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Formulation of Essential Oil Pesticides Technology and their Application

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Abstract

The current study focused on a technology situation that can evolutes the industry of essential oil pesticide technology in Sudan for green production and provide strong base and guides to establish this green technology. The paper discussed what is a formulation? How to Choose a Formulation? Hypothesis and assumptions of prospected technological proposed formulation bits. The paper also discussed research questions What, How, Where, Why and when can achieve green evolution of essential oil for plants diseases and pests control. It reviewed different formulation types and techniques, adjuvant, spraying, proposed bits. It also discussed the expected proper bits of formulation of good essential oil pesticides, samples of more successful technology of essential oil pesticides. The analysis of results with proposed bits finalized by that the proposed bits, baseline and guidelines are a proper models for formulizing essential oils pesticide. In conclusion that essential oil technology in Sudan is a simple applicable and outstanding promising technology.

Keywords: Formulation; Essential oil; Pesticide; Technology; Application; Bits; Adjuvant; Surfactants

Background

The first investigation into the antimicrobial activity of essential oils was a study by Buchholtz who found that thymol has higher growth inhibitory properties on bacteria having been cultivated in a tabac decoction than phenol, which was previously considered to be the best systematic substance for use as surgical antiseptic [1]. The natural chemicals of essential oil have multiple modes of action, including antifeedant and repellent activities, moulting and respiration inhibition, growth and fecundity reduction and cuticle disruption, and can act as a contact, fumigant, repellent, antifeedant, and oviposition inhibition toxicants. Furthermore, the essential oils have been widely used as anti-parasitical, bactericidal, fungicidal, antiviral and insecticidal activities [2].

What is a Formulation?

Pesticides are available in various "formulations". A formulation is simply the form of a specific product that you use. Some insecticide formulations include dusts, gels, granules, liquids, aerosols, wettable powders, concentrates, and pre-mixed solutions. A pesticide formulation typically consists of an active ingredient, plus several inactive materials called adjuvants, or additives. The main purpose of additives is to increase the effectiveness of the active ingredient. Some common additives include spreaders, stickers, wetting agents, compatibility agents, and foaming agents.

How to Choose a Formulation

Any given active ingredient can often be purchased in more than one formulation. Same active ingredient for different products. The reason for this is that different formulations of the same active ingredient behave differently.

Knowing the characteristics of a given formulation will help you to choose the right product for your needs and use that product more effectively. Here are some points to consider when choosing a formulation. This information can usually be found on the product label are; Percent of active ingredient, Ease in handling and mixing, Personal safety risk, Type of environment (agriculture, forest, urban, etc.), Effectiveness against the pest, Habits of the target pest, the crop to be protected, type of application equipment or machinery, danger of drift or runoff, possible injury to crop and Cost.

Introduction

Pesticide can be in terms as; Active ingredient (a.i.), Emulsion, Fumigant, Impregnates, Pheromones, Phytotoxicity, Solution and Suspension. And the pesticide formulation may consist of:

i. The pesticide active ingredient (a.i.) that controls the target pest

ii. The carrier, such as an organic solvent or mineral clay

iii. Surface-active ingredients, such as stickers and spreaders; and/or

iv. Other ingredients, such as stabilizers, dyes, and chemicals that improve or enhance pesticidal activity [3].

Generally the results indicated that using of natural extract is the best choice for organic agric. production. In specific emphasis essential oil as a pesticide in vegetable disease is future conceptual preferable method of control; this because essential oils are: non residual effect component, quickly evaporate naturally, non toxic materials for human and animals whatever it used immediately, can acts as a healthy natural component for human disease treatment, it is a preferable one for vegetables because it is an edible and appreciable crop, easiness of preparation, it can be locally adapted technology even in rural areas, easiness of application, cheapest method, effective naturally method and environment friend components (green environment) [4]. It was postulated that there is a good stock of Sudanese essential oil and its extraction techniques, effectiveness of some essential oils against tomatoes diseases, formulation of essential oil pesticides and the prospective on the success of this technology. Nevertheless there is a possibility of domestication, technology adaptations and innovations of essential oil pesticides in Sudan [5]. And the factors enforce their success according to the previous studies in and abroad; and will be effective technology to green control of tomatoes diseases [5]. There would be negligible chance of development of resistant races after application of essential oils to fruit and vegetables and they are safer antifungal agents [5]. Essential oils and their components are gaining increasing interest because of their relatively safe status, their wide acceptance by consumers, and their exploitation for potential multi-purpose functional use [6]. Essential oils have been used successfully in combination with a variety of treatments, such as antibacterial agents, mild heat and salt compounds [7]. And essential oils are made up of many different volatile compounds and the composition of the oil quite often varies between species [8].

Over 2000 species of plants are known to possess some insecticidal activities. The essential oils are natural, volatile and complex compounds that gives their characteristic odours and they are formed as secondary metabolites in plants. In the nature those compounds plays an important role in the protection of the plants against bacteria, fungi, virus, insects and others herbivores.

Some researchers have demonstrated that essential oils have neurotoxic, citotoxic, phototoxic and mutagenic action among others in different organism, and the essential oils act at multiple levels in the insects, so the possibility of generating resistance is little probable.

Chemical fungicides are generally used in the control of fungal diseases. Recently, growing public concern over the health and environmental hazards associated with the increased levels of chemical pesticides and the lack of approval for the renewal of some of the most effective active molecules, has led to the development of safe, alternative, and natural methods of post-harvest disease control [9]. Many studies were conducted *In-vitro* and *In-vivo* for inspection of the biological activities of essential oil to treat pests and diseases. It seems that the antifungal and antimicrobial effects are the result of many compounds acting synergistically [10], essential oil was found to have some antifungal activity [11], protectant fungicides like mancozeb and chlorothalonil or systemic fungicides in the strobilurin class [12]. Essential oil were found to be more effective against many gram positive and gram negative bacterial; coriander oil can be affective against gram positive and gram negative [13], spearmint can be affective against gram positive and gram negative [14], anise oil can be affective against gram positive and gram negative [15]. Quite a lot of preliminary work has been done to demonstrate the potential of essential oils for use against postharvest pathogens. Regarding the availability of essential oil in Sudan there are a great potentials of essential oils.

Sudan essential oil can be obtained from many sources wild herbs in millions of acres, cultivated herbs and seeds, forest sources and cultivated fruit trees [16,17]. There are many species and cultivars of essential oils in Sudan such as Basil, cympogon spp., cyprous [16,17], *Lavandula coronopifolia* Poir., [18], Seedy essential oil crops such as anise (*Pimpinella anisum* L.) [19]. They can provide a huge potential for organic cultivation and contiguous supply, beside the diversity of more than 360 species can provide an essential oil act ingredients cover any needs for any type of active ingredient from essential oil.

Crops loss due to insect pests varies between 10 and 30% for major crops. Management of agricultural pests over the past half century has been largely depending on the use of synthetic chemical pesticides for field and post-harvest protection of crops.

On the other hand, the main method to control insect pests is using of synthetic pesticides. But, the development of insect resistance to these products, the high operational cost and environmental pollution has created the need for developing of alternative approaches to control many insect pests. In this sense, the usages of essential oils are an alternative to control many field and household insect pests [20-22]. Oils also are easy to apply with existing spray equipment and can be mixed with many other pesticides to extend their performance.

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Aromatic plants and their essential oils are among the most efficient botanicals wherein essential oils are presently regarded as a new class of ecological products for controlling of insect pests [23].

The problem in Sudan is that in spite of many biological researches on antibacterial and anti insect and antifungal studies on essential oil, but there is no exploitation and good formulation of essential oil pesticides. The reason is that there is a poor formulation for different types of essential oil pesticides to face the biological control in Sudan. Therefore the crucial needs for designing good formulate approaches are the challenge of today's.

Therefore the objective of this work is to focus on systematic formulation techniques and procedures of pesticide formulation, and designing bit by bit guidelines to establish strong base for essential oil pesticide formulation know how technology for Sudanese essential oils.

