NSW DPI

Agricultural Pesticide Formulations

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ONLY THE MAIN AGRICULTURAL FORMULATIONS ARE COVERED HERE. (FOR VETERINARY MEDICINE FORMULATIONS, SEE THE SMARTTRAIN LIVESTOCK SUPPLEMENT.)

SMARTtrain Chemical Notes 1

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Registered pesticide products are available in wet and dry formulations. The formulation consists of the active ingredient and the so-called inerts. A pesticide has to be formulated to be:

- as biologically effective as possible in controlling the pest/weed/disease,
- physically and chemically stable in storage (minimum of 2 years),
- easy to mix,
- compatible with other pesticides, and
- stable as a spray solution.

To achieve these qualities, a range of other chemicals are mixed with the active ingredient.

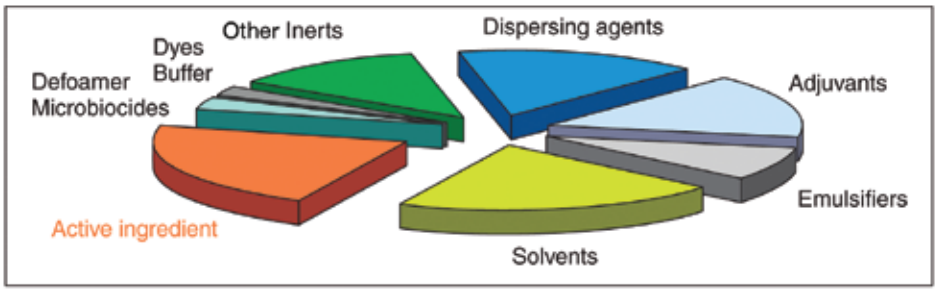


Fig. 1: Formulations contain many chemicals in addition to the active ingredient.

Most pesticides have to be diluted before application. Many home garden and domestic products come in a ready-to-use form, already diluted (but requiring shaking before use), and frequently with a built-in applicator. Commercially applied products almost always require dilution, except for dry formulations like dusts, granules, pellets and tablets.

Active ingredients

The active ingredient or constituent is the part of the formulation that is responsible for the pesticide's biological activity, e.g. in an insecticide it is the part that kills the insect and in a herbicide the part that kills the weed.

The name of the active ingredient and its concentration are given on the front panel of the label under the product name. For example, the herbicide Roundup contains 360 g/L of the active ingredient glyphosate. This means that in 1 L of Roundup product or concentrate, just over one third (360 g) is the active ingredient glyphosate. There are many herbicides which contain glyphosate. While Roundup was the original product, there are now many brands with names like Cleanup, Credit, Gladiator, Ken-Up, Razor, Touchdown, Wipe-Out, and Zero. Because there is a host of product names, all with the same active ingredient and similar use patterns, it is often more helpful to refer to glyphosate products in general than to list all the different brands.

As well as the name of the active ingredient, the concentration is also important. In the case of toxic insecticides, the proportion of the active ingredient will affect the poison scheduling. For example, the highly toxic insecticide parathion is a schedule 6 poison if the concentration of the active ingredient is 45% or less of the total formulation such as the product Penncap-M which contains 240 g/L parathion. On the other hand, the product Folidol M500 which contains 500 g/L parathion, is a schedule 7 poison. The higher poison scheduling in this case reflects the increased risk of acute poisoning due to the greater proportion of the active ingredient, parathion, in the formulation.

Inert ingredients

So-called inert or 'inactive' ingredients are solvents and carriers that deliver the active ingredient to the target – pest, weed or disease.

If the inert ingredient is a scheduled poison or hazardous substance, i.e. harmful to human health, it should be listed on the front panel of the label under the active ingredient but this is not always the case. For example, the insecticide Fastac Duo contains 100 g/L of the active ingredient alpha-cypermethrin and 751 g/L of the solvent xylene. Both the active ingredient and the carrier are poisons in their own right.

Further information about other parts of the formulation can sometimes be found in the MSDS under the section on 'Composition/information on ingredients' in the front of the MSDS. However, instead of specific chemical names, vague general chemical names are often given like 'liquid hydrocarbons', 'hydrocarbon solvent', 'emulsifiers' and 'surfactants'. Other MSDSs are even less helpful, merely listing 'other ingredients (non-hazardous)' or 'inerts (non-hazardous)'.

