HERBICIDE FORMULATIONS

Important Terms

active ingredient
adjuvant
agitation
amine
antifoaming agent
aqueous suspension
crop oil
crop oil concentrate
drift inhibitor
dry flowable
emulsifiable concentrate
emulsion
ester
flowable
formulation
granule
inert ingredient
methylated seed oil
nonionic surfactant
nonvolatile
organo-silicone
pellet
penetrant
soluble powder
solution
sticker
surfactant
suspension
water-dispersible granule
water-soluble concentrate
wettable powder

INTRODUCTION

The **active ingredient** in a herbicide is the chemical that controls the target weed. The herbicide product you purchase is rarely made up only of active ingredients. Often the herbicide is diluted in water or a petroleum solvent, and other chemicals are added before the product is offered for sale. These other chemicals may include wetting agents, spreaders, stickers, extenders, or diluents. They usually make the product easier to apply and more convenient to handle. This mixture of active and **inert ingredients** (inactive) is called a **formulation**.

TYPES OF FORMULATIONS – ADVANTAGES AND DISADVANTAGES

A single active ingredient often is sold in several different kinds of formulations. You must choose the formulation that will be best for each use. In making your choice, consider:

-application equipment available and best suited for the job,
-hazard of drift and runoff (nearness to sensitive areas, likelihood of wind or rain),
-safety to applicator, helpers, and others likely to be exposed,
-growth patterns of the plant (granular vs. foliar spray), and
-cost.

Dry Formulations

Granule (G)

This is a ready-to-use dry mixture of a small amount of active ingredient with inert carriers. Most are made by applying a liquid formulation of the active ingredient to coarse particles (granules) of some porous material such as clay, sand or plant material. Granule particles are much larger than dust particles; will pass through a 4-mesh sieve but not through an 80-mesh sieve (the

number of wires per inch). The herbicide is absorbed into the granule, or coats the outside of it, or both. Inert ingredients may be added to make the formulation handle well. The amount of active ingredient usually ranges from 1 to 15 percent. They are most often used as soil treatments where they have the advantage of weight to carry them through foliage to the ground. They do not cling to plant foliage, but they may be trapped in the whorls of some plants. Granular formulations should always be used dry. Never mix them with water. Granules should not be applied to frozen soil or on steep slopes. Since all are soil active, application in close proximity to root systems of nontarget plants is also a special hazard. The relative large particle size of granules minimizes drift potential and reduces inhalation hazard. Granules also have a low dermal hazard. Examples: Top-Site, Sprakill 13, Arsenal 5G.

Advantages:

-ready to use,
-easy to apply,
-will fall through dense foliage,
-minimizes drift potential,
-reduced inhalation and dermal hazard, and
-simple application equipment.

Disadvantages:

-limited foliage use,
-expensive per pound active ingredient,
-needs moisture to activate herbicide action,
-bulk quantities necessary can be logistical problem,
-hazardous on steep slopes, on frozen soil, and around nontarget plants,
-can be attractive to nontarget organisms such as birds, and
-difficult to spread uniformly around obstacles.

Pellet (P)

Pellets are similar to granules, but their manufacture is different. The active ingredient is combined with inert materials to form a slurry (a thick liquid mixture). This slurry is then extruded under pressure through a die and cut at desired lengths to produce a particle that is relatively uniform in size and shape, but is much larger than a granule. Pellets are similar to granules in that they are ready to use, are applied in the dry form, and contain a small amount of active ingredient (usually 10 to 20 percent by weight) combined with inert carrier. Pelleted formulations may be applied by hand or mechanically, and are used for soil treatment. While drift is not a

problem with this formulation, pellets should not be applied to frozen soil. Use on steep slopes or in close proximity to root systems of nontarget plants are also special hazards. Pellets provide a high degree of applicator safety. Example: Spike 20P

Advantages:

-ready to use,
-easily applied by hand,
-reduced applicator hazard,
-minimum drift potential, and
-effective spot treatment method.

Disadvantages:

-active ingredient expensive,
-hazardous on steep slopes, close to desired plants, and on frozen soil,
-bulk quantities necessary can be logistical problem, and
-difficult to spread uniformly around obstacles.

Wettable Powder (WP or W)

Wettable powders are finely ground solids, typically mineral clays, to which an active ingredient is sorbed. They provide an effective way to apply an active ingredient in a water spray that is not readily soluble in water. These dry preparations look like dust, contain a high percent active ingredient (usually 50 percent or more) and are mixed with water for application. Wettable powders form a **suspension** rather than true solution when added to water. Good **agitation** (mixing) is needed in the spray tank to maintain the suspension. Good wettable powders spray well and do not clog screens. They can be abrasive to pumps and nozzles. The powdery nature of this formulation does present an **inhalation hazard** to the applicator during mixing and loading. Example: Spike 80W.

