of agricultural production may be going sky-high. The sustainable option for preventing or minimizing the outbreak of disease is with the proficient use of Good Agronomic Practices (GAP). GAP is an efficient and excellent tool for effective disease pest management in general and especially for soil-borne pathogens, under change climate scenario. By adopting GAP which is admirable alternatives to pesticides for the plant pathogen management, one should contribute significantly to ecological balance and playing great role in the minimizing soil pollution particularly. The GAP can be used alone or as a component of pest management programs. GAP for pest management can be used before, at or after planting. The basic principles of GAP for pest management are any potential management method may be considered, providing that it is environmentally, technologically and economically feasible, pesticide usages is minimized by combining with other non- chemical or chemical methods. GAPs include crop rotation, fallow, flooding, deep ploughing, soil solarization- which involves a combination of physical and biological process, adjusting planting dates, irrigation, fertilization, sanitation tillage etc. Diseases those are difficult to manage or that involve problematic pesticides should be prioritized. Economic aspects are taken into consideration.

Key words: Climate Change, Crop Rotation, Good Agronomic Practices, Plant Diseases Management, Soil Solarization.

The production potential of a particular crop depends on the environment and the skills of the farmers in identifying and eliminating those factors that reduce the production potential. Adjustment in crop management practices to prevent or minimize disease development represents the oldest and most broadly applicable approach to plant disease management (Anonymous, 1968). The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) confirms that the global average temperature increased by 0.74°C over the last 100 years; and the projected increase in temperature by 2100 is about 1.8 to 4.0°C. Global warming poses a potential threat to agricultural production and productivity throughout the world and this might affect the crop yields, incidence of weeds, pests and plant diseases and the economic costs of agricultural production. There is a 5 per cent decrease in rice yield for every °C rise in temperature above 32 °C. Reduced length of growing seasons as a result of climatic change is causing detrimental effects on agriculture. If suitable measures are not taken, crop yield could be decreased up to 50 percent by 2050 in South Asia probably due to havoc created by disease pests. This climate change has twin effect in front of agricultural production. First, the frequent outburst of diseases are obviously due break of resistance chain of the respective crops and fast acclimatization of disease causing agent i.e. causal organism under changing climate condition (IPCC, 2007). Under these circumstances good agronomic practices (GAP) often offer the opportunity to alter the environment, the condition of the host, and / or the behaviour of the causal agent, to achieve economic management of the disease. Most cultural practices used to management the plant disease are preventive in the nature. Integration of cultural practices, host resistance and pesticides or biocontrol agents may be necessary to provide option for controlling economically important plant diseases (Andrews, 1983; Baker, 1983). For centuries from the drawn of history to modern times, cultural practices were the main or only techniques available for reducing the incidence of diseases caused by pathogens and other pest. Numerous observation and long experiences generated cultural methods for pest management through trial and error, which then became a tradition. The rise of modern plant pathology in the 19th century provide the scientific basis for the systemic development of cultural method for disease management and an elucidation of the mechanisms involved. In the last few decades, however, powerful and effective chemicals for management, such as soil fumigants, have been developed, resulting in declining interest in, and abandonment of, many cultural methods for pest management, especially crop rotation. It is interesting that as early as 1938; a review was published dealing with "departures from ordinary methods in controlling plant diseases". This author described several non-chemical methods for disease management.

The concept of Good Agronomic Practices (GAP):

According to Katan (1996) GAP can be classified in to three categories i.e. (1) Practices, which are usually applied for agricultural purposes not connected with crop protection, such as fertilization and irrigation. They may or may not have a positive or a negative side-effect on disease incidence (2) Practices that are used solely for disease management, such as sanitation and flooding and(3) Practices, which are used for both agricultural purpose and for disease management, such as crop rotation, grafting. The objective of studying the effect of GAP on disease has dual purpose: to develop suitable practices as management methods and to obtain information regarding their impact on diseases when they are used as agricultural practices in order to avoid negative side effect. Cultural practices may be employed, before or after planting. Deep ploughing and flooding are used before planting while irrigation and fertilization can be applied several times during the crop season for disease management.