If a formulation includes a significant amount of organic solvents or hydrocarbons as a carrier, it will usually be classified as a Class 3 Dangerous Good (DG), indicating a flammability risk in storage. Sometimes the presence of hydrocarbons will be indicated on the front panel of the label under the active ingredient. If not, it will be listed in the MSDS. In any case, the label will carry the Class 3 diamond and the full DG information will be included in the MSDS in the section on 'Transport information' towards the end of the MSDS.

Adjuvants

Adjuvants are inert ingredients that are added to a pesticide formulation to alter its physical and/or chemical properties to improve its efficacy. Adjuvants are added to assist/improve the ability of the formulation to:

- be retained on the plant, i.e. not bounce or run off leaf surfaces that are difficult to wet such as waxy (water repellent) and hairy leaves,
- achieve a satisfactory coverage of the plant, i.e. good retention and even distribution of the active ingredient, and
- be compatible with the plant surface (contact action) or penetrate the plant (systemic action) whose leaf cuticle protects the plant from water loss but provides a strong barrier against pesticides.

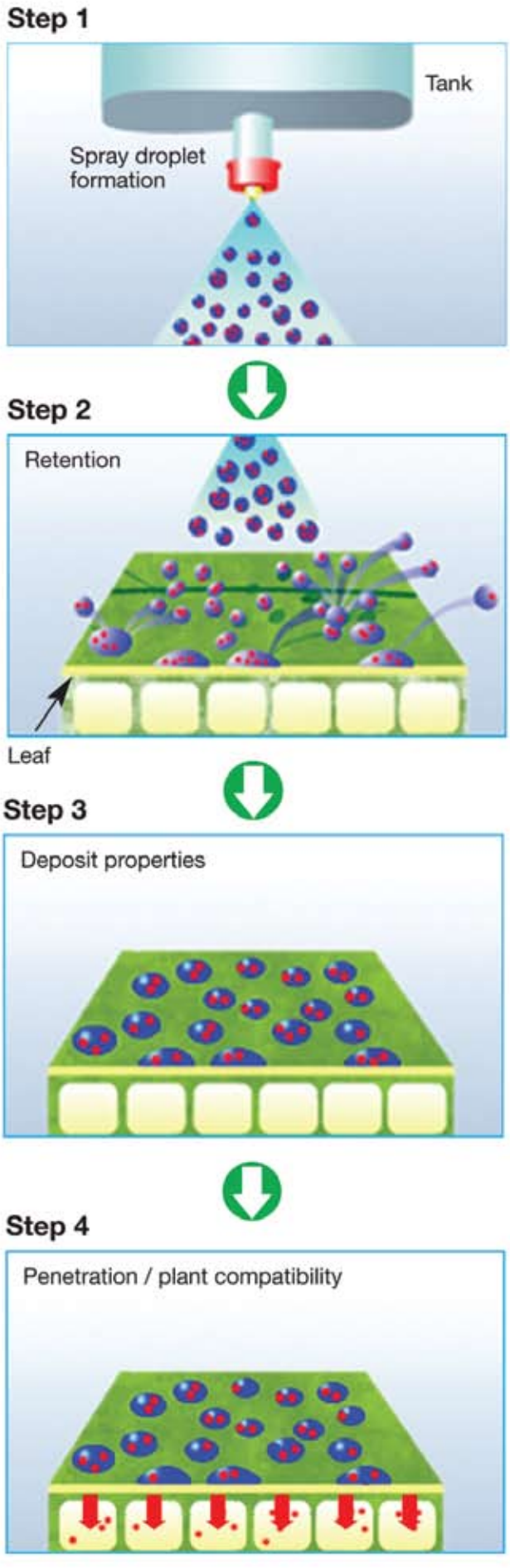
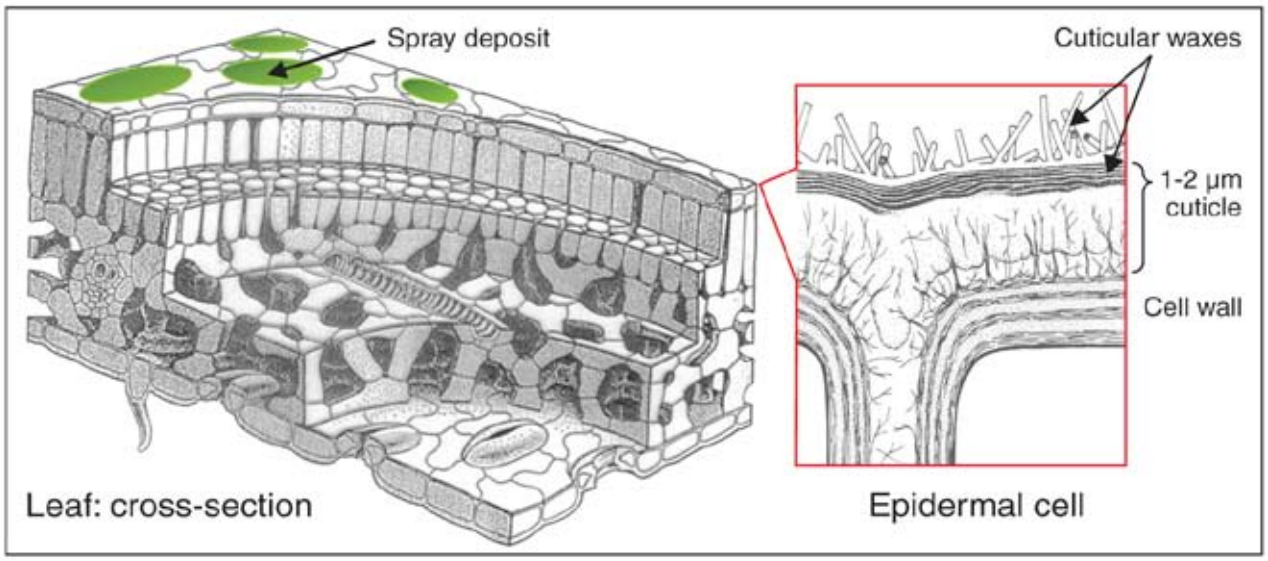


