Pesticides and Their Formulations

Chapter · November 2023

CITATIONS
0

READS
5,555

4 authors, including:

Shailendra Kumar Mishra
Banda University of Agriculture & Technology, Banda UP
51 PUBLICATIONS **20** CITATIONS
SEE PROFILE

Mukesh Kumar Mishra
Banda University of Agriculture and Technology
42 PUBLICATIONS **175** CITATIONS
SEE PROFILE

5

Pesticides and Their Formulations

Mukesh Kumar Mishra[1], Shailendra Kumar Mishra[2], Lakshmi Pandey[3] and Arun Kumar[4]

[1] Assistant Professor
[2] Research Scholar
[3] P.G. Student, Department of Entomology, Banda University of Agriculture & Technology, Banda-210 001 (U.P.)
[4] Research Scholar, Department of Entomology, CSAUA&T, Kanpur (U.P.)
[*] **Corresponding Author** Email: mishraent@gmail.com

ABSTRACT

It is impossible to overstate the importance of pesticides in reducing crop losses, lowering the cost of food, and enhancing food quality. This has highlighted the significance of pesticide formulations. To evenly distribute a little amount of an active chemical over a vast region, pesticide active components are formulated for crop protection. The aim is to maximise pesticide effectiveness while ensuring safety in handling and application. For the minimal effective quantity to be precisely sprayed to target regions, the pesticide formulation must be physically and chemically homogeneous under all predicted storage circumstances. In any pest control procedure including pesticides, choosing the right formulation is a crucial step. It is a crucial managerial choice that affects revenue, client happiness, public safety, and environmental quality. Understanding the characteristics of various formulations is important for both the supervisor and the applicator. Both the concentrated and diluted substance are in close proximity to the applicators. It is necessary to understand the safety characteristics of the formulation being used out of a basic, personal concern for one's health and the health of others.

Keywords: Pesticide, formulation, handling, minimal effective, environmental safety

Introduction

The toxicant must be able to be applied effectively in order to come into touch with the pest or leaf and to leave a uniform and permanent deposit on the plant surface. **Pesticide in chemically pure form is known as technical grade pesticides**. These cannot be applied as such due to high toxicity and complex

physical properties. They are converted into a ready to-use form known as **formulation**. Formulation converts the technical grade pesticide into a product which can be suitably diluted & applied by practical methods. Which have homogeneous distribution over large area, convenient to handle and more attractive to the pest. Formulation **can be defined as "a physical mixture of pesticide with inert ingredients which can be suitably stored, transported and applied by practical means to achieve effective, safe and economic control of pests**" or **it is a substance which processed through formulation in order to increase its storage, handling, application, efficacy, safety for the user and the environment, and financial success**. Grewal (2005) defined as **"formulation is the process of creating a product from an active component by adding various active (functional) and non-active (inert) ingredients"**. or the formulants are defined as inert diluents, they are usually not required to be tested for chronic toxicity **(R. Mesnage *et al*., 2013 & 2019).** It is the last physical state in which pesticide is offered for sale. The mode of application is generally constrained by the formulation, which describes what and how other ingredients are combined with the active component.

There are several "formulas" for pesticides and majority of technical pesticides are created by combining one or more active ingredients (a.i.), which kill pests with inert substances, diluents, preservatives, adjuvants, etc. prior to use in order to create a product that is efficient, simple to handle and apply, has a good shelf life, and is free of unfavourable side effects. The qualities of the inert component, coupled with the properties of the active ingredient, define the signal word that is shown on the product label. Some inert substances offer health concerns to pesticide handlers or applicators. Due to the inert ingredients present in the formulation, pesticide products with the same active ingredient are marketed in the form of granules, dusts, solutions, wettable powder, flowable suspension concentrate, emulsifiable concentrate, spray able oils, aerosols etc. **(H. Muntz *et al*., 2016)**.

