ADJUVANTS

Label rates and formulations of pesticide should be strong enough to handle some adverse conditions during the application process. However, in many instances during mixing, spraying, deposition and uptake of pesticides, losses can be so substantial that efficacy is compromised. Adjuvants can overcome many of those problems. Essentially, they make the application process more robust. To optimise application it is important to choose the right adjuvant for a specific task.

This process is complex and often it is not easy for the applicator to fully understand the functional role of a particular adjuvant. An ever growing number of registered products, many with dubious claims, create additional mystery, resulting in a ‘snake oils’ perception of adjuvants.

Adjuvants, by definition, are substances that enhance or modify the performance of pesticides when added to the spray solution. Label rates and formulations of pesticide should be strong enough to handle some adverse conditions during the application process. However, in many instances during mixing, spraying, deposition and uptake of pesticides, losses can be so substantial that efficacy is compromised. Adjuvants can overcome many of those problems. Essentially, they make the application process more robust. To optimise application it is important to choose the right adjuvant for a specific task.

ADJUVANTS: FUNCTIONAL CLASSIFICATION

<table>
<thead>
<tr>
<th>WETTING/SPREADING AGENTS</th>
<th>PENETRATION AGENTS</th>
<th>STICKER/ADHESION AGENTS</th>
<th>WATER MANAGEMENT AGENTS</th>
<th>DRIFT REDUCING AGENTS</th>
<th>MISCELLANEOUS AGENTS</th>
</tr>
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<tbody>
<tr>
<td>CONVENTIONAL SURFACTANTS</td>
<td>OILS</td>
<td>SURFACTANTS</td>
<td>pH MANAGEMENT BUFFERS</td>
<td>LECITHIN</td>
<td>HUMECTANTS</td>
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<td></td>
<td>ORGANO SILICONES</td>
<td></td>
<td>LI 700</td>
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<td>LI 700, Bonza, Activator</td>
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<td></td>
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<td>WATER MANAGEMENT AGENTS</td>
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<td></td>
<td>ANTIFOAM/DE-FOAM AGENTS</td>
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<td>SUSPENSION/RE-SUSPENSION AGENT</td>
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<td>COMPATIBILITY AGENTS</td>
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<td>LI 700, Bonza, Activator</td>
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<td></td>
<td>FOAM MARKERS</td>
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<td>PENETRATION AGENTS</td>
<td></td>
<td></td>
<td></td>
<td>FEEDING ATTRACTANTS</td>
</tr>
</tbody>
</table>

Figure 57
Pesticide formulations are generally designed to be used with water as the primary diluent and carrier. Water, itself, is an active chemical and it is often overlooked that it normally comprises the largest percentage of the spray solution. Water quality can interfere significantly with the performance of pesticides. The main factors affecting water quality when using agricultural chemicals are pH, hardness, salinity and bicarbonates. It is important to be aware of the quality of each water source used. The pH and hardness can easily be tested with test strips in the field. Other factors such as bicarbonate levels have to be tested in a laboratory. Potential water quality problems can often be overcome with adjuvants.

• Water quality can change with time and measurements should be taken throughout the season
• Manage water quality with adjuvants where possible

MANAGING HIGH pH

A pH value provides a measure of the hydrogen ion concentration of a solution and ranges from 0 to 14. The pH value stands for p(otential of) H(ydrogen) and is the negative logarithm of the hydrogen ion concentration. In pure water the concentration of hydrogen ions is equal to 0.0000001, or 10^{-7} moles per litre = pH 7 = log10(10^{-7}). This is considered a neutral solution. If the concentration of hydrogen ions increases the solution becomes acidic. Consequently the pH drops. For example, a strongly acidic solution with pH 2 represents a concentration of 0.01 or 10^{-2} moles per litre hydrogen ions. Acidic solutions have values below 7. Alkaline, or basic, solutions have values above 7 and contain less hydrogen ions than neutral solutions.

Most pesticide formulations perform best in slightly acidic conditions around a pH of 5. This can create problems if the water source used is alkaline (for example the majority of bore water sources or water stored in concrete tanks).

ALKALINE HYDROLYSIS

In alkaline water some chemicals are broken down rapidly by irreversible chemical reactions, commonly referred to as alkaline hydrolysis. A most alarming example of rapid breakdown is the insecticide dimethoate. Half of the product is irreversibly destroyed in an alkaline spray solution of pH 9 in only 48 minutes (Fig. 58).

