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FACT SHEET | MARCH 2024

SPRAY APPLICATION ESSENTIALS

Purpose

Chemicals play an important role in vegetable production and are regularly used to control insect pests, diseases and weeds. When applying chemicals, aim to maximise the amount reaching the target and minimise the amount reaching off-target areas. This fact sheet provides guidance on the essentials of spray application and covers conditions, coverage, compatibility, as well as equipment calibration.

Spray application is important to get right to ensure effective pest control, minimise the risk of resistance, ensure farm worker safety, as well as save money.

1. Spray Conditions

Temperature and humidity (Delta T)

The Delta chart T is used to determine the optimal conditions for spraying a crop with certain product types based on temperature and humidity. Delta T is a guide for the best nozzles to use to achieve the required spray droplet size and achieve optimal spray coverage in the given conditions and for the selected product.

KEY TIPS AND TOOLS

1. **Spray conditions:**
   - Check the temperature and relative humidity using the Delta T chart.
   - Ensure wind speed is below 15–20 km/hr, referring to chemical label instructions.
2. **Spray coverage:**
   - Calibrate spray droplet size using a spray card as a guide to measure the percentage of surface area covered.
   - Select your nozzle type and size in accordance with the type of pesticide you are spraying.
3. **Spray compatibility:**
   - Do a jar test to ensure the spray mix is homogonous
   - Test the water quality to improve spray application and efficacy of the pesticide product.
4. **Equipment calibration:**
   - Check the label for the application rate
   - Ensure all application parameters including: speed, swath width and nozzle type/size are set accordingly to achieve the required output volume.

Hort Innovation

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RMCG

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Delta T values indicate evaporative potential i.e. higher the temperature and the lower the relative humidity, the greater the evaporation will be. Small droplets will dry up really quickly. When the temperature is low and the humidity high, droplets will dry slowly.
High delta T values, exceeding 8 to 10, indicate fast evaporation of the droplet. Low delta T values (e.g., below 2) indicate low risk of evaporation and spray drift. Using coarse droplets will provide efficiency and reduce the airborne fraction.

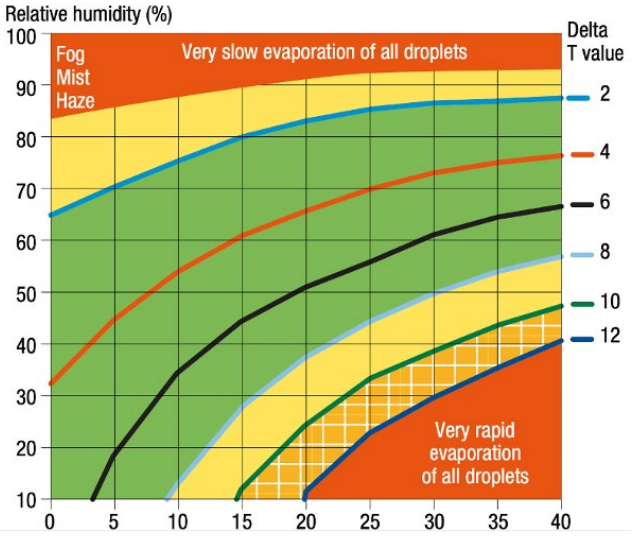


Figure 1: Delta T chart for predicting droplet size relative to temperature and humidity *(Source: Grains Research and Development Corporation)*

Wind speed

Wind speeds should always be below 15 to 20 km/h as measured at the site of application, depending on the label instructions.
When the wind speed is consistently above 4 to 5 kilometres per hour this is usually safer for daytime spraying than night-time spraying.
It has been suggested that night-time wind speeds should be above 11km/h to ensure some mixing occurs and to minimise the impact of a likely surface temperature inversion.