A formulation is categorised as based on their physical condition in the container at the time, solids or liquids buy time. More than one active component may be included in a formulation, and many of them must be further diluted with a suitable carrier (such as water) before usage. Several alternative formulations of the same pesticide are frequently offered for sale and it is grouped in two major categories:

- **Conventional Formulations**: Formulations which are being used in agriculture and public health sector for long time viz., Dustable Powder (DP), Wettable Powder (WP), Emulsifiable Concentrate (EC), Soluble Concentrate (SL), Granules (GR): Coated & Impregnated and Baits formulation.

- **Safer Formulation or New Generation Formulations:** These are safe, user & environment friendly effective products viz., Suspension Concentrate (SC), Water Dispersible Granules (WG), Concentrated Emulsion (EW), Microemulsion (ME), Controlled Release Formulation (CR), Suspo-emulsion Formulation (SE), Tablet Formulation (WT) and Gel Bait.

The pesticide formulations are also grouped on the basis of their physical appearance in the market as solid, liquid and other formulations:

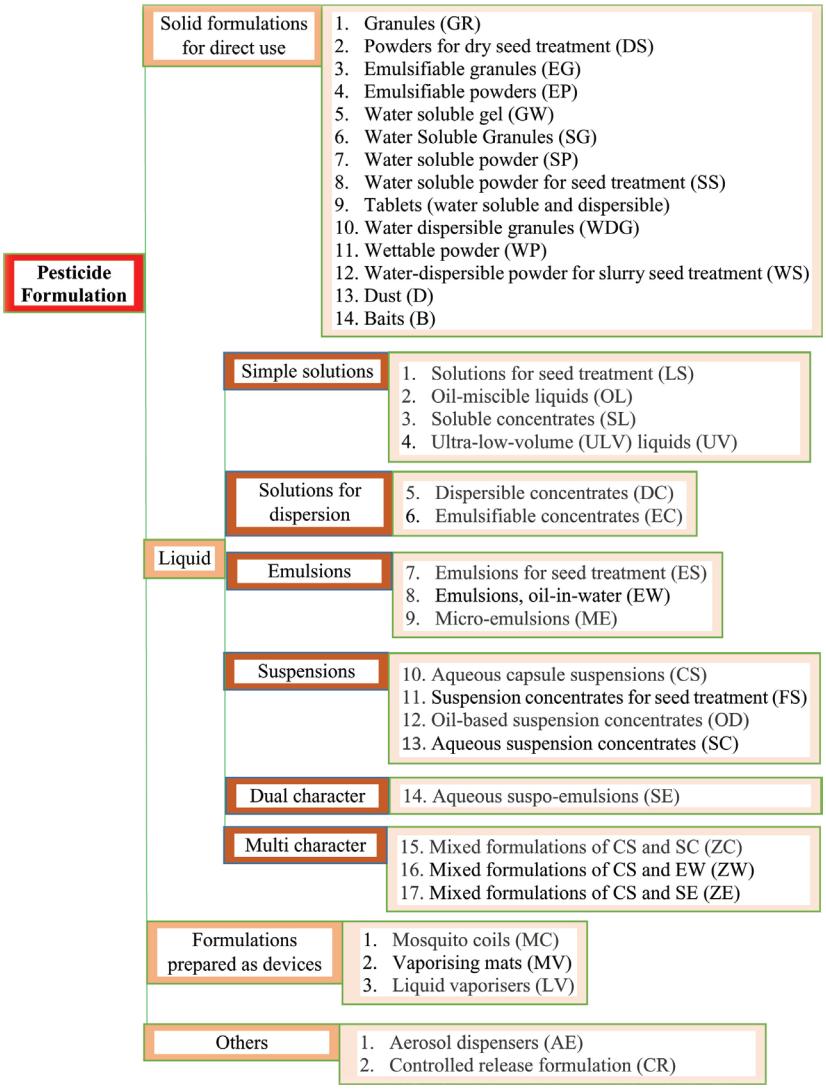

Fig. Classification of pesticidal formulations (Source: http://apvma.gov.au/node/10901)