DISSOCIATION OF ACIDIC HERBICIDES

Weak acidic herbicides such as glyphosate are least likely to be taken up into the plant if they are present as a strongly charged molecule. An alkaline environment (pH above 7) increases the amount of weak acidic herbicides present in the electrically-charged ionic form. To optimise uptake it is advisable to lower the pH. The pH of a spray solution is not only determined by the water source and chemical used. The leaf surface of many weed species, especially broadleaf weeds, is alkaline, e.g. Wild Radish. This can change the pH of a droplet once it starts interacting with the plant surface.

ACIDIFYING

Minimising all these detrimental pH effects can be easily achieved by acidifying the spray solution with LI 700® at a rate of 100 ml/100 L. LI 700 contains propionic acid. Its acidifying and buffering properties do not only protect many pesticides from chemical breakdown in the tank but also provide a more favourable pH environment on the leaf surface for chemical uptake.

• Most pesticides perform best in slightly acidic conditions
• Water with high pH should be managed with LI 700®

MANAGING WATER HARDNESS

The other main factor influencing water quality is hardness. Hardness is caused by an abundance of...
positively charged metal ions, usually Ca\(^{++}\) and Mg\(^{++}\). These ions can bind strongly to negatively charged weak acidic herbicides such as glyphosate and greatly hinder their performance (Fig. 59 and 60).

Hardness is measured in ppm (parts per million). Generally water is classified as hard at 300 ppm and above. Many Australian water sources have a degree of hardness in excess of 1000 ppm.

The addition of Liase will overcome hard water measuring more than 300 ppm. Liase is a high quality aqueous solution of ammonium sulphate. The negatively charged sulphate ions bind with Ca\(^{++}\) ions and effectively take them out of the solution (Fig. 61).

- Hard water above 300 ppm should be managed with Liase.
• Bicarbonate problems for 2,4-D should be managed by using MCPA formulations or LV ester formulations over 2,4-D amine formulations where practical.

MANAGING SALINITY
Salinity is difficult to manage. It is caused by abundance of sodium chloride (cooking salt) and measured in ppm. Generally saline water should be avoided or shandied with good quality water, especially when using sensitive chemical formulations or mixtures.

MANAGING SUSPENSION STABILITY
Most pesticides contain different levels of dispersing systems (see page 42). These surfactant systems have the role of dispersing the chemical in the water and keep the active in suspension. Water hardness, salinity, bicarbonates, high levels of TDS (Total Dissolved Solids) and alkaline water conditions can all put the suspension system under stress and affect the mixing performance of a chemical. These unfavourable water conditions may use up part of the surfactant system resulting in insufficient levels of surfactants to keep chemicals in suspension (Fig. 63).

Using Liase and/or LI 700® according to the water problem will reduce the risk of suspension failure by improving water quality and by providing additional strength to the suspension system. Liase should be considered, especially when mixing ordinary glyphosate mixtures with flowables, such as simazine and atrazine.
• High levels of TDS can interfere with suspension stability
• Boost and protect suspension systems in formulation by adding additional surfactants such as LI 700 and Liase
• Avoid the use of three or more products in a tank mix (Fig. 62)

MUDINESS
Heavy clay content in some water sources will interfere...
ADJUVANTS AND WATER QUALITY

