Herbal Pesticides in Plant Health Management

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Abstract

Our world is facing tremendous crop losses. Crop losses occur due to pathogens which may be fungi, bacteria, nematodes, viruses, etc. It has been observed that the major crops particularly wheat, rice, maize, and potato which are consumed in most of the countries are being affected by the pathogens and causing financial breakout throughout the decade. To minimize the crop losses farmers are consuming chemical pesticides on a large scale. Chemical pesticides control diseases to some extent but its effect is quite dangerous. Chemical pesticides cause great loss to the environment, it kills the beneficial microbes which are present in the topmost soil. It also causes diseases such as cancer, skin diseases to human beings. Thus to minimize the consumption of chemical pesticides, more emphasis should be given to herbal pesticides. Herbal pesticides not only protect the crop from being infected, but it also causes no harm to human being. It is eco-friendly, cheaper, and can be easily produced.

Keywords

Crop, Chemical, Consumption, Herbal

Introduction

Nature Earth constitutes a majority of Plants be it trees, flowers, grass, and so on. Plants are the sole living organisms which prepare the food on which most of the organism depends directly or indirectly. Plants constitute the higher organisms that convert sunlight into chemical energy in the form of carbohydrates, fats, proteins, etc. The survival of human beings and animals is dependent on plants and their products (Agrios, 2005). Plants require sufficient nutrients along with the raw products to prepare their food. However, if any of the raw products or nutrients are not in the normal range, physiological functions are disturbed.

Alike us, plants also become sick which may be due to any unfavorable factor or some biotic agents commonly called pathogens. A sick plant usually shows specific symptoms and growth becomes debarred. Biotic agents include pathogenic microorganisms such as fungi, bacteria, viruses, protozoans, nematodes, and insects. A sick or diseased plant however cannot communicate with us or it is also not known whether they feel pain or discomfort. Some signs are visible externally. Those signs are called symptoms. When the capability of the cell of the plant of any plant part to carry out any of the physiological function is interfered by pathogenic microbes or any other unfavorable factors, the activities of the cells become disrupted or altered. At first, the infection is seen in a few cells, later the reaction becomes widespread to most of the cells. The kind of the cell or tissues which are affected determines the type of physiological activity that becomes disturbed. For example infection of roots disturbs the absorption of

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water and minerals from the soil, infection of foliage disturbs photosynthesis, infection of phloem cells in the veins of the leaves, the infected cells or tissues in most of the cases die or weakens. In many cases, abnormal growth of cells or tissues is also observed.

Crops whether wild or cultivated becomes infected with pathogenic microorganisms or due to any unfavorable condition it cannot grow which leads to crop losses. Crop losses particularly lead to a reduction in crop performance and ultimately in lower yield than the site-specific attainable yield/production of crops. Pests particularly microorganisms or insects attack crops and disrupt all their physiological activities which in turn become died. According to Boote *et al.* (1983) pest reduce the crop productivity through many ways which can be identified based on their impacts as reducers (damping-off pathogens), photosynthetic rate reducers (fungi, bacteria, viruses), leaf senescence accelerators (pathogens), light stealers (weeds, some pathogens), assimilate sappers (nematodes, pathogens, sucking arthropods), and tissue consumers (chewing animals, necrotrophic pathogens). Weeds affect crop productivity especially due to the competition for inorganic nutrients. According to Savary *et al.*, 2012, the yield losses caused by pathogenic microorganisms, pests, and weeds are recorded in between 20% to 40% of global agricultural productivity. Out of all the pathogenic microorganisms, it has been recorded that plant nematodes cause a loss of US$ 100 billion per year to world agriculture (Kayani *et al*., 2017 and Mukhtar *et al.,* 2017a,b).

Crop losses may be quantitative and/or qualitative. Quantitative losses result from reduced productivity, leading to a smaller yield per unit area. Qualitative losses from pests may result from the reduced content of valuable ingredients, reduced market quality, e.g. due to aesthetic features (pigmentation), reduced storage characteristics, or due to the contamination of the harvested product with pests, parts of pests, or toxic products of the pests (e.g. mycotoxins).

Crop losses may be expressed in absolute terms (kg/ha, financial loss/ha) or relative terms (loss in %). The loss rate may be expressed as the proportion of attainable yield (the preferred method of calculation) but sometimes the proportion of the actual yield is calculated. The economic relevance of crop losses may be assessed by comparing the costs of control options with the potential income from the crop losses prevented due to pest control. Often, it is not economically justifiable to reduce high loss rates at low crop productivity, as the absolute yield gain from pest control is only low. In contrast, in high input production systems, the reduction of low loss rates may result in a net economic benefit for the farmer.