Hypothesis and assumptions

The hypothesis and assumptions designed in this study proposed formulation bits that can be ideal proper guidelines method and technical aspects for essential oils pesticide formulation. The following bits can be used for different types of essential pesticides formulation for different targets pests and diseases to achieve green and safe production. The following proposed bits can be considered as an essential bits for proper essential oil pesticide formulation:

a. Extraction of essential oil or using oil of known standard quality according to international standards.

b. Determination of essential oil profile and quality or use known standard oil.

c. *In-vitro* inspection: *In-vitro* inspection of essential oil as pesticide as antibacterial, antifungal, antivirus etc.

d. Determination of *In-vivo* doses and Determination the effectiveness degree.

e. Determination of environmental conditions: Determination of indoor and outdoor environmental conditions for losses.

f. Nature of the essential: Studying the nature of the essential oil on disease or insect.

g. Proper formulation types: Choosing the proper types of formulation for the certain disease or insects stages and behavior.

h. Right types of application: Select right types of application for specific area.

i. Calculation of active ingredients per formula: Calculation the active ingredients per formula and other filling agents.

j. Identify the proper in vivo doses.

k. Formulation of pesticides for the proposed treatment.

Research Questions

a. What is the relationship between general pesticide formula and essential oil formulation?

b. How efficient pesticide formulation can be achieved?

c. Where can use the proper technologies for different pests and diseases?

d. Why using essential oil pesticide formulations against pests and diseases?

e. When the right time and procedure can be chosen?

Review of Formulation, Adjuvant, Spraying, Proposed Bits

Pesticides formulations

Pesticide active ingredients in their "raw" or unformulated state are not usually suitable for pest control. Manufacturers of pesticides mix in other ingredients to "formulate" the pesticide into a usable final product. Pesticide active ingredients by themselves may not mix well with water, may be chemically unstable, may be difficult to handle or store, and may be difficult to apply for good pest control. To make an active ingredient useful, manufacturers add other ingredients (sometimes called inert ingredients) to "formulate" the pesticide into the final product offered for sale [24].

The more important objectives of formulation are to explain the difference between a pesticide formulation and an active ingredient, identify strengths and weaknesses of common types of pesticide formulations and know how to interpret common abbreviations used to describe formulations (For example, WP, DF, EC, RTU, S, G, ULV). And the very important terms to Know are; Active ingredient (a.i.), Emulsion, Fumigant, Impregnates, Pheromones, Phytotoxicity, Solution and Suspension [24].

A pesticide formulation may consist of; the pesticide active ingredient (a.i.) that controls the target pest, the carrier such as an organic solvent or mineral clay, Surface-active ingredients such as stickers and spreaders and/or other ingredients, such as stabilizers, dyes and chemicals that improve or enhance pesticidal activity. A single active ingredient may be sold in several formulations [24].

Before you make the choice, ask yourself several questions about each formulation:

a. Do I have the necessary application equipment for the formulation?

b. Can the formulation be applied appropriately under the conditions in the application area

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c. Will the formulation reach my target and stay in place long enough to control the pest

d. Is the formulation likely to damage the surface to which I will apply it

e. Could I choose a less hazardous formulation that would still be as effective?

Types of pesticides: Different Types of Formulations were adopted internationally. There are common abbreviations in pesticide formula (Appendix 1). Here are some of the most common kinds of pesticide formulations available to give a better understanding of what they are:

Dusts (D): Dusts are made up of a finely ground mixture of low concentration of active ingredient (10% or less by weight) combined with very fine and dry inert carrier made from clay, talc, chalk, nut hulls or volcanic ash in powdered form. Dusts are intended for dry use and should never be mixed with water. The percentage of active ingredient in a dust is generally quite low. Dusts are commonly used for interior wall void and perimeter treatments (seed dressing), as well as for crop-dusting. Dust formula can be used in cracks, crevices, spot treatment to control insects such as cockroaches, insects ingest poisonous dusts during grooming or absorb the dust through their outer body covering, also can be used to control lice, fleas and other parasites on pets and livestock. In case of concentrates a high percentage of active ingredients mixed with few inert carriers before diluted with water or solvent and applying as spray. There are many advantages of dusts; it is most ready use with no mixing, effective where moisture from a spray might cause damage, required simple equipment and effective in hard-to-reach indoor areas. In contrast there are some disadvantages of dust pesticides such as; easily drift off - target during application, residue easily moved off-target by air movement or water, may irritate eyes, nose, throat and skin, will no stick to surfaces as well as liquids, dampness can cause clogging and lumping, and difficult to get an even distribution of pesticide particles on the target surfaces [24].

Granules (G): Are hard, dry particles made up of porous materials and active ingredient? Granular formulations are similar to dust formulations, except granular particles are larger and heavier. The coarse particles are made from materials such as clay, corncobs, or walnut shells [24]. The active ingredient either coats the outside of the granules or is absorbed into them. The amount of active ingredient is relatively low, usually ranging from 1 to 15 percent by weight. The percentage of active ingredient in a granule formulation is higher than that of a dust but lower than that of an EC. Granules are usually safer to apply than dusts or ECs.

Granular formulations are used most often for soil treatments. Granular pesticides are most often used to apply chemicals to the soil to control weeds, nematodes, and insects living in the soil, or for absorption into plants through the roots. Granular formulations are sometimes applied by airplane or helicopter to minimize drift or to penetrate dense vegetation. Once applied, granules release the active ingredient slowly. Some granules require soil moisture to release the active ingredient. Granular formulations also are used to control larval mosquitoes and other aquatic pests. Granules are used in agricultural, structural, ornamental, turf, aquatic, right-of-way, and public health (biting insect) pest-control operations.

Its advantages; ready to use—no mixing, drift hazard is low, and particles settle quickly, little hazard to applicator-no spray, little dust, weight carries the formulation through foliage to soil or water target, simple application equipment needed, such as seeders or fertilizer spreaders and may break down more slowly than WPs or ECs because of a slow-release coating.

Its disadvantages; often difficult to calibrate equipment and apply uniformly, will not stick to foliage or other uneven surfaces, may need to be incorporated into soil or planting medium, may need moisture to activate pesticide, may be hazardous to non-target species, especially waterfowl and other birds that mistakenly feed on the seed-like granules and may not be effective under drought conditions; the active ingredient is not released in sufficient quantity to control the pest.

Pellets (P or PS): Most pellet formulations are very similar to granular formulations; the terms are used interchangeably. In a pellet formulation, however, all the particles are the same weight and shape. The uniformity of the particles allows use with precision application equipment. A few fumigants are formulated as pellets. However, these are clearly labeled as fumigants. Do not confuse them with non-fumigant pellets [24].

Repellents: Various types of insect repellents are available in aerosol and lotion formulations. People apply these to their skin or clothing or to plant foliage to repel biting and nuisance insects. You can mix other types of repellents with water and spray them onto ornamental plants and agricultural crops to prevent damage from deer, dogs, and other animals.

Aerosols: Are sold in cans and contain one or more active ingredients and a solvent under pressure. Aerosols pesticides are sold most often for home and garden use, not for agricultural use. The percentage of active ingredient in aerosols is usually very low. One of the main advantages of aerosols is that they are convenient and easy to use. Many aerosols are used for killing pests on contact, or for time-released control of flying pests.

There are two types of aerosol formulations-the ready-to-use type commonly available in pressurized sealed containers and those products used in electrical or gasoline-powered aerosol generators that release the formulation as a “smoke” or “fog.”

Ready-to-use aerosols: These formulations are usually small, self-contained units that release the pesticide when the nozzle valve is triggered. The pesticide is driven through a fine opening by an inert gas under pressure, creating fine droplets.

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These products are used in greenhouses, in small areas inside buildings, or in localized outdoor areas. Commercial models, which hold five to 5 pounds of pesticide, are usually prefillable.

Its advantages; ready to use, portable, easily stored, convenient way to buy a small amount of a pesticide and retain potency over fairly long time and its disadvantages are; practical for only very limited uses, risk of inhalation injury, hazardous if punctured (overheated, or used near an open flame) and difficult to confine to target site or pest [24].

