Introduction

Agricultural chemicals have an important role in the efficient and economic production of wholesome food and fibre products. Agricultural chemicals are also known as pesticides include herbicides, insecticides, fungicides etc. (ACUM, 2005). Pesticide based strategies among the various strategies available for pest management has been so far dominating. Use of synthetic pesticides has led to the emergence of several problems (chemical hazard) like environmental pollution, residual effect in grain and killing of non-target organism(s). Development of resistant strains of plant pathogens are serious problem of pest management, increase due to the application of only pesticide strategies for pest management (Kumar, 2014) [18]. Hazard is the inherent property of a substance capable of causing harm i.e., toxicity (Carson and Mumford, 2002) [5].

Plant protective tools play important role in healthy crop production. Modern agriculture mostly depends on chemicals i.e., fertilizers and pesticides. Indiscriminate use of chemicals in agriculture is risky due to environmental pollution and health hazards to human beings, animals and beneficial microbes. For second green revolution, it is necessary assimilate alternative management strategies which are eco-friendly but sustainable for long duration. Eco-friendly strategies (Integrated Pests Management) i.e., management of pests through bio agents, botanicals and agronomic practices play important role in sustainable agriculture.

Why need of bio agents?

Environmental safety is one of the leading drivers of bio agent usage because chemical pesticides also kill beneficial insects (bees, butterflies etc.) and microbes (Rhizibium, entomopathogenic fungus etc.). Non-toxic to non-target organisms, including beneficial insects and wildlife, many bio agents also are biodegradable. They decompose quickly and do not negatively impact surface water and groundwater. Bio agents typically are effective in small a quantity which eliminates pollution concerns sometimes associated with traditional chemicals. In addition, bio agents are manufactured from naturally occurring raw materials in an environmentally responsible and sustainable manner.

Integrated Disease Management (IDM)

The management of disease can be done through cultural i.e., crop rotation (Rani and Sudini,
2013) [27], changing in sowing date (Singh and Singh, 2004, Singh et al., 2008, Singh et al., 2015) [30, 31], destruction of plant debris (Rani and Sudini, 2013) [27], soil solarization (Pate et al., 2014) [25], use of resistant cultivars (Ramakant et al., 2008) [26], chemical (Holi and Meena, 2015) [14], biological management (Bhyoe et al., 2011, Biswas et al, 2015) [2, 3]. Cultural and biological strategies are mostly effective at initial stage, specially at sowing time of crops and they can not manage the disease in standing crop and even after appearance of disease. Use of resistant cultivar is also reasonable and easy method for disease management but due to development of new strain among the pathogens, resistant may be break down to susceptible one.

Chemical strategy is very effective but also delicate to environmental pollution, residual effect in grain and killing the non-target organisms (Kumar and Singh, 2017) [19]. Development of fungicide resistance in plant pathogens is a major obstacle of chemical strategy when use continuous and separately (Pate et al., 2014) [25]. Therefore, all the methods have some limitations and draw back and due to least efficiency of single strategy of disease management, integration of various strategy (Integrated Disease Management=IDM) is the foremost need for management of plant disease in near future of agriculture. IDM act as safeguarding against the longer term risks of environmental pollution, hazard to human health and reduced agricultural sustainability (Ciancio and Mukerji, 2007) [7].

Cultural practices
Field sanitation
Plant debris, self-sown crops, ratoon crops, collateral (wild hosts of same families) and alternative (Wild hosts of other families) hosts are reservoirs of many plant pathogens. So, sanitation of above materials is helpful in plant disease management. Self-sown rice plants harbour the pathogen (Rice tungro virus) as well as vector (Nephotettix virescens). Pathogen of sugarcane mosaic disease is harbor in ratoon crop. The fungal pathogen for blast disease of rice (Pyricularia grisea, Teleomorph: Magnaporthe grisea) can infect the grass weeds like Brachiaria mutica, Dinebura retroflexa, Leersia hexandra, Panicum repens (collateral hosts) etc. and survive during off-season of rice crop. Temperate regions the alternate host of Puccinia graminis tritici (black or stem rust pathogen of wheat), the barberry bush (Berberis vulgaris) grows side by side with the cultivated host. In such areas this wild host belonging to a different family is important for survival of the fungus.

Deep summer ploughing
Ploughing the soil during summer months expose soil to hot weather which will eradicate heat sensitive soil borne pathogens. If sunny weather continues for several days or weeks, inactivates or kills many soilborne pathogens such as fungi, nematodes, and bacteria near the soil surface, thereby reducing the inoculum and the potential for disease (Rani and Sudini, 2013) [27]. Soil solarization has been demonstrated to manage soil borne diseases caused by such type pathogens Rhizoctonia solani, Fusarium spp., Pythium spp., Phytophthora spp., Verticillium spp., Bipolaris sorokiniana, Plasmiodiophora brassicae, Sclerotium rolfsii etc. in many crops. Soil solarization has also been shown to significantly decrease the population of disease causing soil borne bacteria. Many nematode diseases caused by Meloidogyne spp., Heterodera spp. etc. have been successfully controlled by soil solarization (Kumar et al., 2017) [17].

