भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS

Doc. No. : PRTD/AR/**PF:03**	Issue No. : 2	Issue Date 30 Sept. 2020	**Report of Action Research**

1.	**Action Research Project No.** *(as assigned by PRTD)*	AR-0145
2.	**Title of the Action Research Project**	New pesticide formulations for eco-friendly and sustainable pest management
3.	**Name & Designation of Officer**	Pravir Kumar Choubey, Sc-C
4.	**Employee No.**	067385
5.	**Deptt./BO/RO & Place of Posting**	PPBO (Panipat)
6.	**Date of Approval of the Project**	22.12.2020
7.	**Objective of the Project**	The objective of this ARP is to develop standards for pesticide formulations for eco-friendly and sustainable pest management.
8.	**Report of Action Research Activities**	Attached as per Annexure I
9.	**Conclusion & Recommendations**	Attached at page no. 7 of ARP report
10.	**Any other relevantinformation**	Nil

Pravir Choubey
31/08/2021

Sign. of Officer with Date

Head of Deptt./BO 31/08/2021

Activity Head (DDG(PRT))

DDG(PRT) 31-8-21

Doc. No. : PRTD/AR/**PF:04**	Issue No. : 1	Issue Date 28 Apr 2020	**DECLARATION OF ORIGINAL WORK**

DECLARATION OF ORIGINAL WORK

I, Pravir Kumar Choubey, Sc-C, PPBO (indicate official's Name & Designation),

Employee No. 067385 hereby declare that the Action Research Project titled

"**New pesticide formulations for eco-friendly and sustainable pest management**" is the original research work done by me. I have not copied from any other Action Research Project or any other work of similar nature and topic done by any person/institution/body either published or yet to be published. Data and information from other sources, used if any, have been with prior permission, wherever required and is duly acknowledged appropriately in the project report submitted by me.

This declaration is made on the 31st day of August 2021.

Pravir Choubey
31/08/2021

Sign. of Officer with Date

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1. Introduction

Pesticide formulations are a combination of one or more **active ingredients,** which control pests, and several inert ingredients. Many active ingredients are not soluble in water. Some may be toxic or unsafe to handle.Whileothers may be unstable during storage. The inert ingredients are included in a formulated product to solve these problems. Some **inert ingredients** pose health risks to pesticide handlers or applicators so their characteristics, along with those of the active ingredient.

Liquid Formulations

Most liquid formulations are diluted with water to make a finished spray. However, some labels direct users to mix the product with another solvent such as crop oil or other light oil as a carrier. Examples of liquid pesticide formulations include Emulsifiable Concentrates (EC), Soluble Concentrates (SL), Suspension Concentrates (SC) etc.

The three main types of liquid formulations are solutions, suspensions, and emulsions:

A **solution** is made by dissolving a substance in a liquid. A true solution is a mixture that cannot be separated by a filter or other mechanical means. Normally, it will not separate or settle out into distinct parts after being mixed. Light can penetrate most solutions.

A **suspension** is an even mixture of very small solid particles throughout a liquid. A suspension that has been on a shelf for some time must be shaken well to mix the liquid and solid portions evenly before pouring it into the spray tank. Water is added to make a finished spray. There must be enough agitation to keep the product evenly distributed in the spray tank during application. Most suspensions are cloudy or opaque; light cannot pass through them.

An emulsion is a mixture of droplets of one liquid in another liquid. Each ingredient keeps its unique properties and identity.

In an emulsion, the active ingredient is dissolved in an oil-based solvent. An emulsifier allows the active ingredient and the solvent to mix evenly with water before application. Some agitation may be necessary to keep an emulsion from separating. As a rule, emulsions have a milky appearance.

Dry Formulations

The active ingredient is on the surface of a solid carrier, such as talc, clay, or ground corncobs. Examples of dry formulations include Granules (G), Wettable Powders (WP), Soluble Powders (SP), Water Dispersible Granules (WDG) etc.