Solid formulation

1. **Granules (G):** (**Ingredient**: Pesticide, carriers, (river sand/marble hips), Coating agent) Formulations that are ready to use are granules. Either the granules' outside is coated with the active component, or it is absorbed by tiny clay, tale, or other carrier particles. The amount of
2. **Powders for dry seed treatment (DS):** This type of formulation look like a powder for application in the dry state, directly to the seed.
3. **Emulsifiable granules (EG):** It is a granular formulation, which may contain water-insoluble formulants, to be applied as an oil-in-water emulsion of the active constituent(s) after disintegration in water.
4. **Emulsifiable powders (EP):** It is a powder formulation, which may contain water-insoluble formulants, to be applied as an oil-in-water emulsion of the active constituent(s) after dispersion in water.
5. **Water soluble gel (GW):** It is a gelatinized formulation to be applied as an aqueous solution.
6. **Water Soluble Granules (SG):** It is a granule formulation to be applied as a true solution of the active ingredient after dissolution in water, but which may contain insoluble inert ingredients.
7. **Water soluble powder (SP):** A powder preparation to be applied as a true solution of the active substance after solution in water but which may contain insoluble. These mixtures resemble wettable granules in appearance. But when combined with water, soluble powders easily dissolve and create a real solution. There is no need for extra agitation after a thorough mixing. Soluble powders include an active component in concentrations ranging from 15% to 95%.
8. **Water soluble powder for seed treatment (SS):** It is a powder formulation to be dissolved in water before application to the seed.
9. **Tablet Formulation** (**Main components**: effervescent tablet includes active ingredients, effervescent disintegrants, thinners, adhesives, surfactants, lubricants, glidants and others.

   It is characterized by low or no water solubility, a complementary delivery system containing an organic acid, an inorganic base, a dispersant, a disintegrant, and a wetting agent an contain about 20% to 75% of a pesticide.

   a) **Water soluble tablets (ST):** It is a tablet formulation to be used individually, to form a solution of the active ingredient after disintegration in water. The formulation may contain water-insoluble formulants.

b) **Water-dispersible tablets (WT):** It is a tablet formulation to be used individually, to form a dispersion of the active constituent after disintegration in water.

10. **Water dispersible granules (WDG):** These are granule-sized, dust-free particles made from compressed WP formulations. The granules disintegrate into a fine powder when they are stirred in water. These products contain wetting agent and dispersing agent similar to those used in wettable powders, but the dispersing agent is usually at higher concentration. Water dispersible granules are usually more expensive than older types of formulations (dusts, wettable powders) but their safety and greater convenience regarding application make them still desirable for many users (Knowles, 2008).
11. **Wettable powder (WP):** (Ingredient: pesticide, diluents/ carrier, wetting and dispersing agents) These are the pesticide formulation consisting of the active ingredient in a finely ground state combined with wetting agents and sometimes bulking agents (www.crodacropcare.com). Wettable powder are free-flowing powders that contain wetting and dispersion agents, carriers, and a majority of technical material between 25 and 75 percent. When dissolved in water, WPs create suspension.
12. **Water-dispersible powder for slurry seed treatment (WS):** It is a powder formulation to be dispersed at high concentration in water before application as slurry to the seed.
13. **Dust (D): (Ingredients:** Pesticide, Carrier/Diluents): It is a pesticide formulation in which, the toxicant is diluted either by mixing with or by impregnation on a suitable finely divided carrier. The finished product may contain 0.1-25 per cent of the toxicant. The particle size of dusts ranges between 1 and 40. In general, the toxicity of an insecticide increases as the particle size decreases.
14. **Baits (B):** (**Composition**: Pesticide, Diluents, food attractant): These are ready-to-use formulations (RTUs) that combine an active component with food or another alluring material. Pests are either drawn to the bait or it is placed in an area where they will locate it.