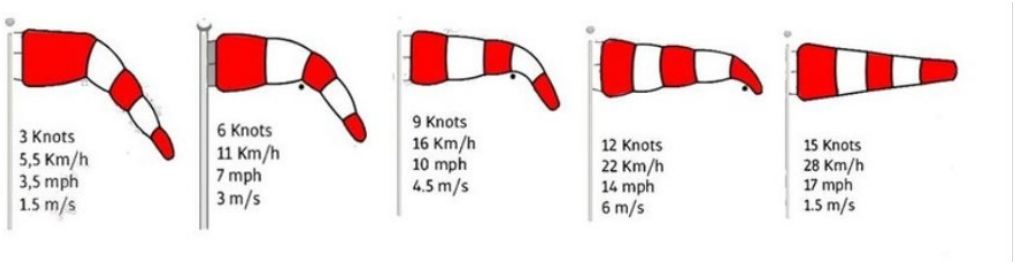


Figure 2: How to estimate wind speed

2. Spray coverage

Quantifying and interpreting spray coverage is important to provide better pest control, reduce the risk of pesticide resistance and optimise spray costs. To maximise spray efficacy, spray droplets must be uniformly distributed on a target surface with minimum losses due to drift, evaporation or run-off. Knowing the importance of the following will help spray operators get the best possible results:

- Droplet size
- Droplet density
- Water rate.

Figure 3 provides a visual of spray coverage using spray cards as a percentage area to help guide spray droplet calibration, with 1 being the least coverage and 6 being the most. The spray card can be interpreted as follows:

1. **0.5% coverage:** Few droplets – Ineffective crop product results
2. **3% coverage:** Minimal droplets – Minimal coverage provides minimal results
3. **30% coverage:** Numerous droplets – Provides reliable results with most broad- spectrum products, but not as effective for target – Specific or contact- only products
4. **50% coverage:** Quality coverage – Maximises the opportunity for success and produces reliable results with nearly all crop protection products
5. **80% coverage:** Maximum coverage – Some droplets run from broken water tension between droplets and is required to be select product that require outstanding coverage
6. **100% coverage:** Point of run-off – Causes product to drip to ground as off- target deposition, though is necessary for certain pest and diseases.

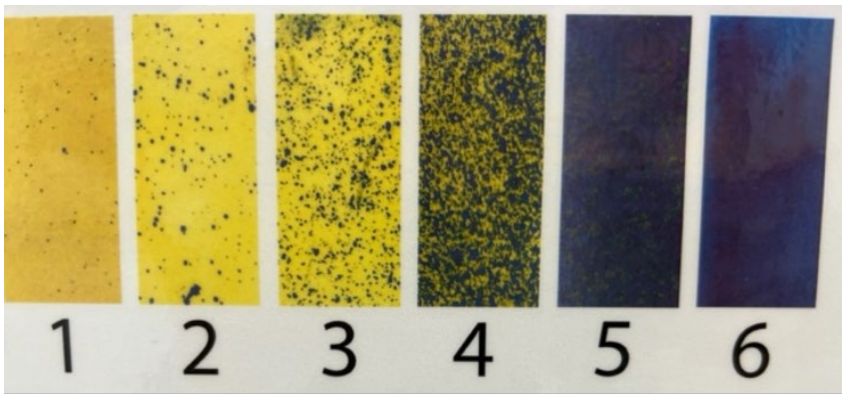
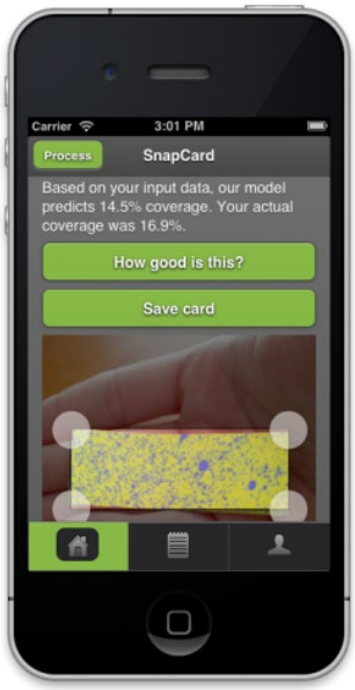


Figure 3: Spray cards showing difference in spray coverage

There are other tools that can be used to optimise spray coverage. SnapCard Spray app is an application which uses spray cards to enable growers to predict spray coverage based on agronomic variables, weather conditions, and spray settings.
SnapCard predicts spray coverage based on current conditions, time of the day, tractor speed, spray nozzles, spray volume, boom height, adjuvants and weather conditions.