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2. ConventionalPesticide Formulations

i) Wettable powders (WP): Wettable powders are finelydivided solid pesticide formulations which are applied after dilution and as a suspension in water. They have been used for many years and are second only to emulsifiable concentrates in terms of the total volume of products produced globally. These particles are larger than the droplets produced by emulsifiable concentrate formulations. It is this factor, coupled with the lack of solvent, which gives WP"s lower biological activity than most liquid formulations. However, this also makes them less likely to cause phytotoxicity to crop.

Disadvantages: Difficult to mix in spray tanks; Poor compatibility with other formulations; Tank mix wetter may be needed: Dust hazard during manufacture: Dust hazard during application.

ii) Emulsifiable Concentrate (EC): EC formulations usually contain an oil-soluble liquid active ingredient, a petroleum-based solvent, and an emulsifier (mixing agent). The emulsifier allows the active ingredient in the solvent to mix with water, these form an emulsion.

Disadvantages: Emulsion stability problems may arise after dilution; Sometimes phytotoxic to vegetable crops; May increase dermal toxicity of active ingredient; Possible fire hazard; Solvents may affect plastics and rubbers in spray applicators.

iii)Soluble concentrates (SL): A soluble concentrate is a clear solution to be applied as a solution after dilution in water. Soluble concentrates are based on either water or a solvent mixture which is completely miscible in water.

Disadvantages: Often requires surfactant wetters for good wetting/spreading on vegetable leaves; Poor low temperature stability; May hydrolyze active ingredients; Corrosive to metals.

3. Eco-friendly Water based Dispersion Technology

i) Suspension concentrates (SC): A suspension concentrate contains tiny particles of active ingredient suspended in a liquid (usually water) and milled to reduce the average particle size. For active ingredients that are denser than water (most are), suspension agents are added to prevent the solids from settling in the packaged product. Among other inert components, wetting agents are usually needed to keep the solid surfaces wetted in water because most active ingredients tend to be hydrophobic.

Advantages: High concentration of insoluble active ingredients; Ease of handling and application; Safety to the operator and environment; Relatively low cost; Enable water-soluble adjuvants to be built-in for enhanced biological activity. They are non-dusty and easy to measure and pour into the spray tank.

ii) Oil-in-Water emulsions (EW):Oil-in-water emulsions are now receiving considerable attention because of the need to reduce or eliminate volatile organic solvents (VOCs) for safer handling. Because they are water based, oil-in-water emulsions can have significant advantages over emulsifiable concentrates in terms of cost and safety in manufacture, transportation and use. Key is that the active ingredient must have very low water solubility to avoid crystallization issues. A solid active may be dissolved in a water–immiscible solvent.

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Advantages: No organic solvent used hence safer handling is possible.

iii) Suspo-emulsions (SE): Suspo-emulsions can be considered to be mixtures of suspension concentrates and oil-in-water emulsions with added surfactants to prevent flocculation and thickeners to prevent separation of the dispersed phases.

Advantages: Convenient to use as the user can apply the correct amount of pesticide and overcome problems of tank mix compatibility.

iv) Microemulsions (ME): Microemulsions are thermodynamically stable transparent dispersions of two immiscible liquids and are stable over a wide temperature range. They have a very fine droplet size of less than 0.05 microns. The total concentration of surfactants for a microemulsion can be as high as 10–30% or more, compared with about 5% for a typical o/ w emulsion.

Advantages: Microemulsions have relatively low active ingredient concentrations, but the high surfactant content and solubilisation of the active ingredient may give rise to enhanced biological activity.

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4. Advantages of water-based pesticide formulation over conventional formulations:

i) Solvent reduction and safer solvent selection.

ii) Safer surfactant components with low toxicity.

iii) Low skin irritation and enhanced biodegradability.

iv) Longer physical and chemical stability.

v) Enhancement of bio efficacy by incorporation of adjuvants.

vi) Controlled and sustained release formulations.

vii) Compatibility of various formulations in tank mixes.