Crop loss rates are differentiated into the potential loss and the actual loss. The potential loss from pests includes the losses without physical, biological, or chemical crop protection compared with yields with a similar intensity of crop production (fertilization, irrigation, cultivars, etc.) in a no-loss scenario. The efficacy of crop protection practices may be calculated as the percentage of potential losses prevented. In contrast, the impact of pesticide use on crop productivity may be assessed only by generating a second scenario considering changes in the production system provoked by the abandonment or ban of pesticides – use of other varieties of the crop, modified crop rotation, lower fertilizer use, etc. – and often associated with reduced attainable yield.

According to Zadoks and Schein (1979), various loss levels may be differentiated, e.g. direct and indirect losses, or primary and secondary losses, indicates that pests not only endanger crop productivity and reduce the farmer's net income but may also affect the supply of food and feed as well as the economies of rural areas and even countries. Crop losses are causing serious financial outbreaks to farmers and landlords. However many protection strategies have been implied accompanying less loss of crops. The estimate of crop losses due to pests is also provided. Crop protection aimed to avoid or prevent crop losses and to reduce them to an economically acceptable level, however, the report on quantitative data on the effect of pathogens, pests, and weeds on crop losses is very much limited. The making of data is however very time-consuming as crop losses vary from season to season and from one period of time to another. Early reports from German authorities imply that animal pests and fungal pathogens caused a total loss of 10% of the cereal yield in 1929. According to Morstatt, 1929 in potato pathogens and animal pests reduced production by 25 and 5%, respectively; while in sugar beet, production was reduced by 5 and 10% due to pathogens and animal pests respectively. Similarly, in the USA, pre-harvest losses caused by insects are up to 10%, after which the US department of agriculture had put records on crop losses 1927, 1931, 1939, 1954, and 1965 (Cramer,1967).

The recent report of crop losses due to pests and pathogens in the year 2001-03 has also been estimated. Wheat losses due from the year 2001-03 have been estimated and it has been observed that in 2001–03, almost 564×10^6 t of wheat were grown on 209.4×10^6 ha (annual data from FAO 2005). With a worldwide average of 2690 kg/ha, the yield per unit of area varied from less than 500 kg/ha to almost 8500 kg/ha in Ireland. Weed is the most important pest of wheat worldwide. It has been observed that the incidence of some pathogens such as *Blumeria graminis, Septoria* spp., and rust fungi increase with the intensity of crop protection and the region where wheat productivity is quite low and without seed dressing, smuts and bunts are symptoms which are commonly seen. Arthropods, rodents, nematodes, and birds cause significant losses to wheat production whereas viruses cause less impact on wheat productivity.

The loss of rice productivity has also been highlighted. It is considered to be one of the most staple food grown worldwide which is grown under different growth conditions with widely differing yield levels, with irrigated and non-irrigated lowland rice and dryland rice being most important. In 2001–03, 583×10^6 t rice was produced on 149.6×10^6 ha giving an average yield of 3900 kg/ha (annual data from FAO 2005). Loss of rice production is caused primarily by weeds, animal pests, and pathogens, especially *Magnaporthe grisea*, *Thanatephorus cucumeris,* and *Cochliobolus miyabeanus*, are regularly of economic importance. The differences in loss of rice productivity resulted from the cropping intensity (diseases, weeds), climatic conditions (especially insects), and cropping systems (weeds). Viruses transmitted by insect vectors, although devastating in some fields, were of minor importance (average potential losses 2%) and caused actual losses of less than 1.5%.

The production of maize is highest in the Americas – the USA is by far the greatest producer and exporter – and in East Asia and most of the region such as in Latin America

and parts of Africa maize is the staple food. In 2001–03, worldwide maize production reached 612×10^6 t on 139.8×10^6 ha (annual data from FAO 2005). Weeds are reported to be the major pest in maize production. The competition from weeds resulted in less maize production. It has been observed that the potential losses due to weeds are much more than the combined loss from animal pests, pathogens, and viruses.

Potato is also one of the most important crops in the world. In 2001–03, potatoes were grown on 19.1×10^6 ha producing 309.0×10^6 t (annual data from FAO 2005). Since potato can produce through vegetative propagation, all the pests are equally very much important in crop losses. The estimates of a loss of potato yield from pathogens, viruses, animal pests, and weeds ranged from 14,7,11 and 8% respectively. Major pathogens responsible for potato losses are pathogens (*Phytophthora infestans, Alternaria solani,* and *Thanatephorus cucumeris*), viruses *(potato leafroll luteovirus*, potato *potyvirus* Y, etc.), and animal pests (potato cyst nematodes, Colorado beetle, *Phthorimaea operculella*, etc.)

