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Biopesticide, their Ecological and Toxicological Effects (Review)

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Abstract: Intensive farming as a way of enhancing food security is utterly necessary and pest control remains indispensable. When highly specified, biopesticides can be utterly benign in their human and environmental effects. But, in recent times, a quasi-exponential increase has been observed in the ecological and toxicological effect of bio-pesticide. This paper focuses on; Biopesticides, Sources, Preparation, Ecological friendliness, Ecological and Toxicological effects. Amongst the factors raising ecological and toxicological effects of bio-pesticide are lack of knowledge about pest/pathogens against which they can be applied successfully, which makes bio-pesticides biological weapons. The consistent use of biopesticides which has the potential of increasing the microbial carriage capacity of the ecosystem, leading to ecological adjustment which ranges from environment contamination to increase microbial strain resistance through horizontal gene transfer.

Keywords: Biopesticides, Ecology, Toxicology

Introduction

The problem of pest control for sustainable agriculture has been of great concern especially, in the tropics. Biopesticides helps in the control of pests, pathogens and weeds in a variety of mechanisms. These groups of pesticides synthesized from natural precursor materials such as; bacteria, fungi and plants product (natural product) inhibits the survival of the target (pest). Some achieve this biocidal mechanism by inhibiting the growth, impending feeding and reproduction of pest or pathogen. To achieve this, some may be used to build a barrier on the host which serves as infection or feeding inhibitor. Biopesticides are a class of pest killers derived from natural or organic materials which include plants (Botanical origin), bacteria, fungi and virus (microbial origin) etc. (Thakore, 2006). Biopesticide generally promotes the principles of green chemistry especially, less hazardous chemical syntheses. But, biopesticides control pests and disease both selectively or with broad spectrum approach and are inherently less toxic than conventional pesticides. The use of biopesticides dates back to the 17th century, when nicotine was used to control plum beetles. Experiment dated far back 1835 shows that white-muscadine fungus (Beauveria bassiana) was used to cause infectious disease in silkworm. The first and still most widely used biopesticides included spores of the bacteria, *Bacillus thuringiensis* (Bt). O'Brien *et al.*, (2009), has put forward that, the society has receive signals about the non-environmental benign nature of chemicals used for conventional pest control. From human to ecological health impacts, there are growing concerns. This concern is gradually raising challenges as well on the use of biopesticides. Consistent use has the potential of increasing the microbial carriage capacity of the ecosystem, and their long term effect causes an ecological adjustment which ranges from environment contamination to increase microbial strain resistance.

Sources of Biopesticides

With the advent of new techniques like molecular genetic engineering and protein engineering, biopesticides have seen an improvement in their production (Leng *et al.*, 2011). The gradual improvement of biopesticides production has developed excellent application prospect with extensive social and economic benefits. According to the US Environmental Protection Agency (2016), 299 biopesticides have been registered.

The sources of biopesticides are the bases for their classification. According to the US Environmental Protection Agency (2016), there are basically, three classes of biopesticides and there sources.

1. Biochemical pesticides (insect sex pheromones, scented plant extracts that attract pests to traps): these naturally occurring substances that control pests by non-toxic mechanisms.

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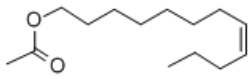
2. Microbial pesticide (bacterium, fungus, virus and protozoan) microbial pesticides can control many different kinds of pests, each separate active ingredient is relatively specific for it targets pest.
3. Plant Incorporated Protectants (PIPs) are pesticidal substances that plants produce from genetic materials that has been added to the plant example, gene of Bt pesticidal protein, introduce into the gene of plants own genetic material and the plant in turn synthesize the substance that destroys the pest and not the plant itself.

Biopesticides despite their coroneted natural advent, can however be seen in two broad sense in term of their sources. These are:

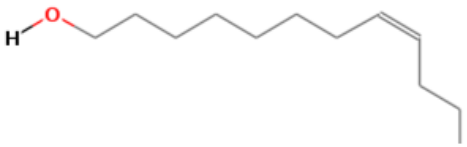
1. Synthetic Sources
2. Natural Sources

Synthetic Sources of Biopesticides

When components are combined to make a whole with specification through a chemical reaction, this can be term synthetic. Although synthesis goes beyond the human synthetic processes, as plants and humans synthesized their own fluids through natural processes. In this paper, we review synthetic sources base on human efforts to improve the natural matter. According to O'Brien *et al.,* (2009), biochemical pesticides are a group of synthetically achieved biopesticides. Since, they can only be distinguished by their non-toxic nature; the active ingredient can be single molecule or a mixture of molecules, such as a naturally occurring mixture comprising a plant essential oil or a mixture of very structurally similar molecules called isomers as in the case of pheromones. In 2002, EPA registered 36 pheromones, which comprised of over 200 individual products (Ware and Whitacre, 2004). The advantages of insect pheromones include their high species specificity and low toxicity. An example of insect pheromone is that employed in the control of Macadamia Nut Borer. This comprises of a combination of three related molecules, with two being isomers of each other and the other an alcohol.