Droplet size

The below table gives an overview of droplet sizes and percentage spray output recommended for different product types. The percentage spray output indicates the type of coverage required for each agricultural chemical and fertiliser application. This is important particularly with agricultural pesticide products to ensure that even coverage of the active constituent is achieved to protect the crop for pest disease and for herbicides to be absorbed into the plant tissues to improve efficacy of the product.

Table 1: Droplet sizes and percentage spray output recommended for different product types

Rating	Droplet size	Percentage of spray output	Application
Fine	150-250µm	40-50%	Crop protection products
Medium	250-350µm	<20%	Herbicides
Coarse	350-450µm	<10%	Herbicides/ foliar fertilisers
Very coarse	450-550µm	<5%	Foliar fertilisers

Droplet size classifications are based on The British Crop Protection Council (BCPC) specifications and in accordance with ASABE standard S572.1. Note that droplets smaller than 80µm cannot readily be seen by the naked eye.

Spray nozzle selection and size

The below guide can be used to select spray nozzles based on droplet size.:

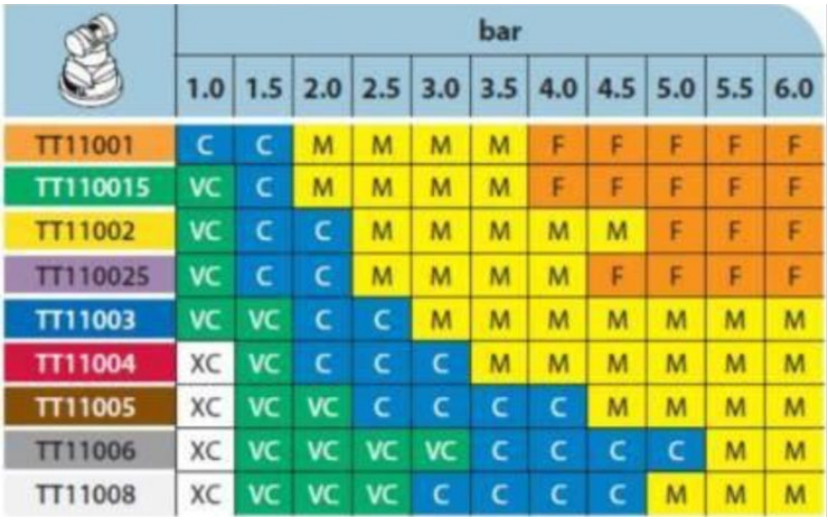
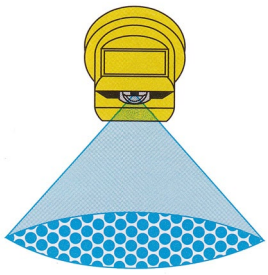
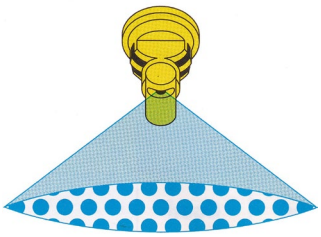
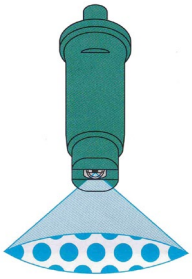


Figure 3: Teejet Spray guide which shows pressure (bar) along the x axis and nozzle size on the y axis with coverage ratings XC (extra coarse), VC (very coarse), C (coarse), M (medium) and F (Fair).