Crop protection

Considering the huge crop losses, the protection of crops from pests is a major concern. Farmers use a variety of pesticides largely chemical pesticides to eradicate the losses caused by pests to the crops. During the 19th century, inorganic agents such as copper and sulphur were mainly used as pesticides to control mildew caused by pathogenic fungi. The first synthetic pesticides were reported to be dinitro cresol, marketed in 1892. During World War II, pesticides named dichloro-diphenyl-dichloro-ethane (DDT) along with others were used primarily to control vermin.

Consequently, farmers in developed countries started using DDT and related hydrocarbon insecticides. Parathion, a by-product of efforts to develop a war gas, was reported to be used quickly in agriculture in the form of insecticides. Shortly after the end of the Second World War first herbicides, 2-4 D was developed. Thus chemical pesticides became a major part of intensive agriculture practices, along with high –yielding varieties, irrigation, fertilizers, and mechanization. Presently pesticides are mainly used in the form of insecticides, fungicides, and herbicides. For cultivating fruits and vegetables, rice, maize, cotton, and soybeans, about 85 percent of the total pesticides are used while in developing countries pesticides are used primarily on high-value crops, of which most of the crops are export crops. In cotton, a large amount of pesticides is used. About 95% of the pesticides are used in West Africa and 50 percent of that used in India is applied to cotton. Moreover, a relatively large amount of pesticides is used in rice. Apart from these relatively little pesticides is used on most of the basic, subsistence food crops (other than rice and, to a lesser extent, potatoes) grown primarily by small-scale producers (Yudelmann *et al*., 1988). Thus, major emphasis was on chemical pesticides by the farmers.

Apart from the chemical pesticides, a little emphasis was given to herbal pesticides. Herbal pesticides are prepared from natural ingredients as compared to chemical pesticides which are less harmful to the environment. Herbal pesticides are eco friendly. Some of the herbal insecticides and pesticides effective against pests reported (Shaeba Mariam shaji *et al*., 2017) are-

• Lemongrass oil-insect repellant

• Neem oil- mealy bug, beet armyworm, aphids, and the cabbageworm, thrips, whiteflies, mites, fungus gnats, beetles, moth larvae, mushroom flies, Leaf miners, caterpillars, locust, nematodes, and the Japanese beetle.

• Chrysanthemum-insect repellant

• Cedar oil- insecticidal and antifungal properties

• Catnip- Mosquito and fly repellant

• Clove-ant repellent

• Nasturtiums-attract predatory insects

• *Anagallis arvensis* –insect repellent

• Venus fly trap-trap insects and arachnids

• Breadfruit-insect repellent

• Eucalyptus oil- insect repellent and biopesticide.

• Orange oil-biological pest control green pesticides

• Chamomile-fungi, insects and viruses repellent

• Spearmint - effective insecticide against adult moths

• Citronella oil-mosquitoes

• *Achillea alpina* - mosquitoes

• *Alpha terpinene* - mosquitoes

• Borage - tomato hornworm, cabbage worms

• Basil - flies, mosquitoes, whiteflies, carrot fly, asparagus beetles

• Castor bean - moles

• Fennel - mosquitoes, snails, aphids, slugs

• Camphor - moths

• Carvacrol - mosquitoes

• Castor oil - mosquitoes

• Celery extract - mosquitoes

• Cinnamon - mosquito larvae

• Citronella oil - mosquitoes

• Dahlias - nematodes

• Dill - aphids, cabbage looper, squash bugs

• Garlic - rice weevil, mosquito, wheat flour beetle

Importance of herbal pesticides and why they are used?

Due to the huge crop losses, farmers are much more dependent on chemical

pesticides. However chemical pesticides have many negative effects on the environment. Some of the major effects of chemical pesticides are-

The emergence of pest resistance

Crop losses can be minimized with the application of pesticides but the continuous use of chemical pesticides has led to increases and unnecessary pests' outbreaks due to the destruction of natural enemies of the pests and emergence of both pest resistance and secondary pests. The increased resistance and outbreaks of pests have pressurized farmers to use stronger pesticides to kill the mutating pests to a greater extent. The mutation in pests' leads to their resistance has worsened over time. The vigorous use of pesticides disturbs the natural environment and ecological balance between pests and their predators in most of the developed and developing countries. It has been reported that the destruction of natural enemies of pests due to the vigorous use of the chemical; pesticides have increased the emergence of many new primary and secondary pests of cotton which includes cotton bollworm, tobacco budworm, cotton aphids, etc.