Wettable powders (WP): Wettable powders are dry, finely ground formulations that look like dusts. They appear similar to a dust but contain additional wetting and dispersing agents so that water may be added for maximum effectiveness. Wettable powders are also more highly concentrated than dusts to contain more active ingredient. The particles do not dissolve in water, they usually must be mixed with water for application as a spray. A few products, however, may be applied either as a dust or as a wettable powder—the choice is left to the applicator. Wettable powders contain 5 to 95 percent active ingredient by weight; usually 50 percent or more. Wettable powder formulations do not form a true solution when water is added, they settle out quickly unless constantly agitated to keep them suspended so frequent agitation of the spray tank is required to keep the formulation in suspension.

They can be used for most pest problems and in most types of spray equipment where agitation is possible. Wettable powders have excellent residual activity. Because of their physical properties, most of the pesticide remains on the surface of treated porous materials such as concrete, plaster, and untreated wood. In such cases, only the water penetrates the material.

Its advantages are; easy to store, transport, handle, less likely than ECs and other petroleum-based pesticides to cause unwanted harm to treated plants, animals, and surfaces, easily measured and mixed and less skin and eye absorption than ECs and other liquid formulations [24].

Its disadvantages are; inhalation hazard to applicator while measuring and mixing the concentrated powder, requires good and constant agitation (usually mechanical) in the spray tank and quickly settles out if the agitator is turned off, abrasive to many types of pumps and nozzles, causing them to wear out quickly, difficult to mix in very hard, alkaline water, often clog nozzles and screens and residues may be visible on treated surfaces.

Emulsifiable concentrates (EC)

Emulsion: An emulsion occurs when one liquid is dispersed (as droplets) in another liquid. Each liquid retains its original identity. Some degree of agitation generally is required to keep the emulsion from separating. Emulsions usually have a milky appearance. The active ingredient is dissolved in an oil-based solvent. When the product is mixed with water, an emulsion (oil in water) is formed. An emulsifying agent (often called an emulsifier) formulated into the product helps prevent the emulsion from separating. Familiarity with these terms and processes leads to a greater understanding and appreciation of the advantages and disadvantages of many commonly used pesticide formulations.

Emulsifiable concentrates are liquid formulations where the active ingredient is dissolved in oil and an emulsifier is added so that the formulation may be mixed with water for spraying. ECs are among the most widely used formulations, along with wettable powders. ECs typically contain two to six pounds of active ingredient per gallon. Unlike wettable powders, ECs require very little agitation and are easy to handle.

They are adaptable to many types of application equipment, from small, portable sprayers to hydraulic sprayers, low-volume ground sprayers, mist blowers, and low-volume aircraft sprayers. Its advantages are; relatively easy to handle, transport, and store, little agitation required—will not settle out or separate when equipment is running, not abrasive, will not plug screens or nozzles and little visible residue on treated surfaces. And its disadvantages are; high a.i. concentration makes it easy to overdose or under dose through mixing or calibration errors, may cause damage to desirable plants (phytotoxicity), easily absorbed through skin of humans or animals (solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate), may cause pitting or discoloration of painted finishes, flammable—should be used and stored away from heat or open flame and may be corrosive [24].

Invert Emulsions: An invert emulsion contains a water-soluble pesticide dispersed in an oil carrier. Invert emulsions require a special kind of emulsifier that allows the pesticide to be mixed with a large volume of petroleum-based carrier, usually fuel oil. Invert emulsions aid in reducing drift. With other formulations, some spray drift results when water droplets begin to evaporate before reaching target surfaces; as a result, the droplets become very small and light. Because oil evaporates more slowly than water, invert emulsion droplets shrink less; therefore, more pesticide reaches the target. The oil helps to reduce runoff and improves rain resistance. It also serves as a sticker-spreader by improving surface coverage and absorption. Because droplets are relatively large and heavy, it is difficult to get thorough coverage on the undersides of foliage. Invert emulsions are most commonly used along rights-of-way where drift to susceptible non-target plants or sensitive areas can be a problem [24].

Oil concentrates (OC): Are liquid formulations where the active ingredient is dissolved in oil so that the formulation mixed with oil for spraying. OCs typically contains two to six pounds of active ingredient per gallon. OCs require very little agitation and are easy to handle.

Gasoline concentrates (GC): Are liquid formulations where the active ingredient is dissolved in gasoline so that the

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formulation mixed gasoline for spraying. GCs typically contain two to six pounds of active ingredient per gallon. It require very little agitation and are easy to handle.

Soluble powders (SP): Are dry formulations similar to wettable powders, but the difference is that when added to water a soluble powder will dissolve completely and form a genuine solution (whereas a wettable powder does not). Some agitation may be required to dissolve the soluble powder initially, but once a solution, agitation is not needed. The amount of active ingredient in soluble powders ranges from 15 to 95 percent by weight; it usually is more than 50 percent. The percentage of active ingredient in a soluble powder is high compared to ECs and WPs, and there are not currently many SP formulations available.

Soluble powders have all the advantages of wettable powders and none of the disadvantages, except the inhalation hazard during mixing. Few pesticides are available in this formulation because few active ingredients are readily soluble in water [24].

Water-soluble Packets: Water-soluble packets reduce the mixing and handling hazards of some highly toxic pesticides. Manufacturers package precise amounts of wettable powder or soluble powder formulations in a special type of plastic bag. When you drop these bags into a filled spray tank, they dissolve and release their contents to mix with the water. There are no risks of inhaling or contacting the undiluted pesticide as long as you do not open the packets. Once mixed with water, pesticides packaged in water-soluble packets are no safer than other tank mixtures.

Tracking Powders: Special dusts known as tracking powders are used for rodent and insect monitoring and control. For rodent control, the tracking powder consists of finely ground dust combined with a stomach poison. Rodents walk through the dust, pick it up on their feet and fur, and ingest it when they clean themselves. Tracking powders are useful when bait acceptance is poor because of an abundant, readily available food supply. Non-toxic powders, such as talc or flour, often are used to monitor and track the activity of rodents in buildings.

Dry flowables: Dry flowables can also known as water-dispersible granules. Are very similar to granules in appearance, and behave in the same way as wettable powders except instead of being dust-like, they are formulated as small, easily measured granules. Water-dispersible granules must be mixed with water to be applied. Once in water, the granules break apart into fine particles similar to wettable powders. The formulation requires constant agitation to keep it suspended in water. Dry flowables have several advantages over WPs because of their shape: they can be easily "poured" and measured just like liquid, and are safer to use because very little dust is released into the air when they are mixed and measured. Dry flowables contain very high percentages of active ingredient.

Dry flowables contain very high percentages of active ingredient. The percentage of active ingredient is often as much as 90 percent by weight. Water-dispersible granules share many of the same advantages and disadvantages of wettable powders, except they are more easily measured and mixed. Because of low dust, they cause less inhalation hazard to the applicator during handling. The main advantages over WPs because of their shape: they can be easily "poured" and measured just like liquid, and are safer to use because very little dust is released into the air when they are mixed and measured [24].

Flowable liquids (FL): Are made with active ingredients that cannot be dissolved completely in water or oil, so the active ingredient is ground up and suspended in a liquid with other suspending agents. The formulation is then ready to mix with water for application. Flowables will not clog spray nozzles, and require only moderate agitation. A flowable or liquid formulation combines many of the characteristics of emulsifiable concentrates and wettable powders. Manufacturers use these formulations when the active ingredient is a solid that does not dissolve in either water or oil. The active ingredient, impregnated on a substance such as clay, is ground to a very fine powder. The powder is then suspended in a small amount of liquid. The resulting liquid product is quite thick. Flowables and liquids share many of the features of emulsifiable concentrates, and they have similar disadvantages. They require moderate agitation to keep them in suspension and leave visible residues, similar to those of wettable powders.

Flowables/liquids are easy to handle and apply. Because they are liquids, they are subject to spilling and splashing. They contain solid particles, so they contribute to abrasive wear of nozzles and pumps. Flowable and liquid suspensions settle out in their containers. Always shake them thoroughly before pouring and mixing. Because flowable and liquid formulations tend to settle, manufacturers package them in containers of five gallons or less to make remixing easier [24].

Solutions and water soluble concentrates (S)

Solution: A solution results when a substance is dissolved in a liquid. The components of a true solution cannot be mechanically separated. Once mixed, a true solution does not require agitation to keep its various parts from settling. Solutions are frequently transparent.

