Information Sheet

5.6 Chemigation of sugarcane: Considerations for chemical selection and fertigation guidelines

Chemigation is a general term that refers to the use of agrochemicals applied through an irrigation system. This includes fertilisers (fertigation) and various chemicals for the control of weeds, pests and diseases. This information sheet highlights the main considerations when selecting chemicals for chemigation.

Fertigation is the most common form of chemigation and is thus the focus of this information sheet. However, where agrochemicals for the control of weeds, pests or diseases are to be used, all product label and legal compliance requirements must be adhered too. Consult the supplier and product labels for specific requirements and conditions of use. For general information on irrigation system requirements for chemigation refer to Information Sheet 5.5: *Chemigation: Principles and fundamental equipment.*

Fertigation

Fertigation refers to the application of fertiliser (dissolved nutrients) to crops through an irrigation system. This allows the timing of irrigation and fertiliser application, as well as fertiliser rates, to be more precisely controlled. In this regard, fertigation systems allow for optimisation of nutrient use.

Key advantages of fertigation include:

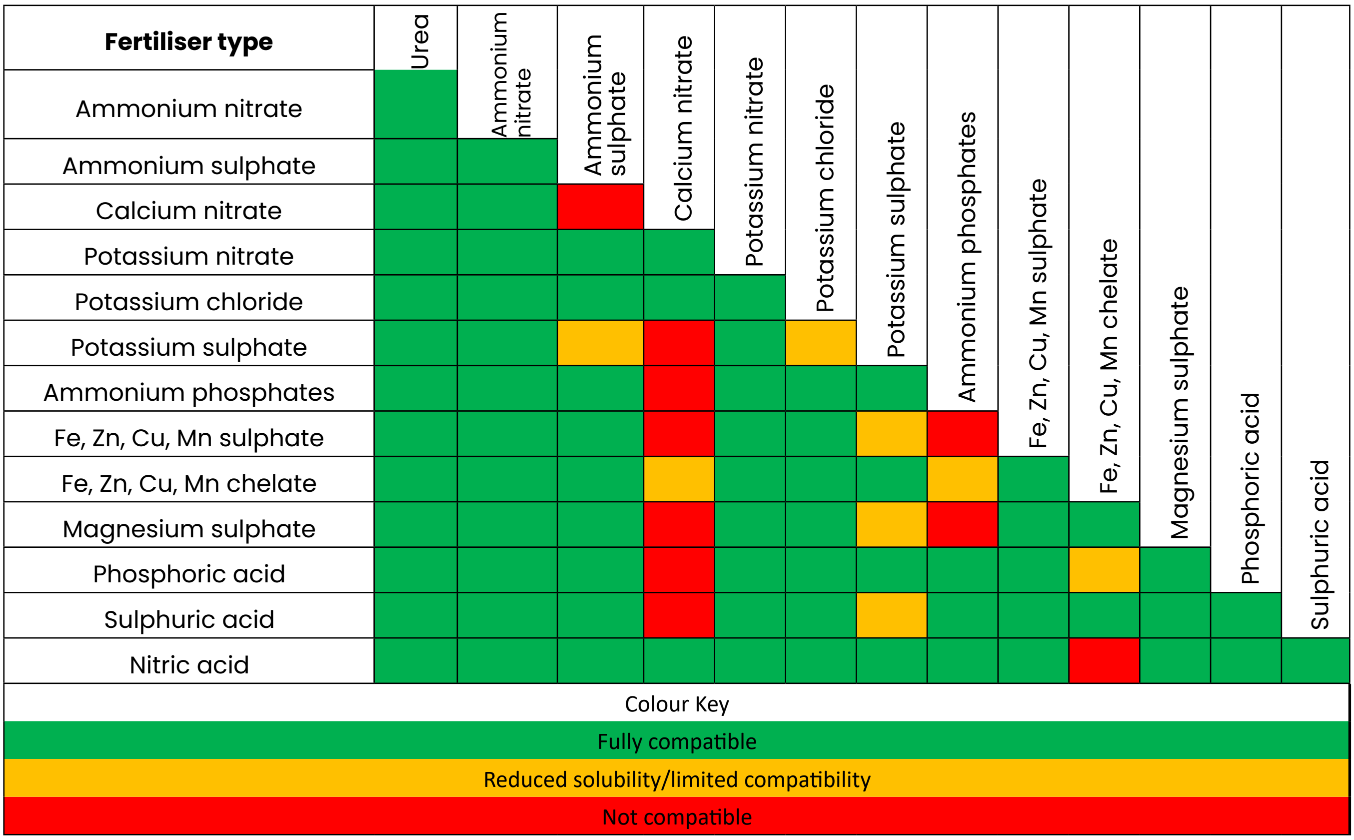
- Plant available (soluble) nutrients are applied near or directly to the root zone, and in combination with water, thus promoting better uptake.
- Deficiencies identified after crop establishment can often be more readily addressed.
- In drip-type irrigation systems, the amounts of water and nutrients can be precisely adjusted to better match site and soil specific conditions as well as crop demand ("teaspoon feeding").
- A reduction in fertiliser rates of between 15 to 30% can be achieved for drip type systems.
- Ability to apply nutrients after cane is too tall for infield access.
- A reduction in infield traffic associated with the mechanical application of fertilisers, thus lowering soil compaction and stool damage.