The Method for disease management through GAP:

Quite a few procedures for disease management through GAP have been described by Singh (2000). In today' s commercial agriculture where sustainability and integrated approach are the guiding principles, all the methods listed are not very relevant, Only those that contribute to sustainability and concept of integration are being described.

1. Effective Crop Rotation Cropping System and Crop Sequence:

Crop rotation may be defined as the growing of economic plants in recurring succession and in definite sequence on the same land as distinguished from a one crop system usually lacking a definite plan. Curl (1963), defined the cropping system as the sequence or combination of crops growing in a single field. The term "crop sequence" is to be preferred, according to Patil (1981), since it also covers monoculture. The sequential sowing of crops may or may not include fallow or green manure. Fallowing, namely, the absence of crop, may contribute to a reduction in disease incidence although in certain cases continuous cropping (monoculture) may lead to disease decline (Cook and Baker, 1983). The crop rotation program determines the frequency of growing each crop, the list of crops (and fallow periods) during a defined period (cycle), the order (history) of crop (and fallow periods) and the agricultural practices which will be employed during the whole cycle. Monoculture is the opposite of such a practice and is applied ironically, both in very primitive agricultural system (out of ignorance) and in the most advanced ones e.g. greenhouse because out of necessity, specialization in crop production and economic consideration (Katan, 1996). The effectiveness of crop rotation in disease management will depend on the nature of the pathogen and the crop, the agricultural practices involved, soil properties and other biotic and abiotic factors. The factors that reduce effectiveness of crop rotation in controlling soil borne disease includes (1) wide host range of the pathogen, (2) pathogens having effective mechanisms for survival in the absence of host, (3) Pathogens producing large inoculums densities as resting structures, (4) Crops that are susceptible to several disease, (5) Crop which stimulate formation of resting structures, that are susceptible to several disease, (6) Crops which stimulate formation of resting structures, (7) Frequent infestation of soil with pathogen

Table 1. Some specific effect of succeeding crop on the pathogen of the preceding crop

Beneficial crop	Pathogen reduced	Preceding crop
Rice	*Verticillium dahliae*	Cotton
Pea	*Gaeumannomyces graminis*	Wheat
Sudangrass, maize, wheat or sorghum	*Ralstonia solanacearum*	Tomato
Legume cover crops	*Ralstonia solanacearum*	Potato
Barley	*Meloidogyne incognita*	Cotton
Legumes, sesame and wheat	*Pratynechus indicus*	Rice
Groundnut	*Meloidogyne incognita*	Tomato
Beet	*Pratylenchus penetrans*	Cereals

from external sources, (8) Soil that are conducive to disease and (9) Poor weed management. Most of the diseases caused by soil borne pathogens can be significantly reduced by crop rotation. Examples are wilt of sugarcane, ergot and smut of pearl millet, bunts and flag smut of wheat, leaf smut and bunt of rice, bacterial wilt of potato and tomato, and cereal cyst nematode. Examples of a few accurate effect of succeeding crop on the pathogen of the preceding crop are listed in Table 1.

The success of crop rotation for disease management depends on proper selection of crops in the sequence. The crop(s) grown between the susceptible host crops should be resistant or immune to the pathogen or should be non host and their root exudates should not directly or indirectly favour survival of the pathogen. In case of pathogens having very large host range such as the root knot nematodes of vegetable crop, choice of the crop from various vegetables is sometimes difficult.The vegetables have to be rotated with cereals like wheat or rice. However, immune or highly resistance varieties of the vegetable crop such as tomato can be included in the rotation. Rotation does not help against pathogens which have strong saprophytic survival ability in absence of the host. The structure of survival and its longevity in soil should be known to decide the length of rotation or gap between the susceptible crops. A one year rotation for pegion pea wilt is likely to fail if the plant roots which harbour the pathogen do not completely decomposes. In bacterial wilt of potato, only very long rotations can work since the bacterium has unusual longevity in soil. Although crop rotation is one of the oldest plant disease management practices, being in existence since ancient times, and has been an effective method in subsistence agriculture being followed by farmers having small holding, it is not encouraged in sustainable agriculture system which emphasize intensive cultivation with the help of chemicals. The choice of food grain crops being limited; it has its own limitation even with farmers having limited land. Thus, rice- wheat (both cereals) has become the predominant rotation in most part or India. Crop rotation as a tool for disease management has been thoroughly discussed by Curl (1963), Bruehl (1987), Cook and Baker (1983), Patil (1981), Schippers *et al.* (1987).