Are liquids in their original state and are fully soluble in water and any other solvent. Solutions that are prepared the right way will not leave unsightly residues or clog spray nozzles. Some pesticide active ingredients dissolve readily in a liquid carrier such as water or a petroleum-based solvent. When mixed with the carrier, they form a solution that does not settle out or separate. Formulations of these pesticides usually contain the active ingredient, the carrier, and one or more other ingredients. Solutions may be used in any type of sprayer, indoors or outdoors.

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Ready-to-use Low-concentrate Solutions (RTU): Low-concentrate formulations are ready to use and require no further dilution before application. They consist of a small amount of active ingredient (often 1 percent or less per unit volume) dissolved in an organic solvent. They are especially useful for structural and institutional pests and for household use. Major disadvantages of low-concentrate formulations include limited availability and high cost per unit of active ingredient. Many organic solvents are harmful to foliage, so they often cannot be used as plant sprays.

Utra-low Volume (ULV): These concentrates may approach 100 percent active ingredient. They are designed to be used as is or to be diluted with only small quantities of a specified carrier and are used at rates of no more than a half-gallon per acre. These special-purpose formulations are used mostly in outdoor applications, such as in agricultural, forestry, ornamental, and mosquito- control programs. Ultra-low Volume (ULV) advantages are; relatively easy to handle, transport, and store, remain in solution; little agitation required, not abrasive to equipment, will not plug screens and nozzles, leave little visible residue on treated surfaces. And its disadvantages; difficult to keep pesticide on target—high drift hazard, specialized equipment required, easily absorbed through skin of humans or animals, solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate, calibration and application must be done very carefully because of the high concentration of active ingredient.

Suspension: A Suspension is a mixture of finely divided, solid particles dispersed in a liquid. The solid particles do not dissolve in the liquid, and the mixture must be agitated to keep the particles evenly distributed. Most suspensions will have a cloudy, murky appearance. The label directs the user to shake well before using. Such products also form suspensions when mixed with water for application as a spray. Explicit label information describes the need for sufficient agitation to keep the solid particles of the product dispersed in the spray tank.

Liquid Baits: An increasing number of insecticides and rodenticides are being formulated as liquid baits. Liquid rodenticides are mixed with water and placed in bait stations designed for these products. They have two major benefits. Liquid rodenticides are effective in controlling rodents, especially rats, in areas where they cannot find water. They are also effective in areas of poor sanitation where ready availability of food renders traditional baits ineffective. Liquid insecticide baits are used primarily by the structural pest control industry for controlling ants and, to a lesser extent, cockroaches. They are packaged as ready-to-use, sugar-based liquids placed inside bait stations.

Liquid insecticide ant baits have a number of advantages. They are very effective against certain species of sugar-feeding ants. These ants typically accept and transfer liquid baits into the ant colonies. However, some ants will not feed on liquid baits. Liquid baits also must be frequently replaced [24].

Poisonous baits: Are food-like substances mixed with a pesticide specifically designed to attract and be eaten by insects or other pests and eventually poison them to death. Baits are commonly used for rodent control, including mice and rats. However, baits are also used to control roaches, ants, flies, and other insects. Bait formulations can be used indoors or outdoors. When compared to ECs or other formulations, the percentage of active ingredient in bait is low [24]. A bait formulation is an active ingredient mixed with food or another attractive substance. Are food-like substances mixed with a pesticide specifically designed to attract and be eaten by insects or other pests and eventually poison them to death. Baits are commonly used for rodent control vertebrate pests such as mice and rats. However, baits are also used to control such as rodents, other mammals, and birds. Bait formulations can be used indoors or outdoors. Indoor to control ants, roaches, flies, other insects, and rodents. Outdoors, they sometimes are used to control snails, slugs, and insects such as ants and termites. When compared to ECs or other formulations, the percentage of active ingredient in bait is low. Its advantages are ready to use, entire area need not be covered, because pest goes to bait and controls pests that move in and out of an area. Its disadvantages are can be attractive to children and pets, may kill domestic animals and non-target wildlife outdoors, pest may prefer the crop or other food to the bait, dead vertebrate pests may cause odor problems, other animals may be poisoned as a result of feeding on the poisoned pests and if baits are not removed when the pesticide becomes ineffective, they may serve as a food supply for the target pest or other pests.

Pastes, Gels, and Other Injectable Baits: Pastes and gels are mainly used in the pest-control industry for ants and cockroaches. Insecticides formulated as pastes and gels are now the primary formulations used in cockroach control. They are designed to be injected or placed as either a bead or dot inside small cracks and crevices of building elements where insects tend to hide or travel. Two basic types of tools are used to apply pastes and gels—syringes and bait guns. The applicator forces the bait out of the tip of the device by applying pressure to a plunger or trigger.

Its advantages are; they are odorless, produce no vapors, have low human toxicity, and last for long periods; applicator exposure is minimal, hidden placements minimize human and pet exposure, very accurate in their placement and dosage and easily placed in insect harborage for maximum effectiveness. Its disadvantages; can become contaminated from exposure to other pesticides and cleaning products, when exposed to high temperatures, gels can run and drip, may stain porous surfaces and repeated applications can cause an unsightly buildup of bait [24].

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Encapsulated pesticides: Are a new kind of formulation in which the active ingredient is held in a very small capsule (Microencapsulated). Manufacturers cover liquid or dry pesticide particles in a plastic coating to produce a microencapsulated formulation. These capsules are then suspended in a liquid. This formulation of suspended capsules is then mixed with water and maybe applied with a sprayer. After spraying, the plastic coating breaks down and slowly releases the active ingredient. Microencapsulated materials have several advantages; highly toxic materials are safer for applicators to mix and apply, Encapsulated pesticides are safe and easy to use, delayed or slow release of the active ingredient prolongs its effectiveness, allowing for fewer and less precisely timed applications, the pesticide volatilizes slowly; less is lost from the application site, allowing for greater effectiveness and these formulations often reduce injury to plants. Microencapsulated materials, however, pose a special hazard to bees, may pose a threat to bees when they carry the capsules back to their hive; foraging bees may carry microencapsulated materials back to their hives because they are about the same size as pollen grains. As the capsules break down, they release the pesticide, poisoning the adults and brood. Breakdown of the microencapsulated materials to release the pesticide sometimes depends on weather conditions. Under certain conditions, the microencapsulated materials may break down more slowly than expected. This could leave higher residues of pesticide active ingredient in treated areas beyond normal restricted-entry or harvest intervals with the potential to injure fieldworkers. For this reason, regulations require long restricted-entry intervals for some microencapsulated formulations [24].

Impregnates: Formulators may impregnate (saturate) fertilizers and other materials with a pesticide. Such materials must be handled as pesticides and their use must follow all pesticide laws, regulations and safety and environmental requirements. Some materials are impregnated in ways that allow the pesticides to evaporate over time so the vapors provide control of nearby pests. These types of pesticide impregnated products include pet collars, livestock ear tags, adhesive tapes, and plastic pest strips. Some paints and wood finishes have pesticides incorporated into them to kill insects or retard fungal growth.

Formulations for smoke or fog generators: These aerosol formulations are not under pressure. They are used in machines that break the liquid formulation into a fine mist or fog (aerosol) using a rapidly whirling disk or heated surface. These formulations are used mainly for insect control in structures such as greenhouses and warehouses and for mosquito and biting fly control outdoors. Their advantage is easy way to fill entire enclosed space with pesticide. And its disadvantages are; highly specialized use and equipment, difficult to confine to target site or pest and may require respiratory protection to prevent risk of inhalation injury.

Fumigants: Fumigants are pesticides that form a gas when applied. Some active ingredients are liquids when packaged under high pressure and change to gases when they are released. Other active ingredients are volatile liquids when enclosed in an ordinary container and therefore are not formulated under pressure. Others are solids that release gases when applied under conditions of high humidity or in the presence of water vapor. Fumigants are used for structural pest control, in food and grain storage facilities, and in regulatory pest control at ports of entry and at state and national borders.

In agricultural pest control, fumigants are used in soil, greenhouses, granaries, and grain bins. Its advantages are; toxic to a wide range of pests, can penetrate cracks, crevices, wood, and tightly packed areas such as soil or stored grains and single treatment usually kills most pests in treated area.