Liquid formulation

A. Simple solution

1. Solutions for seed treatment (LS): It is a clear to opalescent liquid to be applied to the seed either directly or as a solution of the active constituent after dilution in water. The liquid may contain water-insoluble formulants.

2. Oil-miscible liquids (OL): It is a homogeneous liquid formulation to be applied as a homogeneous liquid after dilution in an organic liquid.
3. Soluble concentrates (SL): It a clear to opalescent liquid to be applied as a solution of the active constituent after dilution in water. The liquid may contain water-insoluble formulants.
4. Ultra-low-volume (ULV) liquids (UV): It is a homogeneous liquid ready for use through ultra-low-volume (ULV) sprayer. These products are designed to be sprayed without dilution, and thus must be applied very carefully with specialized equipment. In addition to the active ingredient and a solvent system in which the active is very soluble, UL products often contain surface-active agents and drift control substances.

B. Solutions for dispersion

1. **Dispersible concentrates (DC):** It is a liquid homogeneous formulation to be applied as a solid dispersion after dilution in water.
2. **Emulsifiable concentrate (EC):** (**Ingredient**: Pesticide, Solvents, Emulsifiers, Stabilizers)The formulation consists of the toxin, the toxin's solvent, and an emulsifier. It is a transparent solution that, when diluted with water to spray strength, forms an emulsion of the oil-in-water kind. Spraying a solvent causes it to swiftly evaporate, leaving a toxicant deposit where water also evaporates.

C. Emulsions

1. **Emulsions for seed treatment (ES):** This formulation is a stable emulsion for application to the seed, either directly or after dilution.
2. **Emulsions, oil-in-water (EW):** (**Composition:** Active ingredient, emulsifier, antifreezing agent anti- foaming agent and preservative and water); This formulation is physically stabilised by specifically identified polymeric surfactants incorporated at an appropriate level. The emulsion has already been established in the formulation and is only diluted further in the spray mixture. They can be considered as a safer and more environmentally friendly alternative to emulsifiable concentrates. In an EW the continuous phase is water (as opposed to an organic solvent for ECs) which offers the benefit of lower phytotoxicity, no flashpoint concern, ease of handling, and a lower environmental impact.
3. **Microemulsion (ME)** (**Composition:** Active ingredient, Min. solvent Emulsifier, Co- surfactant water); Microemulsion is water-based formulations with a very small emulsified droplet size; this makes the formulation transparent. It is thermodynamically stable over a wide

temperature range due to this very fine droplet size, usually between 0.01 and 0.05 μm.

D. Suspensions

1. **Aqueous capsule suspensions (CS):** This formulation is designation for a stable suspension of micro-encapsulated active ingredient in an aqueous continuous phase, which is normally intended for dilution with water before use.
2. **Flowable concentrates for seed treatment (FS):** It is a modification of suspension concentrates with supplemental additives for adhesion to the seed surface and colourants as safety markers to indicate that a seed has been treated with a product. It can be to the seed, either directly or after dilution and now the most popular type of seed treatment because they are concentrated formulations and are safer to apply as they are water based.
3. **Oil-based suspension concentrates (OD):** It is stable suspension of active constituent(s) in water-immiscible fluid, which may contain other, dissolved active constituent(s), intended for dilution with water before use. It is containing high melting a.i. with low solvent solubility and dispersed in oil as fine particles.
4. **Aqueous suspension concentrates (SC):** (**Composition**: Active ingredient, surfactants, thickener, antifreezing agent, antifoaming); The active component is included in this liquid formulation as a solvent that is compatible with water. During spraying, the solvent is combined with water and dissolves, leaving the active component intact. A surfactant is used to provide wetting power. They are created using a wet grinding technique, and their range of particle sizes is 1 to 10 m. Small particles are kept from re-aggregating during the grinding process by inert substances that are adsorbed onto particle surfaces. Due to the active ingredient's increased access to plant tissues due to the smaller particle size, these substances frequently display improved bio efficacy when used. They have several benefits since they are water-based, including ease of pouring and measuring, operator and environmental safety, and affordability. Consequently, they are growing in popularity as a formulation type **(Woods, 2003; Knowles, 2005).**

