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A Review - Diplomacy of Fungicides: The Boon Becoming Threat for Sustainable Agriculture

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A B S T R A C T

In order to feed increasing population there is need of solution which can provide quick result which is possible with fungicides. Fungicides are necessary evils to kill unwanted pest and disease causing organisms in the agro-ecosystem. These are indispensible tool for protecting the crops and increasing food production. Soil applications of fungicides have been frequently used to control soil borne fungal diseases. Fungicides are used for killing or inhibiting the growth of fungus. They are extensively used in pharmaceutical industry, agriculture, in protection of seed during storage and in preventing the growth of fungi that produce toxins. Hence, fungicides production is constantly increasing as a result of their great importance to agriculture. On the other hand some fungicides affect humans and beneficial microorganisms including insects, birds and fish thus public concern about their effects is increasing day by day. Moreover, certain fungicides, usually systemic fungicides, are said to be 'at risk' to the development of resistance if they are used repeatedly. In order to enrich the knowledge on beneficial and adverse effects of fungicides this article summarized impact of fungicide on photosynthesis, lipid steroid & membrane, nucleic acid, amino acid & protein synthesis, respiration, mitosis and cell division, and Multisite activity, as well as on their side effects on non target organisms

Introduction

Agriculture is the backbone of Indian economy. In India, around 70% of the population earns its livelihood from agriculture. It still provides livelihood to the people in our country. It fulfils the basic need of human beings and animals. It is an important source of raw material for many agro based industries. India's geographical condition is unique for agriculture because it provides many favourable conditions. There are plain areas, fertile soil, long growing season and wide variation in climatic condition etc. According to the Census 2011, India's population over the decade has

increased from 102.8 crore in 2001 to 121.1crore in 2011. The increasing global population and higher demand of food leads to sustainable increase in food production through intensive agriculture concerning the public health. To solve the problem of food crisis and to increase in food production in the country the "Green revolution" began in 1960s through the introduction of high-yield crop varieties and application of modern agricultural techniques. To improve agriculture in India, introduction of high-yielding varieties, increased use of chemicals and irrigation is done which led to the increase in production thus making the India self-sufficient in food grains. In the last 60 years, the use of chemicals in agriculture has risen astronomically in India to provide sufficient food to increasing population but its indiscriminate use results in deterioration of soil health in many parts of the country. In 1951-52, chemicals usage has risen to 133 kg per hectare in the country which was earlier averaged less than one kg per hectare. Soil microorganisms can have both positive and negative effects on plant growth (Table 1 and 2).

They can facilitate nutrient absorption by plants, promote plant growth or stimulate seedling development by producing hormone-like substances suppress and control plant pathogens and diseases through various antagonistic activities or adversely affect plant growth through their pathogenic behaviour. The overuse of chemical deteriorating the soil microbial community. Soil microbial community plays an important role in various ecosystems. Thus the change in it affects the ecosystem. Among the chemicals fungicides significantly affect soil microbial characteristics. Fungicide affects microorganisms in agricultural soil specially involved in Nitrogen cycle. It deserve a great deal of attention as it play crucial role in environment. Application of fungicide to soil may affect the microbial communities composition and characteristics thus disturbing the soil fertility and food production. In view of the deterioration in soil health and human health hazards, the Government, in 2008-09 launched a new scheme, namely the National Project on Management of Soil Health and Fertility, to promote soil test- based balanced and judicious use of chemicals in conjunction with organic manure. In addition, the National Project on Organic Farming was started in 2004-05 to promote the use of organic fertilisers.

Importance and uses of fungicides

Worldwide, 20% yield reductions occur in major food and cash crops due to the plant diseases (Gullino *et al.,* 2000). Fungicides are a vital solution to control plant disease caused by pest and pathogen. In the past few years, there has been increased controversy over whether fungicides should be applied to field crops in the absence of disease.

Fungicides are the chemical compounds that may be fungicidal or fungistatic which kill or inhibit respectively the growth of fungi or fungal spores (Gullino *et al.,* 2000). Fungicide use play crucial role in controlling the plant disease in the agriculture system. It control fungi and became the primary means due to its low cost, effectiveness and ease of use (Xia *et al.,* 2006). However, the new resistant strains of pathogen appear due to extensive use of these chemicals to the available commercial products (Garcia *et al.,* 2003).

Fungicide toxicity has also been demonstrated in mammals (Belpoggi *et al.,* 2002) including humans (Mendes *et al.,* 2005), not always restricted to the target pest organism. The indiscriminate fungicides use to control fungal disease in plant protection generates long term residues in food and in the environment (EFSA, 2009; Petit *et al.,* 2008).

To assess the hazards in agriculture associated with use of fungicide, it is important to understand the effect of fungicides on the beneficial activities of microorganisms. By controlling fungal pathogens and preserving beneficial organisms, crop production and economics returns can be maximize. To promote sustainable agriculture, fungicide modes of action and its possible side effects on non-target microorganisms must be clarified. Fungicides mode of action and side effect has never been well understood. Therefore, fungicide use may have negative impacts that are difficult to predict.

One side fungicide proves to be a boon for farmer by controlling many pathogens listed below in Table 3. On the other hand it develops resistance in pathogen due to extensive use.

Fungicidal resistance

Fungicidal resistance is the inherited ability of plant disease causing organism to survive doses of a fungicide that would normally control it. Resistance usually develop after frequent, or fungicides from the same activity group (Table 4).