Advantages:

-easy to store, transport and handle, and
-relatively inexpensive.

Disadvantages:

-inhalation hazard while pouring the powder,
-requires agitation,
-may clog strainer and screens,

-abrasive to sprayers,
-residues may be visible, and
-concentrate spills can be difficult to clean up from porous surfaces.

Soluble Powder (SP)

This is a dry formulation that contains a high percent (usually above 50 percent) active ingredient. Soluble powders look like wettable powders but they form a true solution when added to water. Agitation in the spray tank will help this formulation to dissolve. After dissolving, no more agitation is usually needed. Few herbicides are available in this formulation because few active ingredients are soluble in water. Soluble powders are nonabrasive to equipment. Inhalation hazard is a characteristic of this formulation. Example: Solution.

Advantages:

-easy to mix,
-limited agitation required, and
-easy to store, transport, and handle.

Disadvantages:

-inhalation hazard while pouring powder, and
-concentrate spills can be difficult to clean up from porous surfaces.

Water-Dispersible Granule or Dry Flowable (WDG or DF)

Dry flowables are manufactured in the same way as wettable powders except that the powder is aggregated into granular particles. They are mixed with water and applied in a spray exactly like a wettable powder. This dry formulation usually contains 70 to 90 percent active ingredient. The formulation pours easily without the windblown dust associated with wettable powders and readily disperses in water to form a suspension. Constant agitation is required. Because of their larger particle size, inhalation hazard for the applicator is reduced. The labels of some dry flowables do permit application of the product in the dry state, with special application equipment. Example: Diuron 80, Escort, Karmex IWC, Oust, Sahara, Velpar DF.

Advantages:

-easy to store, transport, and handle,
-reduced applicator exposure when mixing the dry formulations, and
-concentrate spills are most easy to clean up from porous surfaces.

Disadvantages:

-good agitation required,
-residues may be visible,
-abrasive to sprayers,
-may be slightly more expensive than other dry formulations, and
-rapid pouring from large container can cause mixing problem when product mass settles to bottom of the tank.

Liquid Formulations

Liquid formulations do not exhibit the variety of physical forms possible with dry formulations. However, liquid formulations differ markedly in the nature of their characteristics that influence selection, rate and method of application, and environmental impact.

Water-Soluble Concentrate (WSC)

Water-soluble concentrates form a true **solution** when added to water and are applied with water as the carrier. These herbicides usually have an **amine** (ammonium salt) or mineral salt in the molecule that enables water solubility. These formulations are essentially **nonvolatile**. There are usually 2 to 6 pounds of active ingredient per gallon of formulation. Agitation is not necessary to maintain the herbicide in solution. Example: Arsenal, Formula 40, Garlon 3A, Krenite, Roundup Pro, Tordon K, Vanquish, Veteran 720.

Advantages:

-readily mixes with water,
-equipment cleans up easily,
-essentially nonvolatile,
-not abrasive to equipment,
-will not plug strainers, and
-no agitation necessary.

Disadvantages:

-**eye irritation** with some salts,
-some products are reactive with unlined steel tanks, and
-mixing concentrates together could have compatibility problems.

Emulsifiable Concentrate (E or EC)

An emulsifiable concentrate formulation usually contains the active ingredient, one or more petroleum solvents, and an emulsifier that allows the formulation to be mixed with water. Emulsifiable concentrates usually contain 2 to 8 pounds of active ingredient per gallon. These concentrates are soluble in oil and form an emulsion in water. The emulsion-forming characteristic results from the addition of adjuvants to the herbicide formulation. The oil droplet containing the herbicide is dispersed in the water (oil-in-water emulsion). The milky colored appearance when mixed with water is typical of emulsifiable concentrates. Usually by-pass agitation is sufficient to keep the emulsion from separating. There usually is a **dermal** (skin contact) hazard associated with this formulation.

It is not uncommon for the growth regulator herbicides to be formulated as emulsifiable concentrates as well as water-soluble concentrates. The emulsifiable concentrate formulation (**ester**) is generally more phytotoxic than its water-soluble (amine) counterpart. The ester form is more toxic to fish than the amine form. These ester forms have a potential to be volatile and suggested maximum soil or air temperatures may appear on the herbicide label. Example: Garlon 4.

Advantages:

-little agitation required,
-not abrasive,
-will not settle out or separate when equipment is running, and
-little visible residue on surfaces.