Its disadvantages; the target site must be enclosed or covered to prevent the gas from escaping, non-specific—highly toxic to humans and all other organisms and require the use of specialized protective equipment, including respirators specifically approved for use with fumigants.

Attractants: Attractants include pheromones, a chemical that is secreted by an animal, especially an insect, which influences the behavior or development of others of the same species. Other attractants are sugar and protein hydrolysate syrups, yeasts, and rotting meat. Pest managers use these attractants in sticky traps and capture bags. Attractants also can be combined with pesticides and sprayed onto foliage or other items in the treatment area.

Animal systemics: Systemic pesticides protect animals against fleas and other external blood-feeding insects as well as against worms and other internal parasites. A systemic animal pesticide is one that is absorbed and moves within the animal. These pesticides enter the animal's tissues after being applied orally or externally.

Oral applications include food additives and premeasured capsules and liquids. External applications involve pour-on liquids, liquid sprays, and dusts. Most animal systemics are used under the supervision of veterinarians [24].

Combining different formulations: Sometimes two different pesticide formulations are combined to create a more effective application. However, not all pesticides can be combined safely. Before combining various formulations, always consult the label or a pest control professional to find out whether the two formulations are compatible. The mixing of two incompatible pesticide formulations may be fatal. Incompatibility can be either chemical or physical. These incompatibilities should be

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clearly indicated on the product label, however, it is still a good idea to contact a professional if you have any questions.

Pesticide mixtures and adjuvant

Combining two or more pesticides and applying them at the same time is convenient and cost effective. Most pesticide manufacturers sell some of their products as pre-mixes, but often you must combine two or more pesticides at the time of application. Combinations may, however, affect the toxicity and the physical and chemical properties of any of the components of the tank mix increase residues, and damage or injure the target site, plant, or animal. Adjuvants are products that have no pesticidal activity, but are also available to add to spray mixtures to increase mixing, ease application and help the pesticide work better. In this Section, pesticide applicators will learn how to safely mix different pesticides and use adjuvants.

Learning objectives: Describe how you would determine if two mixed pesticides might be incompatible. Describe what labels may tell you about pesticide adjuvant. Terms to Know:

- Tank mix
- Field incompatibility
- Adjuvant
- Surfactants

Pesticide Mixtures: When you combine mixtures of two or more pesticides and/or fertilizers at the time of application, you create a tank mix. A common tank mix involves combining fungicides with insecticides as a spray for tree fruit crops. Another involves combining two or more herbicides to increase the number of weed species controlled. Some people mix pesticides with micronutrients or fertilizers. This practice saves money by reducing the time, labor, and fuel required for multiple applications. Tank mixes reduce equipment wear and decrease labor costs. They lessen the mechanical damage done to crops and soil by application equipment. If you mix danger-poison pesticides with warning or caution pesticides, treat the mixture as danger-poison pesticide. You must use the required safety equipment and follow all other label restrictions found on the component of the pesticide mixture that has the greatest toxicity—the label with the greatest restrictions.

Incompatibility: Incompatibility is a condition that prevents pesticides from mixing together properly to form a uniform solution or suspension. The formation of flakes, crystals, oily clumps, or severe separation is unacceptable. Such incompatible mixtures clog application equipment and limit even distribution of the active ingredient in the spray tank. This prevents good pesticide coverage.

The cause of incompatibility may be the chemical nature of the materials you are mixing. Impurities in the spray tank or water also may affect compatibility. Even the order in which you mix pesticides in the spray tank is important. Sometimes the types of formulations being mixed influence compatibility. Pesticide formulations of the same type are rarely incompatible with one another because they usually contain many of the same inert ingredients and solvents. Always evaluate a tank mixture by performing the compatibility test described in.

Adjuvants: Adjuvants are chemicals that do not possess pesticidal activity. Adjuvants are either pre-mixed in the pesticide formulation or added to the spray tank to improve mixing or application or to enhance pesticidal performance. They are used extensively in products designed for foliar applications. Adjuvants can be used to customize the formulation to specific needs and compensate for local conditions. The right adjuvant may reduce or even eliminate spray application problems, thereby improving overall pesticide efficacy. Before using any adjuvant, consult the pesticide label. Many registered pesticide products have very specific label recommendations on use with one or more adjuvants. Failure to follow these instructions is as much a violation of the product label as misuse of the pesticide.

If you have questions about the specific properties of an adjuvant, contact the manufacturer before attempting to use it. Companies that produce adjuvants can provide labels, technical data sheets, Materials Safety Data Sheets (MSDS), supplemental labeling, and promotional literature about their products.

Adjuvants are designed to perform specific functions, including wetting, spreading, sticking, reducing evaporation, reducing volatilization, buffering, emulsifying, dispersing, reducing spray drift, and reducing foaming. No single adjuvant can perform all these functions, but compatible adjuvants often can be combined to perform multiple functions simultaneously.

Types of adjuvants: Much of the confusion surrounding adjuvants can be attributed to the lack of understanding of adjuvant terminology. For example, many people use the terms Adjuvant and surfactant interchangeably. These terms can refer to the same product because all surfactants are adjuvants. However, not all adjuvants are surfactants. Adjuvants include:

Stickers: A sticker is an adjuvant that increases the adhesion of solid particles to target surfaces. These adjuvants can decrease the amount of pesticide that washes off during irrigation or rain. Stickers also can reduce evaporation of the pesticide, and some slow down the degradation of pesticides by sunlight. Many adjuvants are formulated as spreader-stickers to make a general-purpose product.

Extenders: Some adjuvant manufacturers have named their products "extenders." Extenders function like stickers by retaining pesticides longer on the target area, slowing evaporation, and inhibiting degradation by sunlight.

Plant penetrants: These adjuvants have a molecular configuration that enhances penetration of some pesticides into plants. An adjuvant of this type may increase penetration

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of a pesticide on one species of plant, but not another. Enhanced penetration increases the activity of some pesticides.

Compatibility agents: Pesticides are commonly combined with liquid fertilizers or other pesticides. Certain combinations can be physically or chemically incompatible, which causes clumps and uneven distribution in the tank. Occasionally the incompatible mixture plugs the pump and distribution lines resulting in expensive cleanup and repairs. A compatibility agent may eliminate these problems. Read product label directions carefully before adding a compatibility agent to a spray mix. You may wish to do a compatibility test in a quart jar to determine the stability of the mixture. After adding the desired pesticides and the compatibility adjuvant to the jar, shake the mixture and then check for clumping, separation, thickening, and heat release. Any one of these signs indicates an incompatibility problem.

Buffers or pH modifiers: Most pesticide solutions or suspensions are stable between pH5.5 and pH7.0 (slightly acidic to neutral). Above pH7.0 (alkaline or basic), the pesticide may be subject to degradation. Once a pesticide solution becomes alkaline, the risk exists that the pesticide degrades. Buffers and acidifiers are adjuvants that acidify and stabilize the water in the spray tank. Buffers must be added to the tank mix water first. The water must be neutralized or slightly acidified prior to adding pesticides and adjuvants.

Drift Control additives: Drift is a function of droplet size. Small, fine drops with diameters of 100 microns or less tend to drift away from targeted areas. Drift control additives, also known as deposition aids, improve on-target placement of the pesticide spray by increasing the average droplet size. Drift reduction can be very important near sensitive sites and may well be worth the small reduction in efficacy that may result from the change in droplet size.

Defoaming agents: Some pesticide formulations create foam or a frothy "head" in spray tanks. This is often the result of both the type of surfactant used in the formulation and the type of spray tank agitation system. The foam usually can be reduced or eliminated by adding a small amount of a defoaming agent.

Thickeners: As the name suggests, thickeners increase the viscosity (thickness) of spray mixtures. These adjuvants are used to control drift or slow evaporation after the spray has been deposited on the target area. Slowing evaporation is important when using systemic pesticides, because they can penetrate the plant cuticle only as long as they remain in solution.

How to choose the right adjuvant: Many factors must be considered when choosing an adjuvant for use in a pest-management program. Following are some guidelines: Use only adjuvants manufactured and marketed for agricultural or horticultural uses. Do not use industrial products or household detergents with pesticides, because they may interfere with pesticide performance.