E. Dual character liquid formulation

1. **Aqueous suspo-emulsions (SE): (Composition:** Insoluble solid (a.i.) as dispersed particle, insoluble liquid (a.i.), as oil droplets, surfactants, water as bulk phase); It is a fluid, heterogeneous formulation consisting of a

stable dispersion of active constituent(s) in the form of solid particles and fine globules in a continuous water phase. The formulation is intended for dilution into water prior to spray application.

F. Multi character liquid formulation

1. **Mixed formulations of CS and SC (ZC):** It is a mixed formulation of capsule suspensions and suspension concentrates. This formulation consists a stable aqueous suspension of microcapsules of one technical material combined with a fine particle of second technical material in an aqueous phase together with suitable formulants. In microcapsules, the active ingredient is inside discrete, inert, polymeric microcapsules to provide slow release second active ingredient is free to provide immediate effect. This formulation is intended for dilution into water prior to spray application and it is easy to handle and measure, dust free, non-flammable and offer good miscibility with water. It is working as broad spectrum pesticide formulation.
2. **Mixed formulations of CS and EW (ZW):** It is a mixed formulation of capsule suspensions and emulsions, oil-in-water. The formulation consists of an emulsion of fine droplets of technical material in the form of the combination of a suspension of microcapsules in an aqueous phase together with suitable formulants. In the case of microcapsules, the active ingredient is present inside discrete, inert, polymeric microcapsules. After gentle agitation the material must appear homogeneous and be suitable for dilution in water worked and provide a broad-spectrum pest control.
3. **Mixed formulations of CS and SE (ZE):** It is a mixed formulation of capsule suspensions and suspo-emulsions. The formulation consists of an emulsion of fine droplets of technical material and a suspension of fine particles of technical material in an aqueous phase, together with suitable formulants. After gentle agitation the material must appear homogeneous and be suitable for dilution in water.

G. Formulations prepared as devices

1. **Mosquito coils (MC):** It a coil that burns without producing a flame and releases the active constituent into the local atmosphere as a vapour.
2. **Vaporising mats (MV):** It is a mat, which made from pulp, or other suitable inert materials, and impregnated with an active constituent. The mat is intended for use in a heating unit designed to produce slow volatilisation of the active constituent.

3. **Liquid vaporisers (LV):** It is liquid formulation in a cartridge, designed to fit a suitable heating unit, from which the formulation passes up a heated wick and evaporates into the local atmosphere.

H. Other formulations

1. **Aerosol dispensers (AE):** It consist of a liquid formulation in a pressurised, non-refillable aerosol dispenser, containing propellant(s), synergist(s) and other formulants, as required, intended for release of the active ingredient into the air in the form of an aerosol.
2. **Controlled release formulation (CR)** (**Composition**: Active ingredient Polymer, Surfactant) Controlled-release formulations are absorbed more slowly than conventional tablets and produce more stable serum levels during the day and at night, even when given twice daily as compared with conventional tablets given three times daily. Peak serum concentrations are usually attained within 4–8 h with plain tablets.
3. **Neem based water dispersible granules:** It is a neem-based insecticide formulation with 0.1-3 mm diameter particles which are free flowing and dust free with a homogenous dispersion in water.
4. **Nanoemulsions of botanicals:** Many botanical based nanoemulsions *viz*., castor oil nanoemulsion, cashew nut shell liquid, neem nanoemulsion + biodiesel waste as co-solvent and neem oil nanoemulsion + botanical synergist are also available.

