Information Sheet

5. IRRIGATION

5.6 Chemigation: Guidelines for choosing chemicals

This information sheet provides guidelines for choosing chemicals when applying water soluble fertilisers, herbicides, fungicides, insecticides and growth regulators via an irrigation system. For general information on chemigation, refer to Information Sheet 5.5.

Fertigation refers to the application of dissolved nutrients to crops by means of an irrigation system. The total fertiliser requirement for the crop can be supplied in one single application, or it can be divided into a number of separate applications. 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. During winter, N fertiliser can be split-applied in the first six months after harvest. During summer, N fertiliser can be split-applied during the first five months after harvest. With fertigation, it is also possible to quickly correct nutrient deficiencies.

The choice of fertilisers or nutrient source is important for successful fertigation. Fertilisers are available in water soluble granules, powder or liquid form. The fertigation programme will be developed depending on the crop production objectives, growth stage, the chemical compound, soil characteristics, water characteristics, type of irrigation system and application method. Due to the large number of variables it is important to consult an expert, preferably an agronomist or soil scientist, when developing a fertigation programme.

Many studies have shown that fertiliser use efficiency is increased by fertigation. On the one hand, a reduction of up to 35% in fertiliser use has been achieved without reducing yield and, on the other hand, yields have increased substantially when compared with those obtained by conventional methods of fertiliser application. The Fertiliser Advisory Service (FAS) at SASRI is well placed to give advice on the rates, timing and nutrient carriers to use, as well as providing a monitoring service based on soil, leaf and water analysis.

Important considerations include:

- Irrigation systems should not have any leaks.
- Worn nozzles are very expensive in the long run and should thus be replaced regularly.
- Filters on drip and micro irrigation systems should be in 100% working condition.
- Drip lines should be cleaned before chemigation commences and flushed after chemical applications.
- In the case of drip systems, make doubly sure that a chemical is 100% water soluble – avoid suspensions in these systems.
- If irrigation blocks are over 5 ha, one can expect problems with uniformity of distribution with some injection systems.

Choice of fertiliser products

The main considerations in the choice of fertilisers for fertigation are as follows:

Solubility: High water solubility is an absolute prerequisite in drip systems especially when fertilisers are injected or applied by venturi. The final concentration of nutrients in irrigation water should range from 4 to 100 mg/litre, and should not be allowed to become excessive. First fill the tank halfway with water and then add the fertilisers while the water is stirred to allow even mixing and to prevent insoluble lumps from forming.

pH: Acidic fertiliser products can be corrosive to metal and asbestos cement components. Ensure that the equipment used is resistant to these products. Stainless steel, Teflon, uPVC, polyethylene and polystyrene are the most corrosion resistant materials. Always flush equipment well after use.

Fertiliser interactions: Potential mutual interactions of fertilisers need to be considered. For example, minor or trace elements are commonly applied as chelates, and these decompose in strongly acid solutions of most fertiliser mixtures. Products that contain sulphates are incompatible with products that contain calcium. Similarly, products that contain phosphates are incompatible with products containing calcium and magnesium. These products must be injected into the irrigation pipeline separately and from separate tanks. The following can be used as a guideline for fertiliser combinations (ARC-ILI Irrigation Design Manual, 2003).

Table of permissible combinations of fertiliser solutions (adapted from ARC-ILI Irrigation Design Manual, 2003)

Tank A	Tank B
No fertilisers containing phosphates or sulphates	*No fertilisers containing calcium*
• Potassium nitrate • Calcium nitrate • Urea • Ammonium nitrate • Micronutrients (chelates disintegrate in strong acids)	• Mono-ammonium phosphate • Mono-potassium phosphate • Potassium sulphate • Magnesium sulphate • Potassium nitrate • Urea • Ammonium nitrate • Phosphoric acid

Water quality is an extremely important consideration. Water high in calcium, magnesium and bicarbonates will cause precipitation of phosphates when P fertilisers are injected. Polyphosphate fertilisers react with Ca ions to form a gel which remains in suspension and can cause serious clogging problems. Alkaline solutions such as urea injected into water high in Ca and bicarbonate causes the precipitation of lime. Water pH is also important. The ideal water pH for fertigation is between 5.6 and 6.2. If the pH of irrigation water exceed 7.5 it can lead to precipitation of phosphates, calcium and magnesium carbonates, which can lead to emitter blockages. Perform acid corrections on alkaline water for effective fertigation. Have water samples evaluated for suitability by FAS.

Corrosivity: Under some water and soil conditions, corrosion may be a problem. Avoiding extremes of acidity or alkalinity will minimise this problem. Most storage tanks are now made of fibreglass or plastic rather than metal, but even asbestos-cement pipes can be affected by very acid solutions.

Temperature: As water temperature decreases, the solubility of fertilisers decreases. The capacity of the injectors must therefore be increased, accordingly. The chemical reaction when some fertilisers dissolve causes the water temperature to drop, requiring adjustments to the injectors.

Compatibility of chlorine and acids: Do not mix chlorine and fertilisers as this can lead to an explosion. Acid and acid-based fertilisers will cause toxic gases if mixed. Always clean the mixing tank thoroughly before and after chlorine is used. The effectiveness of chlorine will decrease if ammonia or urea is present in the irrigation water. When mixing, always add acid or chlorine to water and not water to acid or chlorine.

Nutrient sources

A number 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 are soluble enough to create concentrated stock solutions for injection. Urea is not only effective, but is the cheapest form of nitrogen to use. Ammonium forms of nitrogen fertiliser are considered as effective as urea and nitrate sources in drip irrigation, but not under conventional irrigation. Calcium nitrate can also be used when bicarbonates are low. Anhydrous ammonia, aqua-ammonia and ammonium phosphate in most instances cause clogging problems. It is essential to match the nitrogen source with the soil and water characteristics. Nitrogen is critical during the early and rapid (mid) growth stage of sugarcane. Take care not to apply nitrogen within 6 months of harvest date as this will limit cane quality.