Remember, there are no miracle adjuvants. It is generally wise to be skeptical of such claims as "keeps spray equipment clean" or "causes better root penetration" unless the manufacturer has supporting evidence to back up such claims.

Make sure the adjuvant has been thoroughly tested and proven effective for your intended use. Test questionable products on a limited area before proceeding with full-scale use. Certain pesticides and application procedures require certain types of adjuvants. Determine the correct type and use only an adjuvant of that type. For example, do not substitute an anionic surfactant when a nonionic surfactant is recommended.

A particular pesticide label may require one or more adjuvants for a certain use, yet prohibit any adjuvant for another use. Read the pesticide label carefully. Using an adjuvant is not always necessary. It is just as important to know when not to use an adjuvant as it is to know when to use one to achieve the best results. Spray adjuvants can contribute substantially to safe and effective pest control. Many spray adjuvants are available, each formulated to solve problems associated with a particular type of application. Check pesticide and adjuvant labels to make sure adjuvants are suitable for the site you plan to spray, the target pest, your equipment, and, of course, the pesticide you plan to use.

Remember, many pesticide products already contain an adjuvant. If a pesticide is already formulated properly for your crop, using an additional wetting agent, for example, may not give better spreading or coverage; instead, it could increase runoff, reduce deposition, and even severely damage the target plants.

Surfactants: Surfactants, also called wetting agents and spreaders, physically alter the surface tension of a spray droplet. For a pesticide to perform its function properly, a spray droplet must be able to wet the foliage and spread out evenly over a leaf. Surfactants enlarge the area of pesticide coverage, thereby increasing the pest's exposure to the chemical. Surfactants are particularly important when applying a pesticide to waxy or hairy leaves.

Without proper wetting and spreading, spray droplets often run off or fail to cover leaf surfaces adequately. Too much surfactant, however, can cause excessive runoff and reduce pesticide efficacy. Surfactants are classified by the way they ionize or split apart into electrically charged atoms or molecules called ions. A surfactant with a negative charge is anionic. One with a positive charge is cationic, and one with no electrical charge is nonionic. Pesticidal activity in the presence of a nonionic surfactant can be quite different from activity in the presence of a cationic or anionic surfactant. Selecting the wrong surfactant can reduce the efficacy of a pesticide product and injure the target plant.

Anionic surfactants are most effective when used with contact pesticides (pesticides that control the pest by direct

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contact rather than being absorbed systemically). Cationic surfactants should never be used as stand-alone surfactants because they usually are phytotoxic.

Nonionic surfactants, often used with systemic pesticides, help pesticide sprays penetrate plant cuticles. Nonionic surfactants are compatible with most pesticides, and most EPA-registered pesticides that require a surfactant recommend a nonionic type.

Bits of essential oil pesticides formulations guidelines

To formulate an essential oil pesticide the following proposed technology bits can be considered as an essential guideline for proper formulation

Extraction of essential oil: Extraction of essential oil from plant materials by steam distillation [16], or use other types of distillation according to the plant part (stem, seeds, leaves, roots, barks, flowers etc.) presence and nature of essential oil or using previous distilled oil according to international standards. Or use an essential oil of known constituents, standard and source.

Determination of essential oil profile and quality: Identification of essential oil profile by GC-MS to determine the compounds present in the essential oil and its quantity. And determine essential oil quality (Physical and chemical) with respect to international standards and pharmacopoea.

In-vitro inspection of essential oil: The essential oil must be submitted to *in-vitro* antimicrobial, antifungal, antiviral antiniroid, anti locust, etc. *In-vitro* biological activity tests. Salim et al. [13-15] stated that the oil content affected by cultural and post harvest conditions. The more effective doses must be choosed rightly and the condition of oil plant extraction must be considered and GC-MS profile for oil components must be attached with keeping the international standard for the main oil components. This is very important to show the quantitative and qualitative profile of essential oil constituents, to access the effective effects of components according to their availability and concentration. Since Salim et al. [14] postulated that the different essential oils doses acts differently in the biological activities.

Determination the effectiveness degree: The degree of effectiveness must be adopted to ensure that the active ingredient is extra effective to control the pests and diseases.

Determination of *In-vivo* doses: Determination of *In-vivo* doses in plants (disease) and insects must be carefully quantitatively measured, to ensure that the active ingredient in the pesticide is quite enough to get into its targets.

Determination of environmental conditions: Determination of indoor and outdoor environmental conditions for losses. The environmental conditions especially climatic conditions such as; the effect of temperature, sunshine, day duration, sunrays, humidity, winds (speed and direction), rains evaporation rates on the rate of essential oil losses must be adjusted to avoid low effective doses of active ingredients (essential oil), Salim [15] found that evaporation rates, temperature and other climatic factors play the main roles of essential oil losses. The soil and soil conditions, temperature, physical and chemical factors etc. must also be taking into considerations. The losses quantified and submerged in active ingredient content. To ensure that the does incidence is more effective.

Nature of the essential: Studying the nature of the essential oil on disease or insect. Libs & Salim [4,5] postulated that different plant diseases have different responses to different essential oils. Each essential is effective against specific insect or disease according to the behavior of the insect or the caused organism of disease. Essential oils composed of different chemical composition such as alcoholic, acetonic, aldahydedic, ester, etc that reacts differently and synergenically [15].

Proper formulation types: Choosing the proper types of formulation for the certain disease or insects nature and habitats. Since the nature of the insect residence (store pests, flies etc.) or disease shields (Powdery mildew) affected both the formula of active ingredient added and the surrounding environmental conditions. Store pests require fumigation, oily liquids etc., flies aerosols, spraying etc., diseases required direct contact of active ingredient by spraying and etc. Studying the nature of disease and behavior of insects, regarding the different stages of growth development and economic damage and dormancy.

Right types of application: Select right types of application for specific area so that the method of application of the pesticide must be considered, since every method has direct effect on active ingredient effectiveness. Powders with suitable adjuvant are suitable for store pest, while aerosols are suitable for closed areas against flies (mosquitoes) and etc., the right type can affected economic cost.

Calculation of active ingredients per formula: Calculation of the active ingredients per formula and other filling agents must be considered. Good calculation of active ingredient must be considered during the spreading of the pesticide on the target area. Good filling material must be safe to human, animals and environment and have no residual effect so this make essential oil promising pesticide for green environment.

Identify the proper *In-vivo* doses: *In-vitro* and *In-vivo* condition mostly differ, identifying the proper *In-vivo* doses is a vital operation to have good active ingredient. Poor calibration of doses leads to decline the pesticide effectiveness.

Formula of essential oil pesticides

Why pesticide from essential oil?

The main method to control insect pests is using of synthetic pesticides. But, the development of insect resistance to these

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products, the high operational cost and environmental pollution has created the need for developing of alternative approaches to control many insect pests. In this sense, the usages of essential oils are an alternative to control many field and household insect pests [20-22].

Over 2000 species of plants are known to possess some insecticidal activities. The essential oils are natural, volatile and complex compounds, gives their characteristic odours and are formed by secondary metabolites in plants. In the nature those compounds plays an important role in the protection of the plants against bacteria, fungi, virus, insects and others herbivores.

Some researchers have demonstrated that essential oils have neurotoxic, citotoxic, phototoxic and mutagenic action among others in different organism, and the essential oils act at multiple levels in the insects, so the possibility of generating resistance is little probable. Oils also are easy to apply with existing spray equipment and can be mixed with many other pesticides to extend their performance.

Aromatic plants and their essential oils are among the most efficient botanicals wherein essential oils are presently regarded as a new class of ecological products for controlling of insect pests [23].

Essential oil formulation against insects: A study investigated the effects of some essential oils on gypsy moth *Limantria dispar* dispar (Lepidoptera: Lymantridae) larvae, which is one of the most serious pests of cork oak forests. The essential oils are first formulated as oil in water (o/w) emulsions and used in laboratory bioassays to assess their lethal concentration (LC50). Microcapsules containing the most promising oils (*Rosmarinus officinalis* and *Thymus Herbabarona*) are then prepared by a phase separation process, followed by freeze drying. The formulations thus obtained, characterized in terms of essential oil content and composition, morphology, storage stability and release profile, are tested on gypsy moth larvae. The results showed that the tested oils possess interesting larvicidal effects that make them suitable for application in integrated control strategies.