2. Efficient Water Management Practices:

Timing, frequency, amount and mode of irrigation afford the farmers a wide choice of water management option for reducing both foliar and soil borne disease (Rotem and Patil, 1969; Patil, 1981). It alters soil's moisture content and consequently influences the aeration and temperature, which in turn affect soil- borne disease through their actions on biotic and abiotic processes in soil. Irrigation also affects disease incidence indirectly due to•change in agricultural regimes such as intensification of cropping, changes in date of sowing and growing seasons (Katan, 1996). Irrigation water is often a means of transport of inoculum through the field and to adjacent field in the area. Transfer of conidia and *appresoria* of *Colletotrichum falcatum*, sporangia of downy mildew fungi, sporangia and zoospores of *Pythium* and *Phytopthora*, cells of bacteria, can be moved in and outside the field through irrigation or running water. The crop debris carry active or dormant inoculum of pathogens is also transported by irrigation and drainage water in channels through infested field. In many cases under understanding the moisture and aeration requirements of each of the biotic factors involved in the disease, enable the choice of a compromise irrigation regime, that allows reasonable or optimal crop production but is still less favorable to disease development. Thus, the optimal irrigation regime for a crop in a non-infested soil may be different from that in a soil infested with a pathogen (Patli and Katan, 1997).

Today, sophisticated irrigation technology enables good management of the amount and spatial distribution of water in the soil. Soil moisture and aeration are affected by a variety of factors, such as the amount of water given at each irrigation, intervals between irrigations, method of irrigation, physical characteristics of the soil, the plant, and climatic factors. In arid and semi arid zones, irrigation is of crucial importance to crop production. Probably, no other single agricultural practices have a greater influence on the plant- microorganism environment than does irrigation (Cook and Bakers, 1983). Irrigation enable the establishment of new crops and growing seasons in regions where rainfall is not sufficient, but may also enhance the development of soil-borne diseases which were rare or absent before the introduction of irrigation. We should attempt to use water management as a tool to reduce the incidence of soil borne disease, where possible. Salinity of water can affect the incidence of some diseases. Nachmias *et al.* (1993) showed an interaction between salinity and incidence of *Verticillium* wilt in potato. Increase salinity was positively correlated with increased disease incidence and related traits, such as potato stem colonization with the pathogen and plant height reduction. These responses were cultivar-dependent. In recent years, there has been an increasing interest in using irrigation water of a lower quality, due to water shortages in certain regions in the world. The impact of such irrigation water, beyond the dissemination of pathogens propagules, on soil- borne pathogens should not be overlooked. Soil moistures related to many diseases. For example, wet soil favors club root of crucifers, silver scurf of potato and *Cercosporella* on wheat while dry soil increases severity of white mould of onion, common scab of potatoes and *Fusarium* diseases of cereals (Colhoun, 1973). Dampping of the disease caused by *Pythium* spp. can be reduced by maintaining a dry soil surface as zoosporic fungi such as *Pythium* and *Phytophthora* depend on the soil water for zoospores release and motility. The incidence of root rot of chilli peppers caused by *P. capsici* in plots receiving alternate- row irrigation was significantly less than in plants with irrigation of every row (Biles, *et al.*, 1992). According to Ristaino (1991) *Phytophthora* root and crown rot in bell pepper were greater in plots irrigated more frequently with a deep system. Reducing number of irrigations decreases the incidence of root rot caused by *S. sclerotiorum* in lettuce (Steadman, 1979). *Sclerotia* of *S. sclerotiorum, S. minor, S. cepvoirum,* dried for short periods and remoistened results in nutrients leak and are rapidly colonized by microorganisms and rot within three weeks (Smit, 1972). Irrigation will be useful for management of diseases favoured by water stress such as charcoal rots caused by *M. phaseolina* (Gaffar and Erwin, 1969). Moisture status of soil affects microflora and their interaction in soil and thus irrigation can be tool for cultural management. Common scab of potato (*S. cabbies*) can be managed by maintaining soil water near field level during tuberization (Labwood and Hering, 1970).The principles influencing the relation between the timing of irrigation and its frequence, with disease management include: (A) Providing them with uniform water supply to avoid the water stress or excesss, (B) timing of irrigation in relation to host susceptibility and (C) Minimizing period of continuous leaf wetness (Chaube and Singh, 1990).