In India, the excessive and indiscriminate use of the chemical pesticides resulted in increased pests resistance has also been reported. The first report was the use of DDT and benzene- hexachloride (BHC) in 1963, which results in the resistance to chlorinated hydrocarbons and organophosphate-based pesticides. In recent years, a great degree of resistance has been observed in *Herlithesis armigera*, which is prey on cotton, chickpea, and pigeon pea has also increased in recent years. According to Alam, 1995 the average Indian meal consists of a high amount of toxic pesticide residues, the daily consumption of chemicals in the form of pesticide residue is reported to be about 0.51 mg, well above the accepted levels.

Thus the excessive use of pesticides leads to increased resistance of pests, which led to the increase in the use of stronger pesticides, thus causes an increase in the costs of production, decreases the yield, and finally to the destruction of the productivity of the particular area.

Health and environmental effects

According to Conway 1995 and Blackman 1997, it has been noted that widespread presumption of chemical pesticides is harmful to human health and the environment. Most of the pesticides particularly insecticides consists of lots of toxic compounds and cause lots of problems in inhaling, ingesting, contact while spraying, or consuming crops with pesticide residues left on them. Pesticides that are of older types cause cancer, birth defects, genetic mutations, and behavioral changes. They also cause allergies, breathing trouble, and also affect the liver, kidneys, and nervous system. According to Repetto and Baliga 1996; Farah 1994, the concentration of persistent organochlorine compounds such as DDT in the fat of mother's milk causes a lot of health problems to her child. Increased use of chemical pesticides also affects the endocrine system of both human beings and wildlife (WWF 1996; Repetto and Baliga, 1996).

Vigorous use of chemical pesticides also had harmful effects on the environment. Pesticides if persists in the soil for many days break down into more

toxic chemicals that will contaminate crops and water systems (WWF 1996). Pesticides can also cause a threat to the water bodies if washed away to the water system along with rain.

Considering the harmful effects of chemical pesticides, one must rely on herbal pesticides. As herbal pesticides are made up of only natural ingredients, they are seemed to be more useful. Some of the importance of using herbal pesticides is and why we should focus on the use of herbal pesticides are-

- Herbal pesticides are less harmful to nature and human beings.
- Herbal pesticides are cheaper, renewable, and can be handled easily.
- Herbal pesticides are biodegradable.
- They are less toxic to plants.
- Herbal pesticides are more economical.
- It is much more difficult for insects to develop resistance if herbal pesticides are used.
- It also prevents spoilage of stored foods.
- Herbal pesticides are also used to control household pests.
- Herbal pesticides are safe for higher organisms.

Preparation of herbal pesticides formulation

The preparation of herbal pesticides has been carried out by many organizations. The complete process of production of herbal pesticides is somewhat time-consuming. The complete process of production of herbal pesticides is represented in Fig 1 (Singh *et al.,* 2013.)

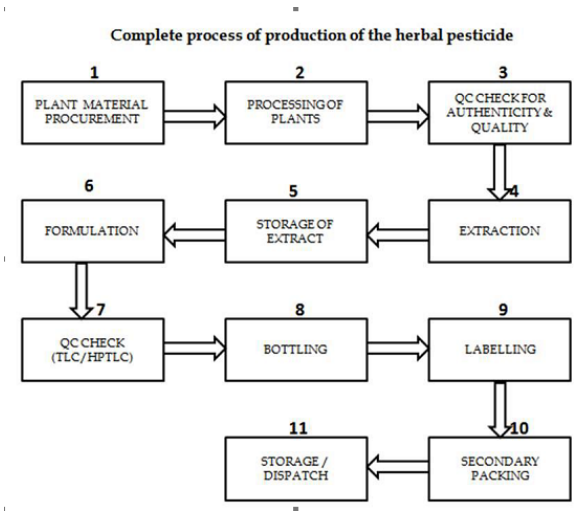

Figure 1. Complete process of production of herbal pesticides

One organization named SRISTI Sarvatra is a voluntary organization which was formed in Ahmadabad Gujarat, India formulated herbal pesticides production. They used different plant parts(*Azadirachta indica, Pongamia pinnata, Ricinus communis, Vitex negundo, Ferula asafoetida*) in different forms (seed cake, aqueous extracts, border crops, etc.) to protect their crops from insect and pest attack.

Conclusion

Plant diseases are increasing at a tremendous rate along with the evolution of new kinds of pathogens. Thus to protect plants from diseases and to overcome the loss, it has become necessary to use pesticides. Pesticides helped in eradicating the crop loss to some extent. Chemical pesticides are used on a large scale, but there should be much more emphasis on the use of herbal pesticides. Herbal pesticides not only protect the crop from severe plant diseases but also protect the environment. Herbal pesticides are eco-friendly and cheaper as compared to chemical pesticides. Many reports highlighted the process of production of herbal pesticides and also in the growing demand for use of herbal pesticides by the farmers. Thus herbal pesticides should be used more to eradicate the crop losses.

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