Selecting fertilisers

The choice of fertiliser to use in fertigation depends on several factors:

Fertiliser solubility and compatibility: It is important that soluble fertiliser types be selected for use in fertigation systems, particularly where fertilisers are injected or applied by venturi and where micro-jet or dripper irrigation systems are used.

Ensuring that the fertilisers being mixed are compatible is critical to prevent the formation of precipitates and scale that both lower nutrient content of the solution and cause blockages in the irrigation system. For example, mixing of ammonium phosphates with calcium or magnesium containing products is typically not advised due to the potential to form precipitates. Figure 1 provides general compatibility guidelines for some common fertiliser types. Where application of incompatible fertilisers are necessary, these can be applied separately at different irrigation events.



▲ Figure 1. Typical fertiliser compatibilities for mixing in fertigation systems.

Fertiliser Concentration: The final concentration of nutrients in irrigation water should range from 4 to 100 mg/L and should not be allowed to become excessive. This is typically calculated based on the amount or concertation of fertiliser to a given volume of water to be applied. Excess nutrient concentrations can lead to precipitates forming and cause blockages or cause salinity that damage plant roots.

Corrosivity and pH reactions: Chemical reactions between fertilisers and some metallic components in fertiliser systems can lead to corrosion and premature wear of these components. In some cases, fertilisers may dissolve to produce alkaline (caustic) or acidic solutions that too can lead to degradation of irrigation system components. Stainless steel, Teflon, uPVC and polyethylene are generally the most corrosion resistant materials. Always flush equipment well after use.

Table 1. Solubility, solution pH and expected corrosiveness of some common fertiliser types used in fertigation systems.

Fertiliser type	Solubility g/L @20°C	Approximate pH of solution	Irrigation material susceptible to corrosion
Urea	1050[1]	9.5	Non-corrosive
Ammonium nitrate	1950[1]	5.5	Galvanised iron/brass
Ammonium sulphate	430	4.5	Mild steel
Potassium nitrate	310	10.5	Most metals
Potassium chloride	340	7-9	Brass/Mild steel
Potassium sulphate	100	8-9	Mild steel/Concrete
Mono ammonium phosphate	400	4.5	Carbon steel
Di ammonium phosphate	600	7.5	Carbon steel
Acids	-	<4	Most metals

[1] The solution temperature drops during mixing thus solubility will be reduced, however, solubility will be restored as the solution temperature increases again after the initial reaction has taken place.

Water quality: The chemistry of both the mixing and irrigation water can affect the reactions and compatibility of fertilisers to be used.

- The ideal water pH for fertigation is between 5.6 and 6.2.
- If the pH of irrigation water exceeds 7.5 it can lead to the formation of scales and precipitates that cause blockages.
- Water high in calcium, magnesium and bicarbonates will cause precipitation of P, Fe, Mn and Zn when these fertilisers are introduced.
- Alkaline solutions, such as urea, injected into water high in calcium and bicarbonate causes the precipitation of lime scales.
- Correction via application of acidic solutions may be necessary to adjust water pH to acceptable standards before the point of fertiliser injection.
- Regular water testing is advised to minimise unwanted reactions and problems and routine monitoring of water pH and electrical conductivity are advised to monitor fluctuations.

See:

Information Sheet 5.13: *Water quality consideration for optimal performance of irrigation equipment* for more information on how water quality can affect the performance of the irrigation system and possible options to remedy or prevent these from occurring.

Information Sheet 5.12: *Irrigation water quality for sustaining soil health and sugarcane yield* provides guidelines for water sampling.

Water temperature: As water temperature increases, the solubility of fertilisers increases.

- Very low temperatures can lead to some fertilisers not dissolving or forming precipitates, which can cause blockages.
- The chemical reaction of urea and ammonium nitrate in water can cause the water temperature to drop very low, which can lower solubility. Continual stirring and allowing the solution temperature to return to the ambient temperature will be necessary for uniform mixing.

Mixing fertilisers

To ensure proper dissolution and distribution of nutrients in mixing tanks, particularly dry products, first fill the tank half to two-thirds with water. Slowly add the fertilisers while the water is stirred to allow even mixing, preventing sudden reactions and to avoid insoluble lumps from forming. Coarse dry products can take longer to dissolve so adequate mixing time should be allowed to ensure complete dissolution. Also prepare fertiliser stock solutions as close to the time of use as possible and avoid letting mixed products stand for extended periods.