Fig. 2: The transfer of pesticides to the target is complex and consists of several steps. Each step is affected and can be



manipulated by the formulation for improved efficacy.

Fig. 3: Barrier for leaf uptake of pesticides: the cuticle.

Many pesticides include an adjuvant in the formulation. Other pesticides require an adjuvant to be added to the solution for some or all label use patterns. If an adjuvant is to be added, the type and rate will be specified in the Critical Comments section of the Directions for Use table and/or under a separate heading like 'surfactants/wetting agents' in the General Instructions section of the label. Unless the addition of an adjuvant is specified on the product label, don't add one.

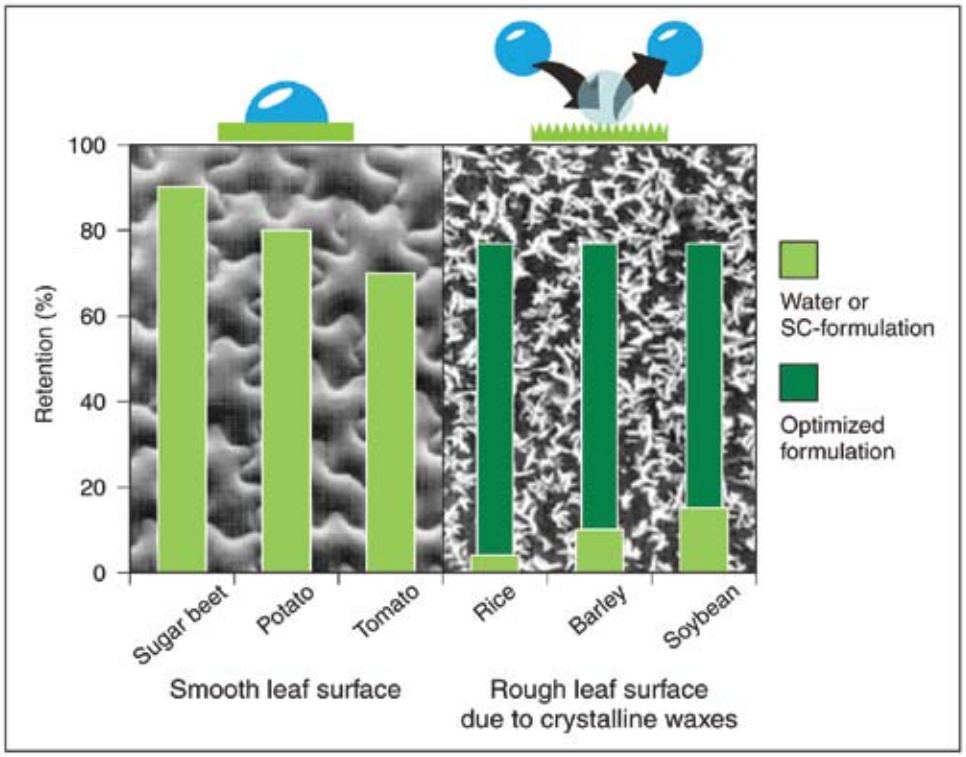


Fig. 4: Optimizing spray retention through the use of adjuvants. Droplets are retained even on crops with rough leaf surfaces.

Adjuvants may be toxic to humans and/or the environment. Many glyphosate formulations include an adjuvant, POEA (**p**oly**o**xy**e**thylene **a**mine), that is toxic to