Products	Droplets
Hollow cone nozzles A popular nozzle for applying insecticides and fungicides. They generally produce a smaller droplet size than most other nozzle types. The characteristic hollow cone shaped spray output is produced when the liquid is forced through slots in the swirl plate (within the nozzle body) then emitted through a narrow orifice.	
Flat fan Nozzles and Double Flat Fan Nozzles Flat fan nozzles are the most common type of nozzle and can be suitable for many different purposes. These nozzles have a rectangular or lens shaped orifice which produce a tapered distribution of droplets across the nozzle swath. Uniform coverage is achieved by overlapping each nozzle 30% with the nozzle each side of it. There are many sizes of flat fan nozzles that can operate under various pressures with a wide range of droplet sizes. Double flat fan nozzles produce two spray swaths from the one nozzle body. These nozzles offer the advantage of the spray being directed from two different angles to improve coverage. These nozzles are suitable for applying insecticides and fungicides if the correct size and pressures are used.	
Turbo and Double Turbo Fan Nozzles Turbo types are also a common type of nozzle and suitable for broadcast spraying. These nozzles have a tapered edge to give a wide angle flat spray pattern. Uniform coverage is also achieved by overlapping each nozzle 30% with the nozzle each side of it. There are also many sizes of these nozzles that can be operated under various pressures to produce a wide range of droplet sizes. The double fan nozzles also produce two spray swaths from the one nozzle so the spray can be directed into the target from two different angles. These nozzles produce a larger droplet size than most other nozzle types when operated at the same pressure.	
Air induction nozzles Air induction nozzles produce large air filled droplets. The air inclusion is usually by venturi action and produce large bubbly droplets. These droplets tend to shatter on impact, further distributing the smaller droplets into the canopy. The main advantage of these nozzles is to reduce drift and allow the operator to spray in windier conditions.	

Droplet density

Droplets not only need to be uniformly distributed over the target area but the density also needs to be sufficient to achieve good results. Different types of chemicals require a different level of droplet density. Systemic type chemicals require a droplet density as low as 20-30 droplets/cm2. When targeting mobile insects or using contact fungicides, a higher density of 70-100 droplets/ cm2 is recommended. The droplet density required will vary with the type of chemical being used. The table below gives a guide to the droplet densities required to ensure adequate levels of control.

Table 2: Desired droplet size by pesticide product type

Products	Droplets/cm2
Insecticides	
Mobile insects	60–100
Systemic	20–30
Contact	50–70
Herbicides	
Pre-emergent	20–30
Post-emergent	30–40
Fungicides	
Systemic	20–30
Contact	50–70
Foliar nutrients	20–30

Water quality

The quality of water used when spraying agricultural chemicals can significantly impact chemical efficacy. It is always advisable to use clean rainwater where possible. This is not always possible and usually water has to be sourced from other places including bores, dams, channels and rivers. The quality of water available from these other sources can be variable and may cause significant application problems. It is preferred that the water is clear, colourless, odourless and neutral (pH 7.0). That is, not acid, alkaline or brackish. Water should be selected for the following characteristics:

- **Neutral pH** – This is the acidity of alkalinity of water with a pH of 7.0 considered neutral. A pH of above 8 (alkaline) causes many chemicals to undergo a process called alkaline hydrolysis causing the breakdown of the active ingredient which can reduce the effectiveness of the pesticide over time. The efficacy of carbamate and organophosphate insecticides decreases sharply in alkaline water above pH 7.0. Very acidic water can also effect the stability and physical properties of come chemical formulations.
- **Low salt levels** – High salt content in water can cause phytotoxicity (damage to plant tissue e.g. burning). This is most common with bore water and high electrical conductivity.
- **Water 'softness'** – Water is termed "hard" when it has a high percentage of calcium and magnesium. Difficulty in producing a lather with soap is an indication of hard water. Hard water can cause some chemicals to precipitate resulting in reduced efficacy.
- **Testing water quality** – Test the pH and EC with kits or meters purchased from hardware or pool stores. Mix a sample batch at the correct dilution rate according to the manufacturer's instructions. Shake the container vigorously for one minute and allow to stand for 30 minutes. It after this time the solution is 'creaming' with separation occurring, the water may not be suitable for spraying the particular pesticide.