Responses varied according to oil type and dose, and developmental stage of the insect. Bay, caraway seed, clove leaf, lemon eucalyptus, lime, pennyroyal, peppermint, rosewood, spearmint and tea tree oils are highly effective against T. *Vaporariorum* adults, nymphs and eggs at 0.0023, 0.0093 and 0.0047l/ml air, respectively. These results indicate that the mode of delivery of these essential oils is largely a result of action in the vapour phase [25].

In a study, the toxic effects of three different natural essential oils of medicinal plants, namely garlic (*Allium Sativum*), mint (*Mintha Pipereta*) and eucalyptus (*Eucalyptus globulus*) are tested on 1st nymphal instar of the grasshopper (*Hetera crislittoralis*). The LC50 values of the tested oils are estimated after 14 days from feeding on treated diet mixed with different concentrations of the oil. The LC50 of the tested oils are arranged as follows as 0.067, 0.075 and 0.084ml/100ml diet for garlic, eucalyptus and mint, respectively. The effect of LC50 concentration of the oils on the biological aspects and histological changes that observed on the alimentary canal and fat bodies are recorded.

Garlic oil inhibited egg lying by the resulting female's offspring of the treated 1st instar nymphs. High reduction in the deposited eggs and egg fertility caused by eucalyptus or mint oil and marked malformation are observed. Histological changes on the alimentary canal and fat bodies of the remaining nymphs after treatment with garlic oil (the most effective oil) are detected by the light microscope and have been recorded. The results suggest that the natural plant essential oils of garlic, eucalyptus and mint may be used in IPM control program against H. *littoralis* grasshopper [26].

Essential oil formulation against diseases: Several studies have shown that it is possible to use essential oils to control plant diseases. Medicinal plants contain substances that are able to play an important role in plant-pathogen interaction, by activating plant defense mechanisms. Antifungal substances, similar to fungicides, may also be present in those plants, acting directly on the pathogens. Medice et al. (2007) observed that essential oils from eucalyptus [*Corymbia citriodora* (Hook.) K.D.Hill and L.A.S. Johnson], thyme (*Thymus vulgaris* L.), neem (*Azadirachta indica* A. Juss.), and citronella [*Cymbopogon nardus* (L.) Rendle.] completely inhibited the germination of urediniospores of Asian soybean rust (*Phakopsora pachyrhizi* Syd. and P.Syd.) and reduced the severity of the disease in greenhouse trials. Ranasinghe et al. (2002) reported the fungitoxic and fungistatic activity of the essential oils of clove [*Syzygium aromaticum* (L.) Merr. and L.M. Perry] and cinnamon (*Cinnamomum zeylanicum Blume*) on *Colletotrichum musae* (Berk. and M.A. Curtis) Arx, *Lasiodiplodia theobromae* (Pat.) Griff and Maubl., and *Fusarium proliferatum* (Matsush.) Nirenberg. Lucas et al. found that clove essential oil reduced the severity of tomato bacterial spot and induced an increase in activities of β-1,3-glucanase, chitinase, and peroxidase. In an ultra-structural study, Rasooli et al. showed that the essential oils of *Thymus eriocalyx* (Ronniger) Jalas and T. x-porlock provoke severe damage to the walls, membranes, and cell organelles of *Aspergillus niger* spores, when in direct contact, causing morphologic alterations in the hyphae, rupture of the plasma membrane, and mitochondrial destruction. Researchers have used ATP production in the cell, bacterial mobility, and cationic exchange to evaluate the action of essential oils on bacteria. However, Gustafson et al. observed, by transmission electron microscopy, that the electron-dense material of *Escherichia coli* bacteria exposed to the essential oil of tea tree (*Melaleuca alternifolia Cheel*) was lost, which indicates cell wall loss. In spite of previous research, little is known about the mode of action of these compounds on plant-pathogenic bacteria.

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The effect of EOs, at 0.1%, on the severity of tomato bacterial spot was evaluated in tomato seedlings under greenhouse conditions. The effects of citronella, lemongrass, clove, and tea tree EOs, at 0.1%, on *X. vesicatoria* cells were evaluated by transmission electron microscopy. All EOs showed direct toxic effect on the bacteria at a 10%-concentration in vitro. Under greenhouse conditions, the EOs of clove, citronella, tea tree, and lemongrass reduced disease severity. Under greenhouse conditions, the EOs of clove, citronella, tea tree, and lemongrass reduced disease severity. The EOs at a concentration of 0.1% reduce the severity of the disease.

In-vitro, the growth of both fungi was completely inhibited by the EO of *C. citrinus* and C. citratus at 4,520µg/ml and 452µg/ml, respectively. Under laboratory conditions, seed treatment with the EO of *C. citrinus* reduced the incidence of *B. oryzae* in seeds by 85-100 % compared to the non-treated controls. Under field conditions, the combined use of the essential oil of *C. citrinus* as a seed treatment and spraying the plants with 2% ethanol followed by 2% (w/v) aqueous extracts of *C. citrinus* or C. *citratus* increased the emergence, tillering, panicles/plant and the grain yield by 25-55% of the irrigated rice. In addition, the brown spot severity was reduced by 36-42%. For the upland rice, the treatments led to similar results with the grain yield increase of 54-137% and 20-80% reduction in the brown spot severity. From our results, we concluded that the EO and solvent extracts of *C. citrinus* and C. *citratus* have potential as control agents against brown spot and other seed-borne fungal diseases in rice under both conventional and organic farming.

Formulation for postharvest diseases

Biochemical characterization of oregano essential oil: Mancini et al. [27] studied the biochemical characterization of *O. vulgare sp*. hirtum essential oil from the Southern Apennines (Italy). *O. vulgare* is composed mainly of phenolic compounds belonging to the carvacrol/thymol chemotype. The possible inhibitory fungicidal activity of *O. vulgare* was determined against M. laxa (Aderh. & Ruhland) Honey, M. fructigena and *M. fructicola* as follows: prepare different concentrations of each oil + potato dextrose agar (PDA) + (0.2%) with 0.2% Tween 20 and 250, 500, and 1000ppm of each essential oil under study, then pour 14ml of PDA+ oil in Petri dish.

Following that, completely dry off the preparation under laminar flow, 0.5cm disc from the studied fungi 96h old was inoculated in the centre of each Petri dish. All plates were incubated at 22 °C for 96h in the absence of light, and the diameter of any fungal mycelium growth was measured in mm. PDA plates + Tween 20 without oils were inoculated with the same fungi as a control. Fungitoxicity was expressed as the percentage of growth inhibition (PGI) and calculated according to Zygadlo et al. [28] as follows:

$$PGI\ (\%) = 100 \times (GC - GT) / GC$$

Where, GC represents the average diameter of fungi grown in PDA (control); GT represents the average diameter of any fungi cultivated on the treated PDA containing the essential oil. The oils tested have shown antifungal activity against *M. laxa, M. fructigena* and *M. fructicola* [27] and have neither shown any phytotoxic activity against germination and initial radicle elongation of *Sinapis arvensis L., Phalaris canariensis L., Lepidium sativum L. and Raphanus sativus L.,* nor have they shown any haemolysing effect against the cell membrane of bovine erythrocytes [28] (Table 1).

Table 1: Inhibition percentage (PGI %).

Treatments		M. laxa	M. fructigena	M. fructicola
O. vulgare (M)	1000ppm	100.0±0.0a	100.0±0.0a	100.0±0.0a
O. vulgare (MP)	1000ppm	100.0±0.0a	100.0±0.0a	100.0±0.0a
O. vulgare (SGP)	1000ppm	100.0±0.0a	100.0±0.0a	100.0±0.0a

In-vitro and *In-vivo* antifungal activity of the single constituents of oregano essential oil: Elshafie et al. [29] evaluated the antifungal effect of the single components of *O. vulgare* ssp. hirtum essential oil against the post-harvest pathogens *M. laxa, M. fructigena* and *M. fructicola in-vitro* and in-vivo. The chemical characterization of *O. vulgare* reported by Mancini et al. [28] explained that it contains five main single components: carvacrol, thymol, linalool, citral and trans-caryophyllene.