frogs and is the reason glyphosate labels include Safety Directions to avoid skin and eye contact. For use near water, glyphosate products such as Roundup Biactive that include a different surfactant not toxic to aquatic life are recommended.

Types of formulation

Formulations are either wet or dry. Wet formulations will be expressed as concentration of active ingredient per litre. Dry formulations as concentration of active ingredient per kilogram.

The type of wet or dry formulation is often incorporated at the end of the product name as an abbreviation, e.g. Talstar 100 EC (emulsifiable concentrate), Bistar 80 SC (suspension concentrate), Spraytop 250 SL (soluble concentrate), Copper Oxychloride WP (wettable powder), Logran 750 WG (water dispersible granules).

These abbreviations for the type of formulation are known as formulation codes and are standardised by the APVMA.

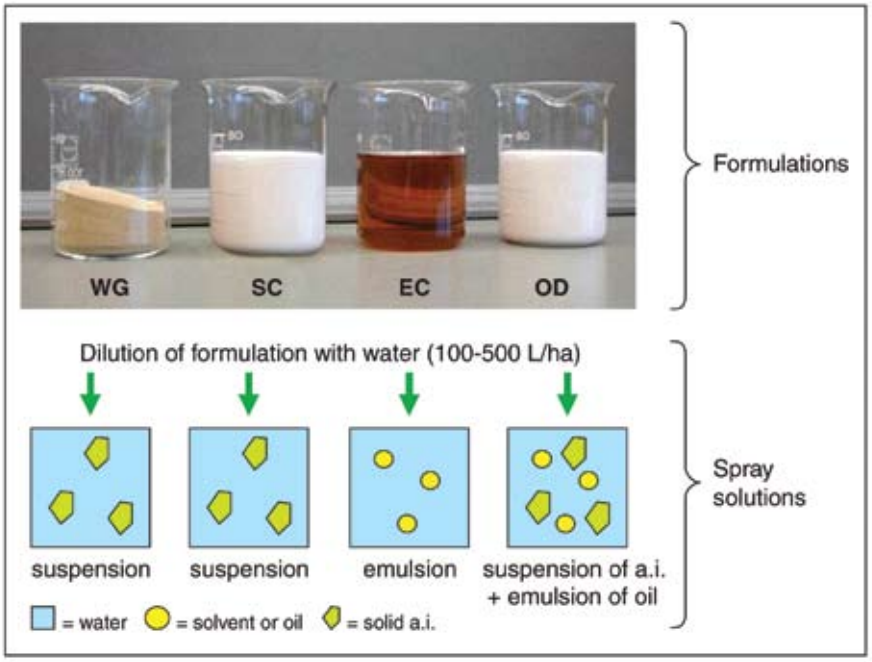


Fig. 5: Important formulation types. WG: Water Dispersible Granule, SC: Suspension Concentrate, EC: Emulsifiable Concentrate, OD: Oil Dispersion.