(Z) – 8 Dodecen-1-yl acetate



(Z) – 8 Dodecen-1-ol

O'Brien *et al.,* (2009) has summarized a mixture of dodecene isomers used to control a given species of pest.

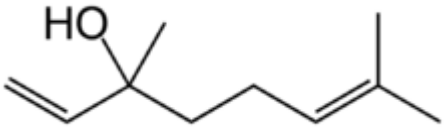
Table 1. Isomeric Mixtures of Sex Pheromones

Insect species	Scientific Name	Acetate isomers	Alcohol Isomers
Tea Torix	Homona magnanima	Z	
Black headed fireworm	Rhopobota naevana	Z	
European corn borer	Sotrinia nubilalis	Z and E	
Omnivorous leafroller	Platynota stultana	Z and E	Z and E
Tufted apple moth	Platynota	E	E
Light Brown Apple Moth	Epiphyas postvittana	E	

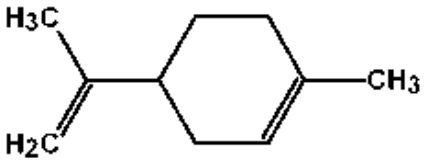
Natural Sources of Biopesticides

This class of biopesticides are often called botanical biopesticides or extract. They are mostly derived from plants extract and are term natural sources. It still remains a myth that all products derived from natural sources are safe. Literatures have reported that rotenone is very harmful to fishes and relatively toxic to human especially when ingested or inhaled NIOSH (1994). Pyrethrum is an extract from a specie of chrysanthemum and is commonly used in organic agriculture, yet it can be highly toxic. Pyrethrum quickly paralyzes and kills insects by altering the way their electrical impulses are transmitted by the nervous system; the mode of action is similar to that of DDT (Ware and Whitacare, 2004). This is indicative that if these extract (Pyrethrum and rotenone) are send into the ecosystem in high doses, they can be of harm to aquatic organisms, animals that create a balance of the ecosystem and even man.

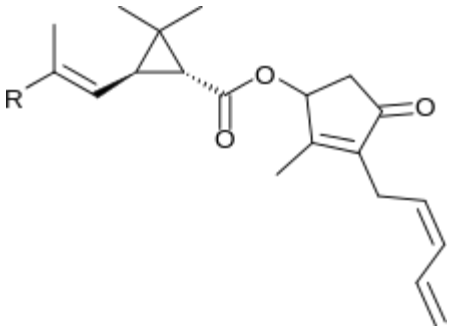
Nawaz *et al.*, (2016), have listed some plants products used as biopesticide; and linalool, Neem, Pyrethrins, Rotenone, Ryania, Sabadilla



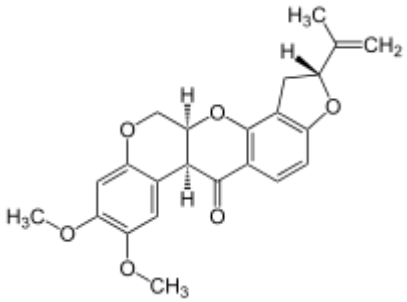
Linalool (birch trees, mint, citrus fruits, cinnamon plants)



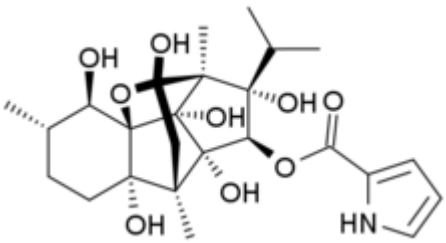
Limonene (citrus fruit)



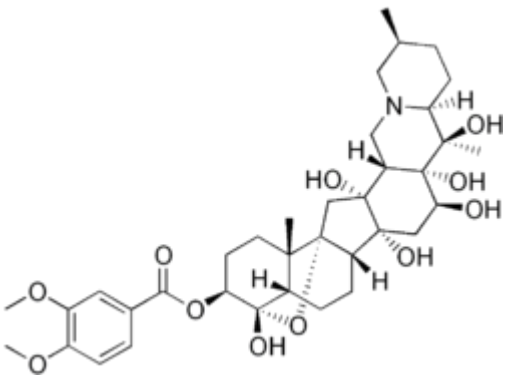
Pyrethrins (Chrysanthemum cinerariifolium)



Rotenone (barbasco, cub, haiari, nekoe, and timbo)



Ryanodine (*Ryania speciosa*)



Veratridine *(Veratrum* and sabadilla seeds)

ECOLOGICAL FRIENDLINESS

Agricultural productivity is the underlining benefits of biopesticides (Kumar, 2015). Baily *et al.*, (2010) has it that, a biopesticide is a mass-produced biologically based agent manufactured from a living microorganism or a natural product and which is sold for the control of plant pests. This reveals a pointer to their environmental advantage over conventional pesticides. It is no longer unknown that biopesticides shows benign tendencies on the environment which cannot be offered by the conventional pesticides. According to PAN (2010), a conventional pesticide affects both plants and animals. Repeated applications leads to loss of biodiversity, they persist in the soil, leach to ground water and surface water. Biopesticides are relatively friendly to the environment. Bioworks (2008), have listed the benefits of biopesticides as thus;

1. Help reduce use and cost of chemicals
2. Help reduce resistance to pesticides
3. Lower REI (restricted-entry interval)
4. Safer to use.