In-vitro antifungal activity: The possible fungicidal activity of the above five standards was determined according to the method of Soylu et al. [30]. Three-mm-thick and 0.5cm diameter PDA plugs, axenically taken from the peripheral portion of basic colonies, were inoculated onto the central part of PDA Petri dishes pre-treated with different concentrations of each single component (50, 150 or 250ppm) dissolved in 0.2% Tween 20. All plates were incubated at 22 °C for 96h in the absence of light. Negative controls comprised either PDA plates without any treatments, or PDA plates treated only with 0.2% Tween 20. The antifungal activity was expressed by measuring the diameter of any mycelium growth in mm [31].

Carvacrol and thymol (essential oil constituent) have exhibited the highest activity during *In-vitro* tests against all tested post-harvest *Monilinia* pathogens. Citral showed moderate antifungal activity, lower than that of carvacrol and thymol. Linalool and trans-caryophyllene showed slight antifungal activity against all studied pathogens. On the other hand, thymol showed fungitoxic inhibition, whereas carvacrol and citral showed fungistatic activity.

***In-vivo* antifungal activity:** The bioactive treatments which exhibited *In-vitro* activity were selected for evaluation of their in vivo activity against three *Monilinia* species causing

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brown rot of peach fruits, following the method of Hong et al. [32]. Tested peach fruits cv. ''Springcrest'', were not treated with either pre- or post-harvest chemical pesticides, and were superficially sterilized with 2% sodium hypochlorite solution, then later washed with sterile distilled water, before they were finally, air dried and inoculated with the above mentioned three phytopathogenic fungi at room temperature. Each inoculum was performed by injuring the surface of the fruits with a sterile needle and then adding 10µl of fungal suspension containing 106spore/ml. Liquid fungal cultures were prepared by adding two 3mm thick and 0.5cm diameter (4 days old) fungal discs to 150ml of sterilized potato dextrose broth (PDB) medium. Then they were then incubated at 22 °C for 7-9 days. One day after inoculation, each fruit group was sprayed with an emulsion containing different concentrations of each single component at 150 or 500ppm, dissolved in 0.2% Tween 20. The negative control composed of three groups of fruit sprayed only with sterile distilled water, whereas the positive control composed of three groups of fruits inoculated only with *Monilinia* isolates. The severity of symptoms induced by infection of the single *Monilinia* isolates was determined by measuring the diameter of brown rot lesions in mm after 3-5 days of incubation at room temperature (16–24 °C).

Carvacrol and thymol have shown a promising inhibition of the brown rot of peach fruits caused by *M. laxa, M. fructicola* and *M. fructigena in-vivo* especially at a dose of 500ppm. In particular, carvacrol showed the highest significant antifungal activity against *M. fructicola.*

Where: 150 and 500 are the concentrations of each single substance in ppm.

Application of essential oils

Application Procedures and Equipment: Sometimes tank mixes seem compatible during testing and after mixing in the spray tank, but problems arise during application. This is known as field incompatibility. The temperature of the water in the tank can cause this problem. It could also be due to water impurities. Water pH (acidity vs. alkalinity) also may unexpectedly change for some unknown reason. Sometimes the amount of time the spray mixture has been in the tank causes field incompatibility. Choosing suitable type of sprayers are an important issues in pesticide application.

Handle sprayer for small areas and indoor: (Figure 1)

Figure 1: Handle sprayer for small areas and indoor.

Aerosols (Figure 2)

Figure 2: Aerosols.

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Back knapsack sprayer (Figure 3)

Figure 3: Back knapsack sprayer.

Portable (Figure 4)

Figure 4: Portable.

Trailed (Figure 5)

Figure 5: Trailed.

Mounted (Figure 6)

Figure 6: Mounted.

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Aircraft (Figure 7)

Figure 7: Aircraft.

Remote aircraft: Small, unmanned aircraft systems (UAS) provide an opportunity for pesticide spray application in which the applicator can be displaced from close proximity of the spray discharge and in which the spray application can be made with highly targeted spatial resolution, particularly in challenging geographic terrain (Figure 8).

Figure 8: Remote aircraft.

Smoke or fog generator: (Figure 9)

Figure 9: Smoke or fog generator.

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Duster (Figure 10)

Figure 10: Duster.

Results and Summary

The investigated formulation showed that there is many types of formulations depend on the nature of the insects and the condition of application, but it covers all kinds of insects and diseases control. And the formulation bits can be achieved in formulation of Sudanese essential oil in different forms nevertheless, Sudanese essential has a diversity of active ingredients can substitute any recommended imported essential oil. The sources of essential oil and techniques were available for this green technology. We can come to conclude that there are different sources, tools, models and methods for essential oil pesticide management can control any type of plant pest or diseases in Sudan.

Conclusion

We can come to conclude that up to right now, all the techniques and resources are positively favor the essential oil pesticide technology in Sudan.

Recommendations

1. It is recommended that choosing the proper type of formulation that suite the specified plant pests and diseases behavior and condition.

2. It is recommended that selection of a good adjuvant is necessary for good controlling of plant pests and diseases.

3. Precise using of bits model can lead to achieve good formulation and resulted in good controlling of plants pests and diseases.

4. Optimization spraying equipment techniques, considering that all types of application techniques can be used in Sudan from aircraft, remote air craft to aerosol (different conditions, environments and small or large areas).

5. Most plant pests and diseases in Sudan such as, postharvest diseases, powdery mildew, scale insects, locust, store pests etc can be controlled by Sudanese essential oil.

Appendices

Appendix 1: Common abbreviations is pesticide formula

A: Aerosol

AF: Aqueous flowable

AS: Aqueous solution or aqueous suspension

B: Bait

C: Concentrate

CM: Concentrate mixture

CG: Concentrate granules

D: Dust

DF: Dry flowables

DS: Soluble dust

E: Emulsifiableconcentrate

EC: Emulsifiableconcentrate

F: Flowable (liquid)

G: Granules

GL: Gel

L: Liquid (flowable)

LC: Liquid concentrate or low concentrate

LV: Low volatile

M: Microencapsulated

MTF: Multiple temperature formulation

P: Pellets

PS: Pellets

RTU: Ready-to-use

S: Solution

SD: Soluble dust

SG: Soluble granule

SP: Soluble powder or soluble packet

ULV: Ultra low volume

ULW: Ultra low weight or ultra low wettable

W: Wettable powder

WDG: Water- dispersible granules

WP: Wettable powder

WS: Water soluble

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WSG: Water-soluble granules

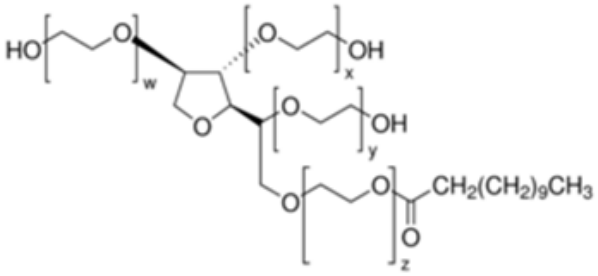
WSL: Water-soluble liquid

WSP: Water-soluble powder or water-soluble packet

Appendix ii

a. Tween 20

Polysorbate 20 (common commercial brand names include Scattics, Alkest TW 20 and Tween 20) is a polysorbate-type nonionic surfactant formed by the ethoxylation of sorbitan before the addition of lauric acid. Its stability and relative nontoxicity allows it to be used as a detergent and emulsifier in a number of domestic, scientific, and pharmacological applications. As the name implies the ethoxylation process leaves the molecule with 20 repeat units of polyethylene glycol; in practice these are distributed across 4 different chains leading to a commercial product containing a range of chemical species [2]. Tween and Tween 20 are registered trademarks of Croda Americas



Polysorbate 20

Chemical compound

Polysorbate 20 is a polysorbate-type nonionic surfactant formed by the ethoxylation of sorbitan before the addition of lauric acid.

Density: 1.1g/cm^3

Formula: $C_{58}H_{114}O_{26}$

Molar mass: 1,227.54g/mol

CMC: 8.04×10^{-5}M at 21 °C

HLB: 16.7

Main hazards: Irritant

Appearance: Clear, yellow to yellow-green viscous liquid **(Chunhee Kim and You-Lo Hsieh, 2001; Ayorinde et al., 2000)**.

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