Dry formulations

Wettable powders (WP)

Wettable powders are usually fine mineral clays to which an active ingredient has been added. They are diluted with water to form a suspension. The solid powder particles are not dissolved in the liquid but dispersed through the liquid. They require agitation to remain dispersed.

Outside home garden products, wettable powders are becoming less common these days, except for fungicides like copper which are difficult to formulate otherwise. Wettable powders fell out of favour because they are difficult to mix, difficult to keep suspended, clog filters and increase nozzle wear.

Water dispersible granules (WG)

Instead of a fine powder, these are formulated as granules. Like wettable powders, they form a suspension and require constant agitation. Many herbicides are formulated as water dispersible granules. Water dispersible granules have gained in popularity as their packaging does not pose the same environmental problem as liquid formulations whose containers have to be specially rinsed and recycled. Water dispersible granules often contain high proportions of the active ingredient, up to 90%.

While it is possible to put water dispersible granules in water soluble packaging, this has not been adopted much in Australia. Water soluble packaging is a de-facto closed transfer system, as the product itself does not have to be handled by the applicator. An example of such a product is the forestry herbicide Eucmix Preplant (terbacil plus sulfometuron-methyl).

Dusts (DU)

Also like wettable powders, dusts are very fine particles of clay (or talc or chalk) to which an active ingredient has been added. But dusts are applied dry. They are still formulated for ready-to-use home garden products like rotenone (Derris Vegetable Dust) and are popular for urban pest control for termites and ants – the insects track the dust back to the nest and spread it through the nest giving very good control.

Pellets (PE)

Pellets are like granules but are mixed as a slurry or thick liquid which is then extruded under pressure like a long sausage and cut into a uniform shape, e.g. snail pellets and mouse baits.

Granules (GR)

Granules are applied dry and consist of an active ingredient in clay. They are applied to soil where they are incorporated (or mixed in) and work by breaking down in the soil in response to soil moisture, e.g. aldicarb (Temik) which is used to control soil pests like nematodes.

Tablets (TA)

Tablets are similar to granules in that they consist of an active ingredient with a dry inert. The most common agricultural tablets are phosphine tablets, used for grain fumigation and rabbit control. On exposure to air, the phosphine tablets absorb moisture and break down to give off phosphine gas, a very toxic fumigant at extremely low concentrations.

Baits (BA)

These are reserved for control of vertebrate pests, rodents and molluscs. Shelf stable baits, e.g. Foxoff, a protein cube that is attractive to the pest and which contains a vertebrate pest poison to control the pest – in this case 1080. Other baits are prepared just before use, e.g. chicken wings injected with 1080 for fox control or carrots injected with RHDV (rabbit haemorrhagic disease or calici virus) for rabbit control.

Wet formulations

Emulsifiable concentrates (EC)

Emulsifiable concentrates consist of an oil-soluble active ingredient in a solvent (neither of which is soluble in water) with an emulsifying agent. They are

diluted with water, the droplets of the concentrate being dispersed through the solution. The emulsifying agent keeps the oil droplets suspended in the water rather than separating out and forming a layer on top, like petrol on water. Emulsifiable concentrates have a milky appearance and require agitation. They are a very popular formulation, especially for insecticides, despite their increased dermal toxicity and flammability risks. Organic solvents and hydrocarbons carry an increased risk of phytotoxicity or crop damage and can also damage rubber and plastic components in spray equipment.

Suspension concentrates (SC)

Suspension concentrates are essentially a water dispersible granule in a pre-mix. Fine granules (1-3 microns) are suspended in water, to be further diluted in the spray tank. Another very popular formulation, used for most types of pesticide.

Soluble concentrates (SL)

Soluble concentrates are true solutions where the concentrate is fully dissolved when mixed with water, i.e. they cannot be mechanically separated. They do not require agitation. Examples include paraquat (Gramoxone), 2,4-D amine and most glyphosate herbicides.

Microencapsulates (ME)

Microencapsulates are essentially a granule in a plastic or starch coating, usually in a pre-mix where they are suspended in water. Once diluted and sprayed out, the capsule provides a slow release of the active ingredient, e.g. Penncap-M (microencapsulated parathion).