Effect of fungicides on photosynthesis

Application of fungicides alters the crop physiology, in terms of growth and development along with nitrogen, and or carbon metabolism (Saladin and Clement 2005).

Several works on photosynthesis fluctuations after fungicide application on various crops report modifications of both photosynthetic activity and chlorophyll fluorescence (Krugh and Miles 1996; van Iersel and Bugbee 1996; Untiedt and Blanke 2004; Xia *et al.*, 2006).

Copper has a pronounced effect on chloroplast ultrastructure (Baszynski *et al.*, 1988).

Chemicals exerts an influence on photosynthesis by clogging stomata mechanically also impeding CO_2 diffusion, by changing optical property of leaves (change in reflectance, decrease of light intensity), altering the heat balance of leaves (cooling effect or light coloured sprays, warming effect of dark spray, metabolic interferences of absorbed compound and stimulating changes in anatomy. Bordeux mixture spray sometimes causes slight decrease in photosynthesis. Lime sulphur spray checked photosynthesis greatly. Lime sulphur also caused 20 percent reduction of photosynthesis in Mcintosh and Baldwin variety of apple trees (Kozlowski and keller, 2009).

Fungicides effects on Lipids, Sterol Synthesis and Other Membrane Components

The cell membrane separates the cell content from the outside environment as it is a selectively permeable. It perform many biological functions in all living cells. It provide shape to the cell, maintain cell water, interrupt the passage of large molecules and are involved in signal transduction [Albert *et al.,* 2002]. Structure and function of soil microbial communities alter due to negative impacts of fungicide on the membrane of microorganisms

Effects on Amino Acids and Protein Synthesis

Protein is made of amino acids. They are the important building blocks in living organisms. It perform some important biological functions such as delivering signals among cells, making up the cytoskeleton and catalyzing biochemical reactions (Lodish *et al.,* 2000). Several fungicides affecting the biological functions of organisms by interfering of amino acids and proteins biosynthesis.

Table.1 Fungicides used in India agriculture

1.	**Highest consumption**	**Mencozeb (2828MT) Sulphur (2628MT)**
2.	Registered fungicides in India	47
3.	Mancozeb, Sulphur, Copper oxychloride, Carbendazim, Thiram	86.8% of total fungicide, used in India in which
4.	Mancozeb consumption	25%
5.	Carbendazim	7.4%
6.	Thiram disulphide	3.8%

Table.2 Crop wise consumption of fungicides

1.	**Pome fruits**	**12.7%**
2.	Potato	12.2%
3.	Rice	12.0%
4.	Tea	9.40%
5.	Coffee	8.0%

Table.3 Fungicides with their doses and pathogen controlled

Fungicides	Dosages (%)	Pathogen controlled
Bordeaux mixture	1	Phythium, Phytophthora
Copper oxychloride	0.2 to 0.3	Phythium, Phytophthora
Captafol	0.3	Macrophomina, Phythium, Phytophthora, Rhizoctonia
Carbendazim	0.15	Rhizoctonia, Fusarium, Sclerotium
Metalaxyl	0.2	Phythium, Phytophthora
Vitavax	0.15	Rhizoctonia, Fusarium, Sclerotium
Fosetyl-Aluminium	0.2	Phythium, Phytophthora

Source: Plant Pathology an overview

Table.4 Fungicides that develop resistance against some pathogen due to Indiscriminate or over use

Pathogen	Fungicides
Penicillium spp.	**Diphenyl**
Tilletia spp.	**Hexachlorobenzene**
Rhizoctonia spp.	**Pentachloro Nitro benzene (PCNB)**
Venturia inaequalis	**Dodine**
Erwinia amylovora	**Streptomycin (bactericide)**
Cladosporium cucumerinum	**6-azauracil**
Pyrenophora avenae	**Chlorinated nitrobenzene and organic mercury compounds**
Sphaerotheca fuliginea	**Benomyl, Dimethirimol**
Erysiphe graminis	**Ethirimol**
Botrytis cinerea	**Dichloran, PCNB**
Ustilago maydis	**Antimycin A**
Downy mildew fungi	**Metalaxyl**

Source: Plant Pathology an overview

Effects on mitosis and cell division

Seiler (1975) and McCarroll *et al.,* (2002) reported that the mitosis and cell division in target fungi was effected by methyl benzimidazole carbamate (MBC) fungicides. Gupta (2004), Davidse (1986) and Koo *et al.*, (2009) reported that these MBC fungicides bind on β-tubulin in microtubules inhibiting their proliferation and suppressing their dynamic instability. Previous research also revealed the inhibitory effects of these fungicides on tubulin polymerization into microtubules.

Effect on respiration

Several fungicides with different modes of action were reported to inhibit microbial respiration

The relationships existing between fungicides, the soil microorganisms, and other environmental factors are complex and difficult to predict. On the other hand, the multiplicity of fungicides' modes of action increases the difficulty of evaluating the risks associated with fungicide use. Understanding fungicides mode of action and impact on metabolism could help us using fungicide more wisely in agriculture.

It is expected that fungicides remain an essential tool for plant disease management and will continue to play a crucial role in optimizing yields thus overall production from the world crops. Therefore, the development of new chemical compounds with lower negative impact in plant physiology is a future challenge. This will provide benefits not only for plants yield but also for the environment and human health.

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