Crop rotation
Pathogens are able to infect susceptible plants by only under certain congenial environmental conditions. A slight change in sowing dates might be escape to this congenial environmental (Singh et al., 2015) [31]. Continuous cultivation of the same crop in the same field helps in the perpetuation of the pathogen in the soil. Soils which are saturated by the pathogen are often referred as sick soils. To reduce the incidence and severity of many soil borne diseases, crop rotation is adopted. Crop rotation is applicable to only root inhabitants and facultative saprophytes, and may not work with soil inhabitants e.g., Panama wilt of banana (long crop rotation), wheat soil borne mosaic (6 yrs) and club root of cabbage (6-10 yrs), etc.

Use of resistant variety
Using disease resistance varieties is one of the best disease management practices. With a highly resistant variety, a plant disease can be managed with no added cost and no health risks to the farmer, farm workers or environment. Resistance may be complete or incomplete. Incomplete resistance is most effective when used in combination with other control methods. Economic and environment safety point of view, use of resistant variety is a cheaper and best method of disease control (Kumar and Tripathi, 2018) [20].

Mixed cropping
Cultivation of multiple crops in the same field at the same time is called as mixed cropping. Mixed cropping is practiced to optimize nutrient uptake, control soil erosion, suppress the epidemic spread of airborne pathogens, and improve crop yields per unit of area (Hiddink et al., 2010) [12]. Root rot of cotton (Phymatoirichium omnivorum) is reduced when cotton is grown along with sorghum. Intercropping sorghum in cluster bean reduces the incidence of root rot and wilt (Rhizoctonia solani).

Date of showing
Pathogens are able to infect susceptible plants under certain environmental conditions. Alternation in date of sowing can help avoidance of favourable conditions for the pathogens. Rice blast can be managed by changing planting season from June to September/October. Infection of black stem rust of wheat (Puccinia graminis tritici) is more in late sowing, hence, early sowing helps in reduction of stem rust incidence.

Seed treatment
Seed treatment is a process like vaccination applied in animal as well as human. Seed treatments, in broad terms, are the application of biological, physical and chemical agents and techniques to seed that provide protection to seeds and plants and improve the establishment of healthy crops.

Fungal bio agents
Trichoderma spp. is an antagonistic cellulolytic fungi has been found effective against aerial, root and soil pathogens (Elad, 2000; Chaube et al., 2002; Harman et al., 2004) [11, 6, 13]. Trichoderma spp i.e., T. harzianum, T. viride and T. virens etc., isolates from rhizosphere were found to have good antagonistic potential against many soil born fungi, such as Fusarium oxysporum, Sclerotium rolfsii, Rhizoctonia solani.
**Trichoderma** spp. produce antibiotics and antifungal toxic metabolites viz., *Trichodermin, viridin etc.* and also inhibit pathogens by secreting enzymes like glucanase, cellulase, chitinase, protease *etc.* which disintegrate the cell wall of pathogen and act as a competitor for mineral nutrients.

**Bacterial bio agents**

Various species of the genus *Pasteuria* can be used to control nematodes, microscopic worms that feed on plant roots. The species of bacteria is specific to the species of nematode to be controlled. The spores of the bacteria germinate in the nematode, reproducing and causing death. Bio agents are considered important biological weapons of sustainable agricultural in recent years for managing of many soil-borne plant pathogens, which considers an environmentally friendly and sustainable alternative approach for disease management. The obtained results give a potential of the combination of *B. subtilis* and *P. fluorescens* with compost as efficient protection agents against Fusarium wilt of eggplant (Khairy Abdel-Maksoud Abada et al., 2018) [10].

**Virul bio agents**

A bacteriophage is a virus that infects bacterial cell walls. If the virus attacks bacteria that cause plant disease, it can be used as a pesticide. One example is a product made by Omnilitics to kill *Xanthamonas* (Braverman, 2008). It can replace conventional products include copper or antibiotics such as streptomycin, a commonly used as plant antibiotic. As with bacteria that cause disease in humans, plant pathogenic bacteria develop resistance to antibiotics, and can contribute to the evolution of highly resistant bacterial strains (super bugs) and the cost to develop more potent antibiotics to control them.

**Botanicals**

Bio pesticides from various plants have a long history. Even in Neolithic period (7000 BC) farmers in their own way prepared pesticides from various plant extracts. It is reported more than 600 plant species in the world can control harmful pests. Leaf and fruit extract of bael used against pests in certain region of India. Leaf extract of black mustard (*Brassica nigra*) is also considered as pesticide for jute when leaf extract of brown mustard (*B. juncea*) is an important pesticide for paddy burn spot.

Antifungal properties of leaf extracts of *Lawsonia inermis*, *Erythrina chinap apasana*, *Carissa carandas,Ficus benghalensis*, *Catharanthus roseus*, *Nerium oleander*, *Zingiber officinale*, *Z. cuminii*, *Ricinus communis* and *Aloe vera* and bulb, *Allium sativum* extracts at 2 and 5% concentration were evaluate against *A. brassicae*. Maximum inhibition of mycelia growth of the pathogen was found from extract of *A. sativum* at both concentrations, followed by the extracts of *L. inermis* (30.0%), *E. chiapasana* (25.5%), *R. communis* (16.8%) and *Zofficinale* (16.3%) at 5% each (Meena and Sharma, 2012) [12].

**References**