Ultra low volume (ULV)

ULV solutions consist of the active ingredient in a small amount of organic solvent. ULVs are exclusively insecticides. They are not diluted and are specifically designed for aerial application, although it is common now to add a mineral oil and/or some water to reduce the risk of drift.

Gels (GE)

Gels are essentially intensified emulsifiable concentrates in a semi-liquid or gel form that come in their own ready-to-use dispenser packs and do not require mixing or diluting, e.g. picloram (Vigilant) which is suitable for small scale control of woody weeds.

Aerosol dispensers (AE)

Aerosol dispensers contain small amounts of the active ingredient with a propellant under pressure, ready-to-use. The liquid drops are delivered to the target in a mist of very small particles. They are mostly used for domestic control of nuisance insects like flies and mosquitoes. Some aerosol dispensers put out a foam, like shaving cream, e.g. glyphosate.

Label information on formulations

Mixing

Different formulations need to be mixed differently. General instructions on how to mix the product are included under the heading ‘Mixing’, found in the General Instructions section of the label. The general instructions for Logran, a water dispersible granule, typically read:

- Partly fill the spray tank with water.
- Start the agitation.
- Add the correct amount of product to the spray tank with the agitation system running.
- Continue agitation while topping up the tank with water and while spraying.
- Use the spray mix within 24 hours of agitation.

Formulations that require constant agitation, like water dispersible granules, should not be left in spray tanks as they tend to separate out. It is never a good idea to leave any spray solution in the tank. It is better to calculate exactly what you need for the job and only mix this amount.

Mixing instructions will also include advice on when to add an adjuvant, usually last and when the tank is nearly full to prevent foaming, and the order of mixing other compatible pesticides in a tank mix.

Compatibility

Other products with which the pesticide is compatible are included under the heading ‘Compatibility’, found in the General Instructions section of the label. As well as listing the individual products, as noted above, mixing instructions will also be included.

Compatibility advice tends to be a combination of product specific and active ingredient specific information, e.g. Logran is compatible with Spray. Seed (product) and trifluralin (active ingredient). Where an active ingredient is listed, compatibility will be irrespective of formulation. Where a product is listed, other products with that same active ingredient may be compatible provided the formulation is the same. To be sure, check the compatibility advice on both labels against one another.

Not all labels will have a compatibility section. And the advice on some labels is not very helpful, e.g. ‘most insecticides and fungicides’. As a general rule, like formulations are compatible: wet formulations such as emulsifiable concentrates are compatible with one another, and dry formulations such as water dispersible granules and wettable powders are compatible with one another. Problems generally arise when mixing wet and dry formulations. Emulsifiable concentrates and suspension concentrates are not compatible, although each is

apparently a wet formulation. As mentioned above, suspension concentrates are really a pre-mixed dry formulation.

It is never a good idea to tank mix more than two products. The more products that are tank mixed, the more possible combinations of formulations that may not be either physically or chemically compatible. Physically incompatible mixtures may not be possible to spray because they form a gel or crystals or clog up the sprayer in some other way. Chemically incompatible mixtures may result in a spray failure or cause crop damage.

Tank mixing products may require addition of a different adjuvant to the one(s) specified for use of either product by itself. The reasons for this are to increase compatibility or to avoid crop damage. If this is the case, an instruction to vary the adjuvant normally used will be found in the compatibility section.

For more information on compatibility, see SMARTtrain *Chemical Risk Management Reference Manual*.

Compatibility tables for a range of herbicides, insecticides and fungicides are included in annual NSW DPI production guides such as *Orchard Plant Protection Guide*, *Weed Control in Winter Crops*, *Insect and Mite Control in Field Crops* and *Weed Control in Summer Crops*.

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Bayer CropScience

Formulations exercise

In the table below, next to each of the formulation codes, using the product labels and their MSDSs which your trainer has given you, write:

- the full name of the formulation
- a product example for that formulation
- the active ingredient of the product
- one other ingredient of the product.

The first row of the table has been filled in as an example.

Formulation code	Formulation	Product example	Active ingredient	Inert/other ingredient
ME	Microencapsulated	Banner Maxx Turf Fungicide	propiconazole	vegetable oil ethoxylate
WG				
EC				
WP				
SL				
BA				
SC				

For one product example from the table, give the mixing instructions:

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