Disadvantages:

-phytotoxic hazard usually greater than water-soluble concentrate,
-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,
-may be corrosive,
-volatility potential, and
-equipment cleaning more difficult.

Flowable or Aqueous Suspension (F, L or AS)

In this formulation, very finely ground solid material is suspended in a liquid. Liquid flowables usually contain a high concentration (4 pounds or more) of active ingredient and are mixed with water for application. The formulation has the same major characteristics as a wettable powder; it forms a suspension when added to water, and it enables the application of water-insoluble herbicides in water. They seldom clog spray nozzles and they need only moderate agitation. Example: Diuron 4L.

Advantages:

-can be mixed with water, and

-no inhalation hazard.

Disadvantages:

-agitation is needed after mixing, and

-may leave a visible residue.

ADJUVANTS

The pure form of many herbicides is not soluble in water. Since usually only a few ounces or pounds of this material are to be spread evenly over a full acre of land, the herbicide is diluted in water. Some are already blended into the herbicide; others are purchased separately and added to the herbicide solution in the spray tank. An **adjuvant** is any material that is added to a herbicide solution to enhance or modify the performance of the solution.

There are three important types of adjuvants used with herbicides. Activator adjuvants include surfactants, wetting agents, penetrants, and oils. Activator agents are the best know class of adjuvants because they are normally purchased separately by the user and added to the solution in the spray tank. Spray modifier agents include stickers, spreaders, thickening agents, film formers, and foams. Utility modifiers include emulsifiers, dispersants, stabilizing agents, coupling agents, co-solvents, compatibility agents and anti-foam agents. Utility modifier agents, and to a lesser degree spray modifier agents, are usually found as part of the herbicide formulation and, thus, are added to the herbicide product by the manufacturer.

Important types of activator adjuvants include:

-**surfactants**, which reduce water surface tension and improve dispersion of the spray,

-**penetrants**, which aid in herbicide movement into the plant,

-**oils**, which improve solution spreading and leaf penetration,

-**stickers**, which improves rain fastness,
-**drift inhibitors**, which reduces drift, and
-**antifoaming agents,** which reduces foam resulting from agitation.

Surfactants

Previously it was generally believed that any product that lowered the surface tension of water or increased the wettability of a spray solution could be used as a surfactant. Even soaps and household detergents were sometimes used. However, soaps and detergents can combine with hard water to form precipitates or scums that can interfere with the performance of spray equipment. Agricultural surfactants do not form precipitates and can be used equally well in hard and soft water. Many liquid detergents and soaps make too much foam for use in a spray tank. Most liquid detergents have a fairly low concentration of surfactant (10 to 20 percent) compared with a 50 to 90 percent concentration for agricultural surfactants.

The most important group of surfactants is the nonionic type. **Nonionic** surfactants do not form an overall electrical charge. They are good dispersing agents, stable in cold water, and have low toxicity to both plants and mammals. Surfactants tend to increase the effectiveness of the herbicide on all plants.

Another group of surfactants is the **organo-silicones**. These products are used at much lower rates than nonionic surfactants and are more effective at reducing surface tension of the spray droplet. Surface tension is so reduced that the spray solution can penetrate the stomates on the leaf surface. This does not usually occur with nonionic surfactants.

Oils

Crop oils, **crop oil concentrates**, and **methylated seed oils**, like surfactants, improve the spreading of the herbicide solution. Being oil instead of water, they keep the leaf surface moist longer than water, allowing more time for the herbicide to penetrate, thus increasing the amount that will enter the plant. Crop oil concentrates contains 80 to 83 percent oil and 17 to 20 percent surfactant and are used at rates similar to the nonionic surfactants.

Spray modifier agents include:

-stickers, which reduce the possibility that the herbicide will be washed off the leaves,
-drift inhibitors, which thicken the spray solution to reduce drift, and
-antifoaming agents, which reduce or prevent foam from forming.

Stickers

A sticker is an adjuvant that causes the herbicide to adhere to the plant foliage, thus reducing the possibility that rain will wash it off before the herbicide can penetrate. Many stickers are blended with wetting agents so that they both increase the spray coverage and provide better adhesion action. When combined, the product is often called a "spreader/sticker."

Drift Inhibitors

Other adjuvants serve other specialized functions. Drift inhibitors or thickeners are used to control drift. These may be powders, granules, or liquids that cause the spray solution to be more cohesive; less subject to wind shear as it leaves the nozzles so as to reduce the amount of very small spray droplets.

Antifoaming Agents

Air gap filling or mechanical agitation in partially full tanks can cause excessive foaming. Antifoaming agents cut down on frothing so that the tank can be filled more easily. These are usually silicone-containing products that are used in relatively small amounts to breakdown the foam.