<table>
<thead>
<tr>
<th>ACTIVE/PRODUCT</th>
<th>HARDNESS</th>
<th>BICARBONATE</th>
<th>SALINITY</th>
<th>MUDDINESS</th>
<th>ALKALINITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-D ester (Estercide® Xtra)</td>
<td>Liase</td>
<td></td>
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<tr>
<td>2,4-D amine (Surpass® 475)</td>
<td>Liase</td>
<td></td>
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<td>Li 700°</td>
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<tr>
<td>Chlorsulfuron (Luesta®)</td>
<td>Liase</td>
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<td>Li 700</td>
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<tr>
<td>Clethodim (Sequence®)</td>
<td>Liase</td>
<td></td>
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<td>Li 700</td>
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<tr>
<td>Clopyralid (Archer®)</td>
<td>Liase</td>
<td></td>
<td></td>
<td></td>
<td>Li 700</td>
</tr>
<tr>
<td>Diemba Amine (Kamba® M)</td>
<td>Liase</td>
<td></td>
<td></td>
<td></td>
<td>Li 700</td>
</tr>
<tr>
<td>Diclofop-methyl (Nugrass® 375)</td>
<td>Liase</td>
<td></td>
<td></td>
<td></td>
<td>Li 700</td>
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<tr>
<td>Diviflenic (Agility®)</td>
<td>Liase</td>
<td></td>
<td></td>
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<td>Li 700</td>
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<tr>
<td>Diflufenican/MCPA (Nugrex)</td>
<td>Liase</td>
<td></td>
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<td>Li 700</td>
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<tr>
<td>Dicrofop (Amicide 625)</td>
<td>Liase</td>
<td></td>
<td></td>
<td></td>
<td>Li 700</td>
</tr>
<tr>
<td>Dicrofop + 2,4-D amine (Amicide 625)</td>
<td>Liase</td>
<td></td>
<td></td>
<td></td>
<td>Li 700</td>
</tr>
<tr>
<td>Dicrofop + MCPA (Agritone 750)</td>
<td>Liase</td>
<td></td>
<td></td>
<td></td>
<td>Li 700</td>
</tr>
<tr>
<td>Roundup® DST</td>
<td>Liase</td>
<td></td>
<td></td>
<td></td>
<td>Li 700</td>
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<tr>
<td>Glypho. (Credit® + Bonus)</td>
<td>Liase</td>
<td></td>
<td></td>
<td></td>
<td>Li 700</td>
</tr>
<tr>
<td>Glypho. (Roundup® PowerMAX®)</td>
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<td></td>
<td></td>
<td></td>
<td>Li 700</td>
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<tr>
<td>Agritone 75 amine</td>
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<td></td>
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<tr>
<td>LVE Agritone ester</td>
<td>Liase</td>
<td></td>
<td></td>
<td></td>
<td>Li 700</td>
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<tr>
<td>Diquat/Paraquat (Revolver®)</td>
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<td>Li 700</td>
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<tr>
<td>Tralkoxydim</td>
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<tr>
<td>Chlorpyrifos EC</td>
<td>Liase</td>
<td></td>
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<td></td>
<td>Li 700</td>
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<tr>
<td>Alpha Cypermethrin EC (Fastac Duo®)</td>
<td>Liase</td>
<td></td>
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<td></td>
<td>Li 700</td>
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<tr>
<td>Dimethoate EC</td>
<td>Liase</td>
<td></td>
<td></td>
<td></td>
<td>Li 700</td>
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</tbody>
</table>

Recommendations depend upon the severity of the problem.

- **Can be managed with Liase**
- **Can be managed with Li 700**
- **Generally no problem**
- **Water should be avoided**

Figure 66 Water Quality Management
ADJUVANTS AND SPRAY QUALITY

CHAPTER SUMMARY

- Avoid non-ionic surfactants
- Use drift-reducing adjuvants such as LI 700®, Bonza® or drift-neutral products such as Activator®

EFFECT OF ADJUVANTS ON SPRAY QUALITY

The formation of spray droplets is influenced by three main factors. For most people, only nozzle type and pressure are important; however the nature of the spray solution plays an important role as well.

The final spray solution consists of water, the type and rate of chemical used (including its inert adjuvant system), extra added adjuvants and possibly other additives such as liquid fertilizer. All of these factors can have a profound effect on the spray quality produced.

Normally the applicator has little knowledge about the inert adjuvant system of a formulation but has direct control over the choice of adjuvants.

Again, the main aim is to select a combination that produces the coarsest spray quality without compromising efficacy.

Commonly used non-ionic surfactants generally increase the number of droplets in the fine spectrum and therefore increase the risk of drift and decrease operational flexibility (Fig. 67).

These products should be avoided and whenever possible, be substituted with adjuvants that have the opposite effect.

Several independent studies have shown that LI 700® decreases the number of undesirable very fine droplets that are prone to drift (Fig. 67 to 69). Additionally, LI 700 reduces the number of undesirable very large droplets that are detrimental to good coverage and prone to shattering when they reach their target. Generally, LI 700 narrows the droplet spectrum at both ends of the spectrum and increases the number of droplets in the desirable range.

Most oils will generally have a similar but more variable effect on the droplet spectrum, depending on their nature and the nozzle type they are used with.

Choosing the right adjuvant can be an excellent tool for droplet management. However, it should not be mistaken as a substitute for the right nozzle choice. Choosing the right adjuvant should add to the solution rather than to the problem!

Figure 67 XR TeeJet® 11002 nozzle type sprayed at 2.5 bar

Figure 68 Source: The Centre for Pesticide Application and Safety, Gatton, 2006.