3. Soil Inundation (Flooding):

This is a pre-planting practice which can be regarded as soil disinfestations treatment. The harmful effect of flooding on soil-borne pathogens may be related to lack of oxygen, increased CO_2 or various microbial interactions, e.g. production of substances that are toxic to the pathogen upon anaerobic processes (Bruehl, 1987). A classic case of management on a large scale was demonstrated with the panama wilt disease of banana caused by *Fusarium oxysporum f.sp. cubence* (Stover, 1962). The soil is flooded for 3-4 months or more with a minimum of 30 cm of water. Flooding was not effective when large populations of the pathogen were present, or in soil which contained unknown factors which favored the pathogen. Flooding also apparently destroys *Pseudomonas solanacearum,* and the nematode *Radopholus similes* (Stover, 1962). Newhall (1955) describes several causes where flooding was practiced in the past to eliminate soil borne organism including fungi, nematodes and insect. In this regards, an interesting phenomenon has been observed in the Gaza region. In certain area, the soil becomes flooded by rain for several weeks during winter and spring. The local farmers observed that vegetable crops growing in these soils are healthier, with less diseases and higher yields, compared with non- flooded soil. Flooding can be used as a cultural practice for disease management only in countries where large resources of water are available or where fish are grown in ponds (Patil, 1981). Flooding was found effective in controlling additional pathogens. *Verticillium dahliae* was effectively controlled by long-term summer soil flooding with or without paddy rice culture. The management of *V. dahliae* was directly associated with management of *Verticillium* wilt in subsequent cotton crops and with increased lint yields. In contrast, soil flooding during the winter months and irrigated rice without flooding were ineffective (Pullman and De Vay, 1981). These findings are consistent with a previous report that one year rotation of paddy rice can eradicated *V. dahliae.* The duration of soil saturation was important in both the green house and field experiments where population densities of *V. dahliae* begain to decline after 6-8 weeks of flooding. Anaerobic condition and low oxidation- reduction potentials in flooded soils may be important in the killing of *V. dahliae.*

4. Organic Soil Amendments:

One of the cheapest hazard- free and ecofriendly effective methods of modifying soil environment is amendment of soil with decomposable organic matter. Sun and Huang (1985) had rightly observed that continuous extensive agricultural practices that depend heavily on use of chemical have resulted in loss of organic matter, an increase in acidity, and accumulation of toxic elements in cultivated soils creating an environment favourable for development of certain soil borne pathogen. The reduction in common scab of potato (*S. scabies*) by green manuring through prevention of the build-up of inoculum was the first report of organic amendments as a means of disease suppression. Since this observation of Sanford (1926), numerous reports have appeared regarding the beneficial effect of organic and inorganic amendments of soil. The list of soil- borne disease that have been controlled in glasshouse, micro plots or field plots by organic amendment of soil, is quite exhaustive. Some of the important ones are given in Table 2 and 3.

ment through effect of the decomposition products and microbial metabolites on the pathogen and the host and (3)Suppression of pathogen through direct antagonism.