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5. A brief about Malathion:

Malathion is a man-made organophosphate insecticide that is commonly used to control mosquitoes and a variety of insects that attack fruits, vegetables, landscaping plants, and shrubs. It can also be found in other pesticide products used indoors and on pets to control ticks and insects, such as fleas and ants. It is one of the most commonly used insecticides in India as per the data from Statistical Database of Directorate of Plant Protection for indigenous pesticide consumption during 2016-17 to 2020-21. Average consumption during this period for Malathion was 532.19 MT.

ISO common name: malathion (E-ISO, (m) F-ISO, ESA, BAN)

Chemical name: IUPAC: S-1,2-bis(ethoxycarbonyl)ethyl O,O-dimethyl phosphorodithioate

Molecular formula: $C_{10}H_{19}O_6PS_2$

Relative molecular mass: 330.36

Indian standard specifications exist for different Malathion formulations:

Malathion Dusting Powder (IS 2568),
Malathion Water Dispersible Powder Concentrates (IS 2569) &
Malathion Emulsifiable Concentrates (IS 2567).

A draft standard for Malathion Emulsion-in-Water (EW) is attached with this ARP report. This formulation is eco-friendly as no organic solvent is used in its manufacture.

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6. Specification for Malathion Emulsion-in-Water (EW)

1. SCOPE This standard prescribes the requirements and the methods of sampling and test for Malathion EW.

2 REQUIREMENTS

2.1 Constituents

2.1.1 The material shall consist of malathion, technical together with suitable emulsifiers, defoaming agents and demineralized water.

2.1.2 Malathion, technical employed in the manufacture of the material, shall conform to IS 1832.

2.2 Physical

The material shall comply with the physical requirements specified in 2.2.1 to 2.2.3.

2.2.1 Description

The material shall be homogeneous stable emulsified liquid.

2.2.2 Cold Test

No separation of solid or oily matter or both shall occur when the material is subjected to the cold test at 0 °C as prescribed in 13.1 of IS 6940.

2.2.3 Dispersion

Stability Any separation including creaming at the top and sedimentation at the bottom of 100-ml solution prepared in standard hard water with 5-ml of the emulsion shall not exceed 1-ml.

2.3 Chemical

The material shall comply with the chemical requirements specified in 2.3.1 and 2.3.2

2.3.1 Malathion Content

When determined by the method prescribed in Annex A of IS 1832, the observed malathion content, percent by mass, shall not differ from the declared nominal value by more than the percent tolerance limits indicated below:

Nominal Value, Percent	Tolerance limits, Percent	
Up to 9	+10	of the nominal value
	-5	
Above 9 and below 50	+5	
	-5	
50 and above	+5	
	-5	

2.3.2 pH value

When tested by the method prescribed in 11.3 of IS 6940, the pH of 1% aqueous solution should be between 2.0 to 5.0.

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3. PACKING The material shall be packed in HDPE containers [conforming to IS 7408 (Part 1 or 2)]. The containers shall also meet the general requirements as given in IS 8190 (Part 2).

7. Recommendations

i) New eco-friendly specifications like SC, EW etc. should be developed for all the pesticides which are used in maximum quantity in our country. Data from Statistical Database of Directorate of Plant Protection for indigenous pesticide consumption may be utilized for this purpose.

ii) Indian specification for Propineb and Glyphosate should be developed as they are used in large quantity, however no ISS for their formulations exist (except for technical).

iii) Specifications should be developed for novel formulations like Microemulsions (ME), Oil dispersion (OD), Aqueous flowables (AF) etc.

iv) Manufacturers may be incentivized to diversify to more eco-friendly pesticide formulations. Schemes like rebate in marking fee may be initiated in this regard.

v) A draft standard for **Malathion Emulsion-in-water (EW)** has been prepared which may be taken up for standard formulation, if deemed fit.