TO REMEMBER

- Make the most of favourable weather conditions, especially wind speed
- Ensure the spray solution pH is at the optimal level to improve the efficacy of the product used
- Use the coarsest spray quality that will provide efficiency
- Regularly calibrate and maintain spraying equipment using only clean water
- Maintain boom height to achieve good coverage
- Try to minimise travel speed
- Wind speed should be below 15 to 20 km/h

3. Spray compatibility

To achieve effective spray coverage the product used, be it an adjuvant, fertiliser, biological or chemical product, must be properly mixed in water. If a homogonous solution cannot be achieved it is due to incompatibility either being chemical, when the two elements antagonise each other or physical, when there is sediment, separation, sludging or excessive foaming in a solution.

If the mixture separates but can be remixed the mixture should be able to be sprayed with good agitation. If there is sediment, separation, sludging or excessive foaming in the solution the mixtures are incompatible and should be sprayed separately.

JAR TEST PROCEDURE

Step 1 – Add 70% of water to a clean jar

Step 2 – Add the proportionate amount of product and shake

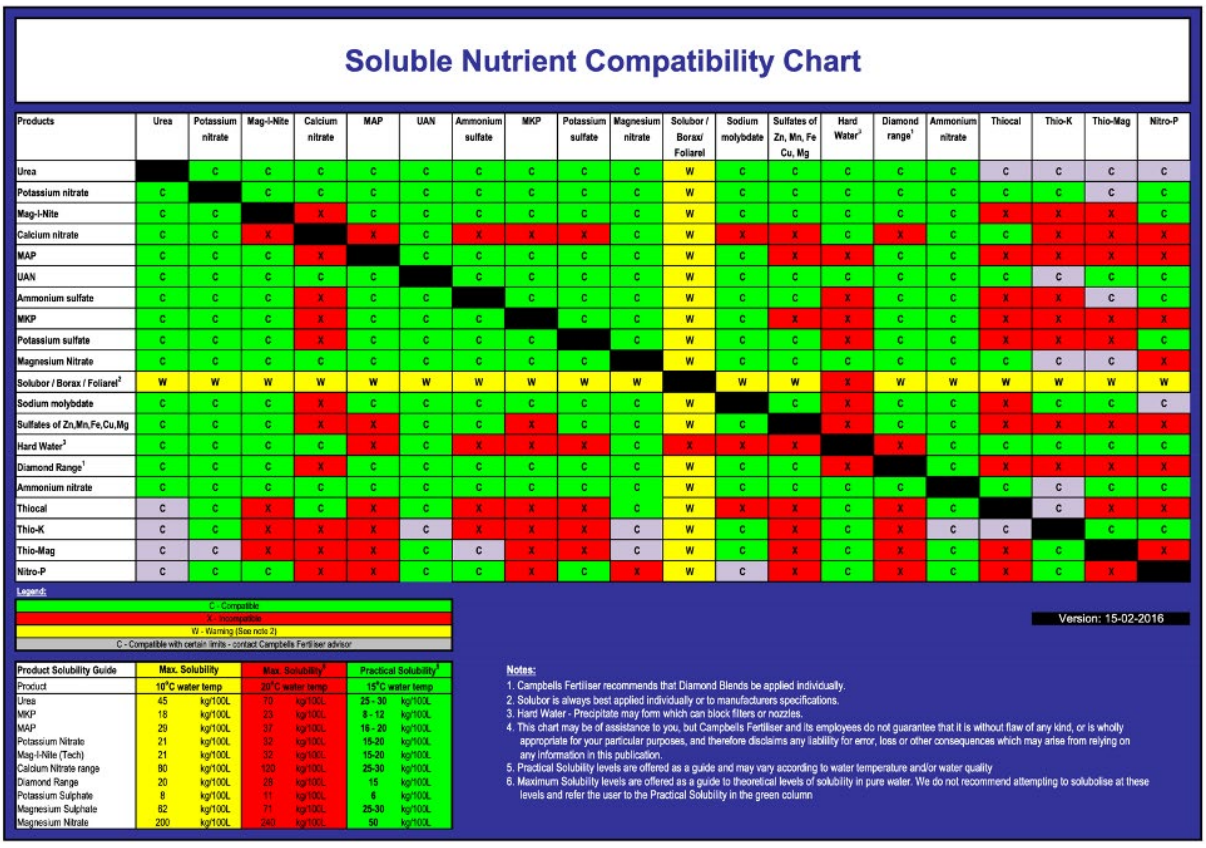
Step 3 – After mixing add any adjuvant

Step 4 – Fill the jar to make 100%

Step 5 – Secure the lid and invert the jar 10 times to mix

A Jar test can be performed to check for physical compatibility of products. Refer to the box to the above for instructions on how to perform a physical compatibility check.