5. Soil Solarization and their Mechanism : Soil Solarization is an advanced field technology for the management of soil borne pathogens. This non-chemical management procedure has been adopted by farmers in several parts of the world. The report on use of solar energy for the management of soil- borne disease was published by Katan *et al.* (1976). Since then hundreds of papers have been published, covering the subject in over 38 countries around the globe (Chaube and Singh, 1990; Tjamon, 1996). Soil Solarization is based on trapping solar irradiation by tightly covering the soil, usually with transparent polyethylene sheets. This results in a significant increase (10-15^{0}C above normal temperature) of soil, temperature up to the point where most pathogens are vulnerable to heat effects. Soil Solarization offers multiple pest management. It management parasitic diseases, soil borne pest, weeds and improve soil suppressiveness and fertility. Major parasitic fungi and disease managed successfully include damping off, root rot, stem rot, fruit rot, wilt and blights caused by *Pythium spp. Phytophthora spp, Fusarium spp., S. rolfsii, R. solani, Sclerotinia sclerotiorum, T. basicola and Verticillium spp.* (Katan, 1981, Chaube and Singh, 1990; Tjamon, 1996). Among the nematodes *Ditylenchus dipsci, Globodera rostochiensis, Heterodera spp.* and *Meloidogyne spp.* have been managed successfully. Bacterial cankers of tomato caused by *Clavibacter michiganensis subsp. Michiganensis* successfully controlled by soil Solarization 1-2 months Tjamon, *et al.*, 1992). (In general most of the annual and perennial weeds successfully management except partially management of *Cyperus rotundus* with soil Solarization (Katan, 1987; Chaube and Singh, 1990; Esfahani, 1991; Khulbe *et al*; 2001 and Chaube, 2002).

Reduction in disease incidence occurring in solarized soil, results from the effects exerted on each of the three living components involved in diseases (Host, Pathogen and Soil *microbiota*) as well as physical and chemical environment which, in turn affect the activity and interrelationship of the microorganism. Although this process occurs primarily during Solarization, they may continue to various extents and in different ways, after the removal of sheets and planting the crops. The most pronounced effect of the soil mulching with polythene is a physical one, i.e., an increase in soil temperatures for several hours of the day. However, other accompanying processes such as shift in microbial populations, change in the chemical composition and physical structure of the soil, high moisture levels and changes in gas composition of the soil should also be considered when analyzing mechanisms of disease management.

6. Fine-tuning planting time and planting geometry:

Disease management can be achieved by this method when the disease is limited in its development to well- defined environments, or where the crop is susceptible to disease only at certain stages of its development. For example, crop susceptible to damping off diseases should only be sown when rapid germination, emergence and lignification of seedling tissue can be expected (Leach, 1947). The effect of crop density on disease incidence was demonstrated with *Sclerotium rolfsii* on carrot (Smith *et al.*, 1988). Thus, the area under the disease progress curve (AUDPC) rate of disease increase was higher in row having52 plants per meter than in rows having 26 per meter. Inter plant transmissions in rows was primarily via root contact, however. S. rolfsii can grow from plant to plant on senescent or dead petioles. AUPDC was greatest in plots having the thickest, most humid canopy environment. When garden cress was inoculated with Pythium, varying the planting of the host population had a similar effect on the frequency of primary infection foci to that produced by varying the density of applied inoculum (Burdon and Chilvers, 1975). In both cases, at low densities the number of primary infection foci was proportional to density. Similarly, in a study with onions infected with *Sclerotium cepivorum*, the proportion of plants infected. Over a range of spacing distance was approximately inversely proportional to the spacing (Scott, 1956). This is consistent with the observation that this pathogen spreads more rapidly between onion plants touching one another than between separated plants. Fusarium root rot in bean was the highest at a high plant density (Burke and Nelson, 1965).

7. Crop and Field Sanitation:

Sanitation is a major practice of disease management. Regular removal of diseased plants from a population is an important sanitary precaution. It is one of the effective recommendations in the management of the viral disease of the field crops. For the management of loose smut of wheat and production of disease free seed, rouging is always recommended in seed plots. Roguing of infected plants is recommended in several other diseases, e.g. smut of sugarcane, red rot of sugarcane, downy mildews of sorghum and maize, wilt of pigeon pea and several viral diseases. The two principal aims of sanitation are to prevent the introduction of inoculum, by whatever means, into the field, greenhouse, farm or community and to reduce or eliminate inoculum present in these sites (Patil, 1981). This is of particular importance in the tropic and can be achieved by flooding, flaming, Solarization, ploughing, chemical treatments to suppress or destroy resting structures, mechanical removal of residues , controlling alternate host (Weeds, Volunteer plants), pruning and other means.