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8. References

- Hazra,Karmakar, Poi,Bhattacharya and Mondal (2017):*Recent advances in pesticide formulations for eco-friendly and sustainable vegetable pest management*: *A review*; *Archives of Agriculture and Environmental Science*
- Randy Rush, PhD, *Back to basics: A review of pesticide formulation types, GCM*
- Pesticide application methods: G Matthews (Book)
- Statistical Database of Directorate of Plant Protection for indigenous pesticide consumption
- FAO specifications and evaluations for agricultural pesticides of Malathion and other pesticides
- Wikipedia

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Availability of ISS for different type of pesticide formulations having maximum consumption in India

Table 1
(INSECTICIDES)

Avg. consumption in last 5 yrs.(in MT)*	Pesticides	Granules	DP	WP	SP	SL	EC	WDG	SC	EW	SE	ME	AF
1026.3	Chlorpyrifos	-	-	-	-	-	Yes	-	-	-	-	-	-
429.59	Cypermethrin	-	-	-	-	-	Yes	-	-	-	-	-	-
363.35	Diclorvos	-	-	-	-	-	Yes	-	-	-	-	-	-
366.89	Fenvalerate	-	Yes	-	-	-	-	-	-	-	-	-	-
396.49	Fipronil	-	-	-	-	-	-	-	Yes	-	-	-	-
532.19	Malathion	-	Yes	-	-	-	Yes	Yes	-	-	-	-	-
364.25	Monocrotophos	-	-	-	-	Yes	-	-	-	-	-	-	-
538.36	Phorate	Yes	-	-	-	-	-	-	-	-	-	-	-
387.08	Profenophos	-	-	-	-	-	Yes	-	-	-	-	-	-
522.76	Quinalphos	Yes	Yes	-	-	-	Yes	-	-	-	-	-	Yes

- **Conventional pesticide formulations**: Granules, Dusting Powder (DP), Wettable Powder (WP), Soluble Powder (SP), Soluble Liquid (SL), Emulsifiable Concentrates (EC)
- **Water based pesticide formulations**: Water dispersible granules (WDG), Suspension concentrates (SC), Emulsion-in-water (EW), Suspo-emulsions (SE), Microemulsions (ME), Aqueous flowables (AF)

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Table 2
(FUNGICIDES)

Pesticides	Avg. consumption in last 5 yrs.(in MT)*	Granules	DP	WP	SP	SL	EC	WDG	SC	EW	SE	ME	AF
Captan	191.19	-	-	Yes	-	-	-	-	-	-	-	-	-
Carbendazim	576.05	-	-	Yes	-	-	Yes	-	-	-	-	-	-
Copper Oxychloride	323.25	-	Yes	-	-	-	-	Yes	-	-	-	-	-
Dodine	121.64	-	-	Yes	-	-	-	-	-	-	-	-	-
Hexaconazole	130.99	-	-	-	-	-	Yes	-	Yes	-	-	-	-
Mancozeb	2629.69	-	-	Yes	-	-	-	-	-	-	-	-	-
Propineb	292.69	-	-	-	-	-	-	-	-	-	-	-	-
Sulphur	3347.63	-	Yes	Yes	-	-	-	-	-	-	-	-	-
Zineb	151.25	-	-	-	-	-	-	Yes	-	-	-	-	-
Ziram	187.28	-	-	-	-	-	-	Yes	Yes	-	-	-	-

Table 3
(WEEDICIDES)

Pesticides	Avg. consumption in last 5 yrs.(in MT)*	Granules	DP	WP	SP	SL	EC	WDG	SC	EW	SE	ME	AF
Anilophos	105.82	-	-	-	-	-	Yes	-	-	-	-	-	-
Atrazine	314.92	-	-	Yes	-	-	-	-	-	-	-	-	-
Butachlor	456.71	Yes	-	-	-	-	Yes	-	-	-	-	-	-
Glyphosate	577.97	-	-	-	-	-	-	-	-	-	-	-	-
Pendimethalin	170.93	Yes	-	-	-	-	Yes	-	-	-	-	-	-
Pretilachlor	411.30	-	-	-	-	-	Yes	-	-	-	-	-	-

* Data for average consumption is based on data from Statistical Database of Directorate of Plant Protection for indigenous pesticide consumptionduring 2016-17 to 2020-21.

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