REDUCTION OF DRIFTABLE FINES WITH LI 700 SPRAYING A GLYPHOSATE FORMULATION

Figure 68 Source: The Centre for Pesticide Application and Safety, Gatton, 2006.
ADJUVANTS AND DEPOSITION

CHAPTER SUMMARY

- Adjuvants will provide elasticity and adhesion
- Consider special deposition and retention agents for fungicide applications
- When using coarser spray qualities with coverage sensitive products, water rates should be increased to counteract potential problems

It is well documented that droplets upon foliar impact may:
- Bounce off or be reflected
- Shatter or be fragmented
- Run-off or drain from the leaf
- Be retained

Droplet behaviour can account for surprisingly large amounts of pesticide loss that is experienced during application. Waxy plant cuticles, especially when they are positioned upright or overhanging, can be difficult for droplets to adhere to.

IMPACT OF SPRAY QUALITY ON RETENTION

The main concern lies with larger droplets. Small droplets have little velocity, fall slowly and their energy level at moment of impact is low (if they ever reach the target). They tend to stick to the leaf. However, even small droplets may not stick to extremely waxy leaves or the lower side of broadleafed plants (important for surface-acting fungicides and insecticides).

In theory large droplets fall faster, have high momentum at time of impact and are more likely to bounce or roll off (Fig. 70). However, in practise, most of the coarser spray qualities will be produced with air induction nozzles. Those droplets will be filled with air inclusions that serve as a type of shock absorber and reduce bounce and shatter. Their velocity will be reduced too because of the air inclusions.

Furthermore, in dense canopies some effect of bouncing, shattering and run off may be even desirable to improve coverage in the lower canopy. If recommendations are followed on most broadleaf plants, the deposition volumes from COARSE droplets for herbicides should not differ critically from finer droplets, especially not when used with adjuvants. However, grasses are generally harder to wet and coarse droplets may need the addition of surfactants.

IMPACT OF ADJUVANTS ON RETENTION

Deposition behaviour of droplets can be significantly improved with adjuvants. Adding an adjuvant will almost always have a beneficial effect on deposition. The dynamic surface tension of droplets is lowered through the surfactant loading most adjuvants have. This increases elasticity and adhesion and increases initial deposition (sticker).

The level of additional retention will vary greatly with products. Products such as Wetter TX (use with herbicides on small grasses) or Bond (use with fungicides and insecticides) are especially effective.
ADJUVANTS AND SPREAD

CHAPTER SUMMARY

- Be aware that in many situations spread is critical, whereas in others it is not – it may even be detrimental.
- DO NOT use organosilicones for general spreading purposes as they are specialised products for specific situations – follow label recommendations.

DOSE RESPONSE OF NON-IONIC SURFACTANT AGRAL 900 ON DROPLET SPREAD (CABBAGE)

Reducing the surface tension value of water will result in droplets that will flatten or spread on the surface upon which they reside. The extent of droplet spread is dependent on the amount of surface tension reduction (dose of surfactant), the nature of the surface of the leaf and the characteristic of the surfactant hydrophobic “tail”. Up to a certain concentration spread will increase (in this case around 100 mL/100L). After this point is reached, more spread is not possible.

Figure 71 Source: Michigan State University

HOW DO SPREADERS (SURFACTANTS) WORK?

Surfactant molecules force water molecules apart which weakens the attractive force (surface tension) between them.

Figure 72

SPREAD

For many pesticides at least some coverage of the leaf surface is critical for performance. The inert surfactant systems of products as well as added adjuvants are important tools to increase the spreading of droplets once they have landed on the plant’s surface.

The word surfactant originates from surface acting agents. Typically surfactant molecules consist of two distinctive parts: a water-soluble head and a fat/oil-soluble tail, similar to soap. Surfactants are amphiphilic (they love both water and oil). Once in water the fat-loving (lipophilic) but water-hating (hydrophobic) part of the molecule is pushed out towards the surface of the water droplet (Fig. 72). As a result the surfactant forces the water molecules apart, which weakens the collective attractive force that creates the surface tension. This causes the droplet to collapse from its spherical shape and flatten out, covering more of the leaf surface (spreading).

The extent of droplet spread is dependent on the nature of the leaf surface and the dose and characteristics of the surfactants (Fig. 71 and 73).

HLB

Differences between surfactants are often seen in the length of the tail and size of the head. The longer the tail (number of carbon atoms) the more pronounced the hydrophobic aspect of the product.

The bigger the head (number of ethoxy groups) the more pronounced the hydrophilic aspect.