8. Deep ploughing :

This is practiced to reduce the contact between plant root and pathogen structures to enhance pathogen killing by burying it, or to expose the inoculum to natural heating and desiccation. A deep covering of organic matter on land followed by "non-dirting" cultivation (the use of a herbicide) effectively controlled *Sclerotium rolfsii* in peanuts (Garren and Duke, 1958). Similarly deep ploughing, compared to shallow disking, reduced incidence of southern blight in tomato caused by *Sclerotium rolfsii* and increase yields (Worley *et al.*, 1966). Garren (1961) reviewed the GAP for the control of *Sclerotium rolfsii.* Newhall (1955) described several cases in which plowing the soil during the hot season in order to expose it to the sun's rays, resulted in decrease in diseased incidence. This effect is apparently due, among others, to physical killing of the pathogen propagules occurring at elevated temperatures and can be regarded as dry- soil solarization.

Conclusion

In the era of climate change good agronomic practices are needs of hours to curb the potential damage to be executed by vulnerable pathogens. The estimated potential threat due disease incidences owing to eminent climate change is only a rough estimate based on some simulation models and study conducted under fully controlled conditions, which seems to be realistic, if happened, if happened , the good agronomic practices will play a key role to manage the event, which is often forgotten in modern literature on plant diseases, even through many traditional farmers have adequately managed plant diseases for millennia, primarily with cultural practices, though many of them are sustainable, although some are highly labor-intensive. It is important to integrate traditional cultural controls into modern pest management system especially those for management of plant diseases, to greater degree than has been done wonder in the past.

LITERATURE CITED

Andrews, J. A., 1983: Future strategies for integrated control, Chapter 40, In: Challenging Problem in Plant Health, T. Kommedahl and P.H. Williams (Eds.), *American Phytopathological Society,* St. Paul, Minnesota, p, 538.

Anonymous, 1968: Plant disease development and control, Vol. I, Principales of plant and animal pest control, Publ. 11596, *Nat. Acad. Sci.*, Washington, DC, p.250.

Baker, K.F., 1983: The future of biological and cultural control of plant diseases. In: Challenging Problem in Plant Health, T. Kommedahl and P.H. Williams (Eds.), *American Phytopathol. Soc;* St. Paul, Minnesota, p, 217.

Biles, C. L., D. L. Lindsey and C.M. Liddell, 1992: Control of Phytopathora root rot of chilli peppers by irrigation practices and fungicides. *Crop Protection,* 11: 225.

Burdon, J. J. and G. A.Chilvers, 1975: A comparison between host density and inoculum density effects on the frequency of primary infection foci in Pythium-induced damping-off disease. *Aust. J. Bot.* 23:899-904.

Burke, D. W. and C. E. Nelson, 1965: Effect of row and plant spacing on yield of dry beans in Fusarium-infected and noninfested field. *Phytopath;* 61: 792-799.

Chaube, H.S., 2002: Soil Solarization and management of seedling diseases of horticultural crops,Technical Bulletin, Directorate of Exp. Sta., G.B.Pant University of Agriculture and Technology, Pantnagar, p. 142.

Colhoun, J., 1973: Effect of environmental factors on plant diseases. *Ann. Rev.,* 29: 413.

Cook, R. J. and K.F. Baker, 1983: The nature and practice of biological control of plant pathogen. *American Phytopathol.* Soc; St. Paul, p. 539.

Curl, E. A., 1963: Control of Plant Diseases by Crop Rotation, *Bot. Rev.*, 29: 413.

Esfahani, Mehdi Naser, 1991: Effect of soil Solarization on soil borne seedlings disease of some vegetable crops, Ph.D. Thesis G.B. Pant University of Agriculture and Technology, Pantnagar.

Gaffar, A. and D.C. Erwin,1969: Effect of soil water stress on root rot of cotton caused by *Maenephomina phasoli, Phytopath;* 59: 795.

Garren, K. H., 1961: Control of *Sclerotinum rolfsii* through cultural practices. *Phytopathology,* 51: 199-202.