Jar-test

Where concerns over compatibility and solubility exist, perform a jar-test. This simple test requires that you combine the source water with the intended fertilisers (or fertiliser stock solutions) in the same ratios as intended for either mixing tanks or to test compatibility of the fertiliser solution with the irrigation water at the injection point. If the solution turns milky, cloudy or presents other unfavourable reactions, this suggests that the water quality and/or fertiliser combination is not compatible and should be avoided. For mixing tank stock solutions, it is suggested that the solutions from the jar-test be allowed to stand for 1 to 2 hours and rechecked for cloudiness to confirm that no unfavourable reactions have occurred with time.

Nutrient sources

Many of the single nutrient fertilisers are soluble and therefore suitable for use in fertigation.

Nitrogen (N):
Most solid forms of nitrogen such as ammonium sulphate, urea and ammonium nitrate (excluding coated or modified products) are adequately soluble to make concentrated stock solutions for injection. Urea is both effective and the cheapest form of nitrogen to use. Calcium nitrate can also be used when bicarbonate levels in the water are low and pH is < 6.5. Anhydrous ammonia and aqua-ammonia (high pH) and ammonium phosphates (P scaling) can cause clogging, thus suitable precautions must be applied to avoid problems.

Phosphorus (P):
Phosphorus is often not recommended for application in drip systems because of its tendency to precipitate with calcium in the irrigation water. However, where water quality is suitable (low alkalinity, Ca and Mg) there are water-soluble P sources (ammonium and potassium phosphates and phosphoric acid) that may be suitable. Where water is alkaline, use of phosphoric acid or other acidifying stock solutions (sulphuric or nitric acids) can prevent this.

Potassium (K):
Most forms of potassium (chloride, sulphate or nitrate) cause few, if any, clogging problems. In some cases, sulphate may react with Ca to form precipitates, thus avoid mixing K_2SO_4 and a Ca-containing product or calcium rich irrigation water (confirm with jar-test). Applying high rates of K, particularly as KCl, to the root zone in a single event should also be avoided as this can cause root burn (localised salinity).

Sulphur, Calcium and Magnesium (S, Ca and Mg):
Where soil or leaf analysis indicates deficiency, both magnesium sulphate and calcium nitrate are good soluble fertilisers, though should generally not be applied together to avoid insoluble salts forming. Application is usually split during the early growth phases similar to P (though generally not together to avoid metal-phosphates precipitating).

Trace elements:
Trace elements such as iron, zinc, copper and manganese can be applied as sulphates or chelates in irrigation water. Where metal complexes are likely to be formed due to poor water quality or fertiliser mixed, then chelates are normally advised. When required, application is usually split during the early growth phases.

Application and scheduling considerations

To optimise the use of fertilisers, the quantity and type of nutrient applied through fertigation can be split to match the growth stage and growth rate of the crop. However, the type of fertigation system, water quality, crop nutrient requirement, cropping season and length, as well as operational factors, all affect the specific fertigation strategies. Due to the large number of variables, it is important to consult a specialist when developing a fertigation programme.

Sugarcane is considered a high nutrient demand crop, though specific requirements vary depending on growth rate of the cane, the length of growing season and the specific crop requirements at different growth stages. In general:

- Cane established during the warmer part of the season grows more quickly thus requiring a larger proportion of the nutrients earlier in the season.
- Conversely, cane established during the cooler part of the season initially grows more slowly, thus initial nutrient demand tends to be lower, but will continue for longer than in faster growing cane as growth rates increase with warming temperatures.
- Ratoon cane generally has a higher initial nutrition uptake rate as the old root system can partially support improved uptake while the new root system develops.
- In plant cane the lack of a root system means that initial uptake of nutrients is slower until the roots have developed adequately.

Nutrient application splits

In flood and overhead (including centre pivots) irrigation systems, it is often simpler to apply basal dressings of solid fertilisers at planting or soon after harvest using conventional methods. Flood and overhead irrigation systems, with appropriate distribution uniformities, can then be used to supplement high demand nutrients (mainly N and K) through the remainder of the growing season. However, caution must be used to prevent applying high concentrations of salts to leaves as this can cause leaf-scorch ("salt-burn").