Nanopesticides: These are nanostructures with two to three dimensions between 1 to 200 nm, used to carry agrochemical ingredients (AcI) and synthesized by using carbon nanotubes and graphene-based nanoparticles. In formulation development and drug delivery, the term 'nanoparticles' refers to a variety of particles used to deliver drug products or proteins to their target site. These include liposomes, solid lipid nanoparticles (SLNs) micelles and polymeric nanoparticles. it increases the solubility of water-insoluble pesticides, attacks only on target pests, and protects the premature degradation of pesticide. The common nanocarrier types include polymers (b1–b4) such as chitosan, cellulose and polyethylene existing in the forms of nanocapsules (b1), nanospheres (b2), nano(hydro)gels (b3) and nanomicelles (b4), clay NMs (for example, silica, montmorillonite and kaolinite; b5), nanocomposites (b6), carbon nanotubes (CNTs; b7) etc. (**Rajna *et al.*, 2019**).

Purposes of pesticidal formulation

Formulations improves the properties of a chemical for handling, storage, application and may substantially influence effectiveness and safety **(Knowles, 1998).**

The following purposes of pesticidal formulations are mentioned below:

a) To make improve handling and application of pesticide easy
b) To maximize biological efficacy
c) To improve defects in pesticides
d) To make pesticides safer for workers and users
e) To reduce harmful effects and impact on non-target organism and the environments
f) To give various order to pesticides in order to broaden their spectrum of activity

Conclusion

Pesticide development, usage, disposal, and storage continue to be issues. Despite the fact that contemporary agrochemical businesses are dedicated to creating secure formulations to prevent persistent and bio accumulative. Given the inherent properties of chemicals, it is difficult to anticipate and prevent all potential detrimental effects of pesticides on human health and entire ecosystems. Even contemporary pesticides with purportedly short half-lives can linger in soil for up to many years in some circumstances, posing a risk to soil invertebrates. Alternative approaches (such as the creation of bio pesticides) might reduce harmful qualities and hasten the emergence of resistance in the quest of safety. To decrease the amount of dangerous ingredients in pesticide products and innovative technology are actively being developed. For instance, Nano carriers lessen pesticide losses and delay release, due to improved affinity to the target pest species, and increase the precision of delivery of active chemicals. Government regulations are a crucial part in ensuring the safety of agricultural goods for consumers. The testing of formulants' safety for non-target species based on thorough and trustworthy data on their effects, the necessary examination of the long-term impacts of adjuvants, and improving the predictive capacity of formulants.

References

Anonymous (2023). Formulation types. Australian pesticides and veterinary medicine authority. http://www.crodacropcare.com/

Grewal, P.S.2005. Formulations and Quality control of entomopathogenic nematodes. Department of entomology, Ohio-state-university Wooster.

H. Muntz, R. Miller, D. Alston. 2016. Understanding Pesticide Risks: Toxicity and Formulation, (accessed March 24, 2021), http://npic.orst.edu/factshee ts/formulations.pdf.

Knowles, A. 2008. Recent developments of safer formulations of agrochemicals. *Environmentalist,* **28**(1): 35-44.

Knowles, A. 2005. New developments in crop protection product formulation. Agrow Reports UK: T and F Informa UK Ltd., pp.153-156.

Knowles, DA. 1998. Chemistry and technology of agricultural formulations. Kluwer Academic, London.

R. Mesnage, B. Bernay, G.E. S´eralini. 2013. Ethoxylated adjuvants of glyphosate-based herbicides are active principles of human cell toxicity, *Toxicology.* **313**: 122–128, https://doi.org/10.1016/j.tox.2012.09.006.

R. Mesnage, C. Benbrook, M.N. Antoniou.2019. Insight into the confusion over surfactant co-formulants in glyphosate-based herbicides, *Food Chem. Toxicol*., **128**:137–145, https://doi.org/10.1016/j.fct.2019.03.053.

Rajna S., Paschapur A. U. and Raghavendra K. V.2019. Nanopesticides: Its Scope and Utility in Pest Management. *Indian Farmer* 6(1): 17-21; January-2019

Woods, T.S. 2003. Pesticide Formulations. Encyclopedia of Agrochemicals, New York, pp. 1-11.