The molecular balance of the hydrophilic and lipophilic groups is the HLB (hydrophilic lipophilic balance). The HLB is a good indicator of surfactant performance.

Highly ethoxylated surfactants are very polar and can interact very well with water but poorly with wax. They are excellent spreaders and often used as horticultural adjuvants, e.g. Agral®, however they are ineffective penetrants. In contrast, surfactants with a balance shifted towards the lipophilic end are less effective spreaders but better penetrants.
**ADJUVANTS AND SPREAD**

**PLANT SURFACE AFFECTS SPREAD**

**CONTACT ANGLE ON FAT HEN**

- **No surfactant**
  - 76°
  - 0.1% v/v non-ionic surfactant
- **66°**
  - No surfactant
  - 0.1% v/v non-ionic surfactant

Figure 73

Droplet (A), containing pesticide and water, may be held from close contact on the living tissue by dust, hair or the waxy cuticle. Absorption of the active pesticide into the leaf will be slow.

Photo: Water on Apple Leaf by Bukovac – Michigan State University

Figure 74

**CRITICAL MICELLE CONCENTRATION: CMC**

![Critical Micelle Concentration: CMC](image)

**RATE DEPENDENCE**

The reduction of surface tension by surfactants is rate dependent up to a point of maximum effect. For most surfactants this will occur at or below 100 mL/100 L (Fig. 75). Adding more surfactant will not increase droplet spread. At rates above this point the hydrophobic ends of surfactants are not only pushed to the droplet surface but increasingly pushed towards each other, forming globular or cylindrical structures called micelles (Fig. 76 and 77). These micelles can contain active, interact with waxy cuticles and increase uptake.

This is the reason why non-ionic surfactant rates to improve glyphosate activity are often 200 mL/100 L (Fig. 75).

![Rate Dependence](image)

**Unimers (individual molecules)**

**Spherical**

**Cylindrical**

**Bilayer Lamella**

![Micelles](image)

**Figure 76 10/00 lipid bilayer micelle structure. Source: Lovelands**

**Figure 77 Micelles**
**ORGANOSILICONES**

Organosilicones are super wetter surfactants. They reduce surface tension of water to extremely low levels and provide up to 12 times (e.g. Pulse®) more spread than conventional wetters (Fig. 78). They are specialized, indispensable tools to achieve coverage in difficult situation, e.g. woody weeds (Fig. 79).

**HUMECTANCY**

Aqueous solutions of ionic compounds, glyphosate in particular, benefit from prolonged drying times on the leaf surface in order to optimise uptake (Fig. 81). This can be achieved by using a coarser spray quality and adjuvants that provide humectancy. Humectancy is the property that enables a droplet to remain wet or liquid for an extended period. Lecithin-based adjuvants such as LI 700®, oils such as Bonza®, or specialised non-ionic surfactants enhanced with glycol and fatty acids, such as Activator®, provide the droplet with a hydration sheet that prolongs drying time (Fig. 80). Humectancy is particularly important during hot conditions (e.g. in summer spraying).

In contrast, the uptake of non-ionic compounds relies mainly on diffusion through the waxy cuticle as these chemicals normally contain a high level of inert solvents that provide a sufficient film on the leaf surface. In general, the uptake of non-ionic actives is less dependent on surface wetness (Fig. 82).
Once on the leaf surface the most difficult hurdle for systemic pesticides is entry into the leaf through the waxy plant cuticular. Layers and layers of hydrophobic waxes protect the moist inside of the plant. Barrier properties are mainly related to the form, thickness and chemical make-up of these waxes. Permeability may vary thousand fold between species.

There are several mechanisms by which adjuvants can critically enhance the transport of pesticides across this limiting layer. For many chemicals the right adjuvant choice is critical to optimise penetration into the plant so label directions should always be followed. Optimised uptake will not only affect the overall diffusion rate but also the speed of uptake and therefore rainfastness.

**PASSIVE DIFFUSION VIA THE LIPID PATHWAYS OF THE FATTY CUTICULA**

Lipophilic actives, in particular, rely on this form of uptake. A high concentration of active on the plant surface drives diffusion into the mostly lipophilic environment of the cuticle. At this stage adjuvants can help to optimise the process by providing an environment that favours undissociated molecules that are generally the preferred form for penetration (Fig. 82).