For information on compatible products, refer to the Soluble Nutrient Compatibility chart in Figure 4 below:



Soluble Nutrient Compatibility Chart

Products	Urea	Potassium nitrate	Mag-I-Nite	Calcium nitrate	MAP	UAN	Ammonium sulfate	MKP	Potassium sulfate	Magnesium nitrate	Solubor / Borax/ Foliarel	Sodium molybdate	Sulfates of Zn, Mn, Fe Cu, Mg	Hard Water[3]	Diamond range[1]	Ammonium nitrate	Thiocal	Thio-K	Thio-Mag	Nitro-P
Urea		C	C	C	C	C	C	C	C	C	W	C	C	C	C	C	C	C	C	C
Potassium nitrate	C		C	C	C	C	C	C	C	C	W	C	C	C	C	C	C	C	C	C
Mag-I-Nite	C	C		X	C	C	C	C	C	C	W	C	C	C	C	C	X	X	X	C
Calcium nitrate	C	C	X		X	C	X	X	X	C	W	X	X	C	X	C	C	X	X	X
MAP	C	C	C	X		C	C	C	C	C	W	C	X	X	C	C	X	X	X	X
UAN	C	C	C	C	C		C	C	C	C	W	C	C	C	C	C	C	C	C	C
Ammonium sulfate	C	C	C	X	C	C		C	C	C	W	C	C	X	C	C	X	X	C	C
MKP	C	C	C	X	C	C	C		C	C	W	C	X	X	C	C	X	X	X	X
Potassium sulfate	C	C	C	X	C	C	C	C		C	W	C	C	X	C	C	X	X	X	C
Magnesium Nitrate	C	C	C	C	C	C	C	C	C		W	C	C	C	C	C	C	C	C	X
Solubor / Borax / Foliarel[2]	W	W	W	W	W	W	W	W	W	W		W	W	X	W	W	W	W	W	W
Sodium molybdate	C	C	C	X	C	C	C	C	C	C	W		C	X	C	C	X	C	C	C
Sulfates of Zn,Mn,Fe,Cu,Mg	C	C	C	X	X	C	C	X	C	C	W	C		X	C	C	X	X	X	X
Hard Water[3]	C	C	C	C	X	C	X	X	X	C	X	X	X		X	C	C	C	C	C
Diamond Range[1]	C	C	C	X	C	C	C	C	C	C	W	C	C	X		C	X	X	X	X
Ammonium nitrate	C	C	C	C	C	C	C	C	C	C	W	C	C	C	C		C	C	C	C
Thiocal	C	C	X	C	X	C	X	X	X	C	W	X	X	C	X	C		C	X	X
Thio-K	C	C	X	X	X	C	X	X	X	C	W	C	X	C	X	C	C		C	C
Thio-Mag	C	C	X	X	X	C	C	X	X	C	W	C	X	C	X	C	X	C		X
Nitro-P	C	C	C	X	X	C	C	X	C	X	W	C	X	C	X	C	X	C	X	