Garren, K. H. and G.B. Duke, 1958: The effect of deep covering of organic matter and non – dirting weed control in peanut stem rot. *Plant Dis. Rep.* 42: 629-636.

IPCC, 2007: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the IntergovernmentalPanel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Katan, J., 1987: Soil Solarization, In: Innovation Approaches to Plant Diseases Control (I. Chet, Ed.), John Wiley and Sons, New York, p. 77.

Katan, J., 1996: Cultural practices and soil borne disease management, In: Management of Soil- borne Diseases, R.S. Utkhde and V.K. Gupta (Eds.), Kalyani Publishers, India, p. 100.

Katan, J., A. Greenberger, H. Alon and A. Grinstein, 1976: Solar heating by polyethylene mulching for the control of disease caused by soil-borne pathogens, *Phytopathol;* 66: 683.

Khuble, D., H. S. Chaube and J. Sharma, 2001: Soil Solarization: An ecofriendly method to raise healthy crop, In: Microbes and Plants, A. Sinha (Ed.), Campus Book, p.158.

Lapwood, U. H. and T. F. Hering, 1970: Soil moisture and the infection of young potato tubers by *Streptomyces scabies* (Common scab). *Potato Res., 13: 296.*

Leach, L. D., 1947: Growth rates of host and pathogen as factors determining the severity of pre- emergence damping off. *J. Agric. Res.* 75:161-179.

Nachmias, A.Z. Kaufman, L. Livescu, L. Tsror, A. Meiri, and P.D.S. Caligari, 1993: Effect of salinity and its interaction with disease incidence on potato grown in hot climates. *Phytoparasitica,* 21: 245-255.

Newhall, A. G., 1955: Disinfestation of soil by heat, flooding and fumigation. *Bot. Rev.*21: 189-250.

Palti, J. 1981: Cultural Practices and Infection Crop Diseases, Springer –Verlag, Berlin, p. 243.

Ristaino, J. B. 1991: Influence of rainfall, drip irrigation and inoculum density on the development of *Phytophthora* root and crown rot epidemic and yield in bell pepper, *Phytopath;* 81: 922.

Rotem, J. and J. Palti, 1969: Irrigation and plant diseases, *Annu. Rev. Phytopathol;* 7: 267.

Scott, M.R. 1956: Studies on the biology of *Sclerotium cepivorum* Berk II . The spread of white rot from plant to plant. *Ann. Appl. Biol.* 44: 584-589.

Singh, R. S., 2000: Plant Disease Management, Oxford & IBH, New Delhi.

Singh, R. S. and K. Sitaramaiah, 1973: Control of plant parasitic nematodes with organic amendments of soil, Exp. Sta. Res. Bull. No-6, G.B.Pant University of Agriculture and Technology, Pantnagar.

Singh, R. S., H. S. Chaube and N. Singh, 1972: Studies on the control of black scurf disease of potato. *Indian Phytopathol;* 25: 343.

Smith, A. M., 1972: Biological control of fungal sclerotia in soil. *Soil Biol. Biochem.*; 74: 255.

Smith, V. L., Campbell, S.F. Jenkins and D.M. Benson, .1988: Effect of host density and number of disease foci on epidemic of southern blight of processing carrots. *Phytopathol;* 78: 595-600.

Steadman, J. R., 1979: Control of plant disease caused by *Sclerotinia* disease. *Phytopathol;* 69: 904.

Sun, S. K. and J.W. Huang, 1985: Formulated soil amendment for controlling *Fusarium* wilt and other soil-borne disease. *Plant disease,* 69: 917.

Tjamon, E. C. 1996: Chemical treatment and soil Solarization for management of soil-borne Diseases, In: Management of Soil –borne diseases. R.S. Utkhede and V.K. Gupta (Eds.), Kalyani Publishers, New Delhi, p. 261.

Tjamon, E. C., P. Antonou and C.G. Panago Pulos, 1992: Control of bacterial canker of tomato by application of soil Solarization, *Phytopathol;* 82(10): 1076.

Worley, R. E., D.J. Morton and S.A.Harman, 1966: Reduction of southern blight on tomato by deep plowing. *Plant Dis. Rep.;* 50: 443-444.