**PASSIVE DIFFUSION VIA THE AQUEOUS PATHWAY**

Within the lipophilic environment of the cuticle is an additional pathway that is much more hydrophilic in nature called aqueous pores. These small channels (<1 nm) are permeable to water and small ionic molecules such as glyphosate. The rate of transport depends on surface wetting, the length of the channel and ion binding resistance along the walls of these very narrow pathways. Adjuvants can assist this form of uptake by providing prolonged drying times and, again, by optimising the chemical environment in the spray solution (Fig. 81).

**ACTIVE TRANSPORT**

**THROUGH EXISTING PHYSICAL OPENINGS**

Morphological openings in plants are minute. Flooding of spray solution into those openings is only possible when surface tension is reduced to very low levels such as those achieved by organosilicones (e.g. Pulse®). Sites of entry include stomata, cracks, crevices, pores or physically damaged areas. Stomatal uptake may be limited due to location of stomata and to the time the stomata is actively open.

**ACTIVE CUTICULAR DISRUPTION**

Adjuvants can actively decrease the barrier properties of waxes and create pathways through cuticle disruption. The disruption is primarily mediated by involvement of surfactant micelles. Adjuvants can reduce the viscosity and melting points of surface waxes (by plasticising or softening). A less viscous environment makes it easier for actives to be taken up and results in higher diffusion rates. This becomes especially important at low temperatures when waxes are very stiff, or for plants growing in dry conditions.

The disruption can be soft and temporary. This may happen when the joining points of crystalline wax platelets are loosened, followed by resettling of platelets. However, effects can also be permanent and may result in a complete meltdown of the wax structure that can extend to a removal or stripping effect (crop safety). To accomplish this accelerating effect of adjuvants it is important to use recommended label rates: non-ionic surfactants e.g. Chemwet 1000, 200 mL/100 L, lecithin-based sprays (e.g. LI 700, a minimum of 250 mL/100 L), oil-based sprays e.g. Bonza®, a minimum of 0.5 L/100 L and enhanced non-ionic surfactants e.g. Activator® at 125 mL/100 L.

**CHAPTER SUMMARY**

- Adjuvants can critically assist systemic pesticides to overcome the hurdle of entering the waxy plant cuticle
- Be aware of possible crop effects different adjuvant types may cause
- Specific chemicals may benefit most from specific adjuvants – follow label directions and manufacturer’s advice
- Observe minimum label rates required, e.g. 250 mL/100 L for LI 700®
**ADJUVANTS AND PENETRATION**

**LI 700 vs OIL – EFFICACY WITH GLYPHOSATE**

*OIL*  
*LI 700**

**DIFFERENCE BETWEEN VEGETABLE OIL AND LECITHIN (ACTIVE IN LI 700)**

**PENETRATION AND MANUFACTURER’S ADVICE**

**GLYPHOSATE EXAMPLE**

Certain pesticides will benefit most from specific penetrants. Therefore it is important to follow the manufacturer’s advice.

For example, glyphosate labels generally do not recommend the use of oils but do recommend the addition of lecithin based adjuvants, such as LI 700®, or alternatively non-ionic surfactants.

Oils will increase droplet survival in hot conditions and prolong drying times of glyphosate on the leaves. They will loosen waxy cuticles and may increase the uptake of glyphosate in some situations. However, oils are hydrophobic and don’t like to interact with polar components such as glyphosate or water. They need emulsifiers to enable mixing with water and their performance greatly depends upon their emulsifier load. The interaction of oil and glyphosate is limited

and variable. Control of grasses particularly in the summer can be compromised when using oils (Fig. 83).

On the other hand, lecithin is already an emulsifier in itself. It has two long carbon chains that give the molecule its lipophilic character and one polar phosphatidyl group that gives the molecule its hydrophilic character (Fig. 84), enabling it to mix readily with polar compounds such as water or glyphosate. Like oil, lecithin will provide prolonged drying times and droplet survival, and will loosen the waxy cuticles.

In some cases glyphosate maybe tank mixed with a mixing partner that requires the addition of an oil. In that situation the use of an oil may add more benefit to the efficacy of the mixing partner than the potential negative effect the oil may have on the glyphosate.

In these situations an oil may be used as long as the applicator is aware of the potential of reduced grass control.

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<th>CHEM WET 1000</th>
<th>WETTER TX</th>
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<th>LI 700*</th>
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*Better effects indicated by higher number of ticks; NEUTRAL indicates no effect; ✘ indicates that the adjuvant has a negative effect on the outcome. A blank square, or no tick, means no effect expected.*

*Figure 85: Adjuvants and their technical fit*