Legend:
C - Compatible
X - Incompatible
W - Warning (See note 2)
C - Compatible with certain limits - contact Campbells Fertiliser advisor

Version: 15-02-2016

Product Solubility Guide	Max. Solubility		Max. Solubility[3]		Practical Solubility[3]	
Product	10°C water temp		20°C water temp		15°C water temp	
Urea	45	kg/100L	70	kg/100L	25 - 30	kg/100L
MKP	18	kg/100L	23	kg/100L	8 - 12	kg/100L
MAP	29	kg/100L	37	kg/100L	16 - 20	kg/100L
Potassium Nitrate	21	kg/100L	32	kg/100L	15-20	kg/100L
Mag-I-Nite (Tech)	21	kg/100L	32	kg/100L	15-20	kg/100L
Calcium Nitrate range	80	kg/100L	120	kg/100L	25-30	kg/100L
Diamond Range	20	kg/100L	28	kg/100L	15	kg/100L
Potassium Sulphate	8	kg/100L	11	kg/100L	6	kg/100L
Magnesium Sulphate	82	kg/100L	71	kg/100L	25-30	kg/100L
Magnesium Nitrate	200	kg/100L	240	kg/100L	50	kg/100L

Notes:
1. Campbells Fertiliser recommends that Diamond Blends be applied individually.
2. Solubor is always best applied individually or to manufacturers specifications.
3. Hard Water - Precipitate may form which can block filters or nozzles.
4. This chart may be of assistance to you, but Campbells Fertiliser and its employees do not guarantee that it is without flaw of any kind, or is wholly appropriate for your particular purposes, and therefore disclaims any liability for error, loss or other consequences which may arise from relying on any information in this publication.
5. Practical Solubility levels are offered as a guide and may vary according to water temperature and/or water quality
6. Maximum Solubility levels are offered as a guide to theoretical levels of solubility in pure water. We do not recommend attempting to solubolise at these levels and refer the user to the Practical Solubility in the green column

Figure 4: An example of a Soluble Nutrient Compatibility Chart.

4. Equipment calibration

Chemicals need to be applied at the correct rate in the appropriate amount of water. To achieve this, all spraying equipment needs to be calibrated. There are many methods of calibrating with an accurate and simple method explained here:

1. Select a 'required water application rate' in L/ha
2. Determine the 'swath width' in metres
3. Calculate the driving speed

$$\frac{\text{Distance driven (m)} \times 3.6}{\text{Time taken (sec)}} = \text{km/hr}$$

4. Select the nozzle type and size to give the 'water output' required
5. Select the appropriate operating pressure from the manufacture's nozzle chart
6. Determine the total 'water output' from all nozzles (L/min)
7. Calculate 'actual water application rate' in L/ha

$$\frac{600 \times \text{total flow from all nozzles (L/min)}}{\text{Swath width (m)} \times \text{tractor speed (km/hr)}} = \text{L/ha}$$

8. Compare the 'actual water application rate (step 7) to the 'required water application rate' (step 1). If the difference is too great, you will need to recalibrate. To increase the water rate per hectare, you can reduce tractor ground speed, increase pressure, or select larger nozzles. To reduce the water rate you can increase tractor ground speed, reduce pressure or select smaller nozzles. It should be remembered that changing the pressure will alter the droplet size and nozzles should not be operated outside the recommendations in the manufacturer's charts
9. Calculate how much chemical to put in the spray tank.

$$\frac{\text{Recommended label rate (L or kg)} \times \text{amount of water in spray tank (L)}}{\text{'Actual water application rate (L/ha)'}}$$

OTHER USEFUL RESOURCES

Visit www.soilwealth.com.au

1. Time to rejig your rig? Five simple steps in spray rig calibration
2. Mega Pests: The Basics of Protecting Your Crops
3. SnapCard Spray app for Apple
4. SnapCard Spray app for Google