Environmental responsibility and sustainability of biopesticides is something to reckon with. They show REIs between 0-4 hours, making them safer. Biopesticides have no pre-harvest intervals, in some cases treated plants can be harvested immediately after application. It has been shown in many literatures that biopesticides are environmentally benign to an **extent**. Tinklein (2015) emphatically put forward that; biopesticides has ecological advantages like; **less toxicity to humans and animals,** they show a **'fairly'** narrow toxicity range, they are effective at relatively low concentration and usually degrade rapidly. In summary, promotion of the use of biopesticides reduce the use of conventional pesticides and also promote high crop yield because of effective pest control. Due to biopesticides environmental friendliness, they have seen an increase in consumption over the past decades. Dickshirt (2010), reported on their consumption rate which clocked approximatelt 1600 (MT) in 2005 to 2006.

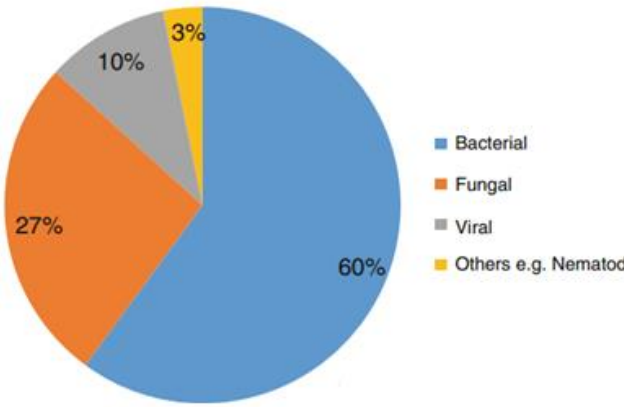


Figure 2: Types of microbial biopesticides used world wide
Source: Kabaluk *et al.*, 2010

ECOLOGICAL AND TOXICOLOGICAL EFFECTS

Yes biopesticides have benign tendencies than the conventional pesticides but, still have it bad sides. Ecological and toxicological effects of biopesticides arise due to formulation/non specificity, poor knowledge on elemental composition and how to use and human quest for biological pesticides resulting to deforestation. These factors must be considered in the preparation of biopesticides. Biopesticides with great specificity has less or no ecological and toxicological tendency (Soesanto, 2012). According to Chandler et al., (2012), most biopesticides are not sufficiently characterize in other to single out elemental components especially those use traditionally. Although carcinogens are often thought to be synthetic, it has been interestingly observed that, numerous carcinogens occur in nature, and in plants (Concon, 1988). Magnuson (1997), put forward that, tannic acid has caused liver tumors in experimental animals, and may be linked to esophageal cancer in humans. It very clear from photochemistry that tannins are present in almost all natural products. This assertion isn't enough for panics but requires a careful evaluation. However, Booth et al., (2012), has results suggesting that, TA has the potential to become an anti-ER+ (Estrogen Receptor Positive) breast cancer treatment or preventative agent. It also worthy of note that biopesticides when use with little or no professional knowledge can cause ecological imbalance. For instance, rotenone a class of botanical pesticide extracted from some tropical legumes is harmful to fishes (IPM, 2006 and O'Brien *et al.*, 2009). This is because the lipophilic rotenone is easily taken up by these aquatic organisms through gills or trachea. Open Chemistry Data Base (2016), have information on rotenone as a Chemical agents that uncouple oxidation from phosphorylation in the metabolic cycle so that ATP synthesis does not occur. The use of biopesticides which are of microbial origin can increase the microbial carriage capacity of the ecosysytem which can in turn lead to opportunistic infections, alteration in microbial genetic composition during horizontal genetic transfer which can lead to resistance in microbial strains to antibiotics (Tree, 2012). It is imperative to note that, horizontal gene transfer is the primary reason for the spread of antibiotics resistance in bacteria (Koonin *et al.*, 2001, Kay *et al.*, 2002, OECD, 2010 and Gyles *et al.*, 2014) and transmission of virulence (Keen, 2012)

CONCLUSION

The toxicity of biopesticides is gradually building up. But, environmental observations show a quasi-negative effect for the use of biopesticides. This is a wake call informing that, a more selective, sensitive and scientific approach should be employed in the synthesis, formulation and applications of biopesticides for a greener environment.

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