In drip systems nutrient supply can be more precisely controlled and delivered, thus multiple application splits are typically used. In most cases, 4 to 6 splits are adequate within the first 6 to 7 months of a 12 month crop. Applications are usually on a monthly basis, but can be reduced to weekly or fortnightly on sandy soils and where the irrigation system design allows. An example of a multiple split applications for N and K (4 to 5 splits in first 6 months after establishment) for different cropping seasons is given in Table 2. Please consult your extension or fertigation specialist to refine these scenarios for site specific requirements. Applying N within 5 to 6 months of harvest is usually not advised due to increased risk of Eldana and potential delays in maturation. Phosphorus (and other minor elements) are usually applied at the start of the season during establishment (via conventional granular applications), but can be applied through the fertigation system in 2 to 4 splits in the first few weeks of establishment. Please take the necessary **precautions** to prevent the formation of precipitates and scales where P, Ca, Mg, Fe and Mn are being considered for use in the fertigation system.

Table 2. Example of a drip-fertigation schedule (% of N and K) based on 4/5 splits for different starting seasons.

Days after planting or harvest	Months after establishment	Approximate Growth Stage	Autumn		Winter		Spring		Summer	
			N	K	N	K	N	K	N	K
1-30	1	Germination	10	10	10	15	20	10	30	15
31-60	2	Germination-Tillering	15	15	20	20	25	20	25	20
61-90	3	Tillering	10	20	30	20	20	20	25	20
91-120	4	Tillering–grand growth	25	20	25	20	20	25	20	25
121-150	5	Grand growth	25	20	10	20	15	25	10	20
151-180	6		15	15	5	5	0	0	0	0
181-210	7*		0	0	0	0	0	0	0	0
211-240	8		0	0	0	0	0	0	0	0
241-Harvest	9-12	Grand growth-Maturation	0	0	0	0	0	0	0	0

***** In sandy soils it may be necessary to provide a small additional amount (usually around 20 kg/ha) in month 7 if heavy rains have led to excessive N leaching in the preceding months. Applying N after this is not advised due to potential negative quality and eldana effects.

Soil sampling recommendations

Similar to conventional sampling, 30 - 40 topsoil samples should be collected and composited to provide a single representative sample for each field. Specific sampling strategies may require adapting depending on the specific fertigation system in use.

Drip/sub-surface drip fertigation systems only

On replant fields where the soils have been disturbed by plough-out and soil mixing, then a more traditional approach (1 sample in the row and 7 - 8 samples from the interrow) can be followed, as advised in Information Sheet 7.16: *Soil sampling.*

In ratoon crops, where all nutrients are exclusively applied through a drip system it is advised to collect 3 samples from the area where fertiliser is applied (drip zone) and 5 samples from the adjacent area (in between drip lines). Drip lines can be on the crop row or on the interrow. If the drip line is on the crop row, then the number of samples taken from the crop row is higher than normally advised because the nutrients and water applied by the drip system are very localised and root systems tend to concentrate in in the wetter zone.

Overhead irrigation or mixed fertiliser application systems

Where fertilisers are applied using overhead irrigation systems, it is advised to adhere to more general soil sampling practices as given in Information Sheet 7.16: *Soil sampling.*

Similarly, in mixed systems, where some fertilisers are applied via irrigation systems (drip, flood or overhead), while other fertilizers are applied using conventional methods (e.g. broadcasting), then a more traditional sampling approach is also advised (1 sample in the row and 7 - 8 samples in the interrow).

Chemigation with other agrochemicals (herbicides, insecticides and fungicides)

Agrochemicals may only be applied via an irrigation system if the product has been registered for this application method and it is clearly stated on the label. The suitability of agrochemicals for chemigation will depend on several factors such as the behaviour of the chemical compound being applied, the mode of action, the requirements and growth stage of the crop, climatic conditions, irrigation uniformity of the irrigation system and very importantly the application volume.

Other factors that influence the suitability of the agrochemicals for chemigation include:

- Timing of chemical application relative to development stage of the crop and target organism/weed, as well as cane row spacing and irrigation system.
- The effect of factors such as moisture, solubility, volatility and adsorption to clay particles and organic material on the agrochemical.
- Environmental factors such as wind speed, sunlight, rain and temperature.
- Salinity: saline water must not be used for chemigation.
- Soil texture (ratio of sand, clay and silt) and organic matter content.

> Information Sheet 10.5: *Water quality for herbicides* provide some guidance on aspects of water quality that could affect efficacy and application.

Many of the factors that affect fertiliser choices will be similar when considering other agrochemicals. Thus, ensuring compatibility of chemicals as well as with water quality and effects on irrigation hardware must be considered.

In all cases, care must be taken to ensure that the application meets all the parameters as indicated on the label of the product. Products that are not registered for application through irrigation systems cannot be applied in this manner.

Where chemigation is to be used, ensuring the safety of operators and staff are of critical importance. All necessary safety precautions must be adhered to prevent unintended injury or death. Furthermore, always take the care to avoid run-off and contamination and pollution of ground and surface water sources as well as excessive wind drift.

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March 2022