Phosphorus (P): This nutrient has generally not been recommended for application in drip systems because of its tendency to react with calcium in the irrigation water to form a precipitate which clogs the filters. However, using phosphoric acid or acidifying the stock solution, either by mixing with sulphuric acid or injecting sulphuric acid immediately after fertiliser injection, can prevent this. It is critical to get the advice from a fertigation expert or soil scientist as incorrect recommendations can result in sedimentation and blockages throughout the system. This is especially important where the water pH, calcium and magnesium levels of the irrigation water are high. Phosphorus requirement is highest during the germination phase and directly after planting.

Potassium (K). Any of the common forms of potassium (chloride, sulphate or nitrate) cause few, if any, clogging problems. These fertilisers move freely in the soil and potassium is exchanged on the clay complex and not readily leached away. Potassium is essential for plant growth, photosynthesis and the movement of sugars.

Sulphur, Calcium and Magnesium (S, Ca and Mg). Routine application of these nutrients is not normally necessary. However, when soil or leaf analysis indicates a deficiency, both magnesium sulphate and calcium nitrate are good soluble fertilisers.

Trace elements. Trace elements such as iron, zinc, copper and manganese can be applied as sulphates or chelates in irrigation water. Normal plant requirements for these nutrients are low, and their application requires careful and precise monitoring to avoid toxic levels developing. It is advisable to base the application of micronutrients on reputable soil and leaf analyses.

Chemigation with other agrochemicals

The suitability of controlling weeds, diseases and insects with chemigation will depend on a number of factors such as the actual chemical compound being applied, the mode of action, the requirements and growth stage of the crop, the application volume, climatic conditions and irrigation uniformity of the irrigation system.

Figure 1. A secondary nozzle package for chemigation with a centre pivot.

Herbigation

This is the application of herbicides by means of irrigation. Herbicide application is, in most cases, more successful by means of micro-sprayer or overhead sprinkler systems. The solubility, volatility and adsorption of herbicides will affect the effectiveness of herbicide application. Consult an expert on herbicides regarding suitable herbicides for herbigation.

- Timing of chemical application relative to weed and cane growth stage, cane row spacing and suitability of irrigation system is important. With surface drip irrigation the application of post emergent herbicides will not be possible. Depending on growth stage, weed type and severity of infestation, spot spraying and hand weeding might still be required.
- Factors such as moisture, solubility, volatility and adsorption to clay particles and organic material will determine the movement of herbicides through the soil. Typically, herbicides will move a shorter distance than water moving through the soil. If using pre-emergent herbicide it is therefore important to apply sufficient water to allow herbicides to move into the germination zone of the weeds.
- When herbicides are applied by means of sprinkler irrigation, the most important environmental factor to consider is wind speed. With the use of moving irrigation systems, the wind speed should not exceed 15 km/h and with static systems, 3.5 km/h. Other important environmental factors to consider are high temperature and low relative humidity, which can increase evaporation and so increase volatility of the herbicide.
- Saline irrigation water must not be used for herbigation. Avoid irrigation water with high levels of sodium, calcium, magnesium and bicarbonate as well as muddy water.
- The volatility of herbicides will increase if applied to wet soils.
- The action of the herbicides will be influenced by the soil texture (ratio of sand, clay and silt) and the organic matter content. Depending on the herbicide, organic material and clay can bind the herbicide thus limiting its movement through the soil.

Insectigation

Insecticides are more commonly applied by pivot or sprinkler systems. Micro-sprayers and surface-drip can be used where the insecticide needs to be applied to the soil surface. Consult the product label or a professional for advice.

To improve effectiveness and residual control, most insecticides must be mixed with an oil before injecting it into the irrigation pipeline. Water soluble insecticides which are also soluble in oil are usually the most suitable for insectigation. Care must be taken to allow for full leaf cover and to prevent insecticides being washed off from the leaves.

Fungigation

As with insectigation, the chemical compound, mode of action, type of insect and growth stage, crop growth stage and climatic conditions must be taken into consideration as well as whether the fungicide needs to be applied to the leaves or soil. Effectiveness of applications will depend on sufficient leaf cover, uniformity of water application, and the volume of water applied. With over-irrigation, the compound can be washed from the leaf. In most cases, fungicides pose a smaller danger of damage to the plants than with insecticides, therefore application accuracy is slightly less critical. It is, however, still important to cover the target area thoroughly. As with insecticides, where the product needs to be applied to the leaves, it is important to avoid washing the product off. Therefore reduced water application is preferred. For fungicides that need to be soil applied, higher water application will be required.

Ripeners. Chemical ripeners can be applied very effectively by sprinkler and movable irrigation systems by means of a venturi-system. With ripeners, a small application volume will be required. The use of irrigation systems to apply ripeners can also reduce the danger of drift.

Planning for chemigation

Chemigation can effectively be used by irrigation growers to optimise crop yield and optimise the use of agrochemicals. Careful planning and strict management is essential to realise the full potential of and to eliminate potential pitfalls associated with chemigation.

In all cases, it is essential to adhere to instructions and application rates of all agrochemicals as indicated on the label and in the applicable legislation and to base fertiliser application on reliable soil analyses.

References: ARC-ILI Irrigation Design Manual (2003). *Agricultural Research Council-Institute for Agricultural Engineering*. ISBN 1-919849-24-6

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November 2016