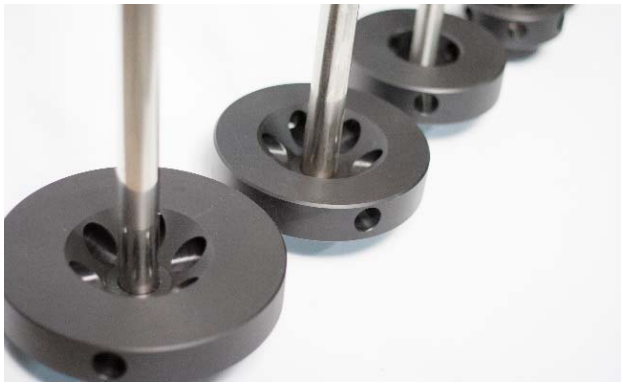
ITC Dosing Pumps

Study of Agitation Efficiency

Results of the comparative tests carried out by Alba Soriano as part of her end of degree project, directed by Ricardo Torres, for the Barcelona East School of Engineering (EEBE - UPC).

Turbine agitator in operation

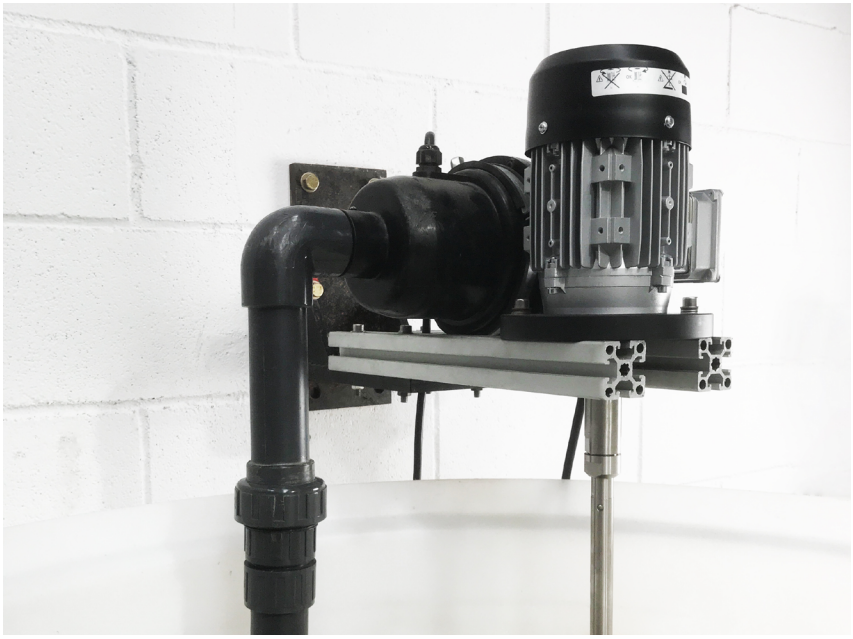
Each type of crop has its own nutritional needs which will be further modified, for example, depending on the growth stage and soil type. Fertigation is the technique which allows the contribution of nutrients via the irrigation network in a more optimised and efficient way, ensuring that all the fertilizer dosed reaches the plant.The use of solid fertilizers in agriculture is common. In order for it to be incorporated into the irrigation network it is a liquid solution must be prepared which can easily be dosed into the irrigation water. To prepare such a solution, the solid fertilizer is mixed with water, aiming for the complete dissolution of the salt. Although fertilizers are soluble in water, some mechanical means is required to stir the mixture and promote its dissolution. The most common agitation systems are turbine agitators and blowers (air compressors).



15 cm diameter turbines

Fertigation is a technique which allows nutrients to be incorporated via the irrigation network in a more optimised and efficient way.

The objective of the study is to evaluate the quality of the two methods in terms of dissolution efficiency, energy cost and installation cost.



Installation setup with equipment used for the tests

To analyze the behaviour of the solution during stirring, the electrical conductivity readings were made at fixed time intervals until the final conductivity was reached. In this way, the evolution of conductivity can be represented as a sample of the state of dissolution, until complete dissolution is reached. Various fertilizer formulations were considered, the final choice being potassium sulphate, which is quite common on various crops and which stands out for its low solubility and difficulty in dissolving.

Various tests were performed at concentrations of 5% and 10%. It should be taken into account that the solubility of K2SO4 is 110 g/l at 20 °C, so the 10% test is at the limit of solubility.

Characteristics of stirring and mixing systems

The test was carried out with a 370 W ITC turbine agitator and a 1100 W blower connected to a structure of PVC pipes branched at the bottom of the tank with 4 mm orifices on their undersides.

Whereas the turbine agitator jets are capable of stirring the bottom of the tank, the blower is not able to produce enough speed and turbulence to dissolve it.

Test results

As can be seen in the graph of the evolution of conductivity during the dissolution, the performance of the mixture is in both very similar for the first three minutes, at which time 80% of the K2SO4 has been dissolved.

TECHNICAL SPECIFICATIONS

AGITATOR	BLOWER
370 W	1,100 W
Turbine Ø 130 mm	Orifice Ø 4 mm
3 axial jets and 3 18 mm radial jets	No. of orifices: 60
20 m³/h	93 m³/h

Turbine agitator

Evolution of conductivity in the solution

From this point on, the agitator continues to dissolve the salt, thereby increasing the EC, whereas the increase in EC is much lower in the blower. In the case of the agitator, dissolution is 97% complete after 10 minutes, and reaches 100% in 16 minutes. The blower takes much longer to reach a stable reading, around 30 minutes. Once the readings have stabilized and the dissolution of all the salt is complete, the blower has reached EC values 5% lower than those of the agitator. This is because part of the product has remained unmixed at the bottom (see photo), so less salt is dissolved in the water and the final EC reading is lower.

Whereas the jets of the turbine agitator are capable of stirring the bottom of the tank, the air that comes out of the orifices in the case of the blower is not capable of generating sufficient speed and turbulence in the fluid to dissolve what remains at the bottom.

Product not dissolved by blower air

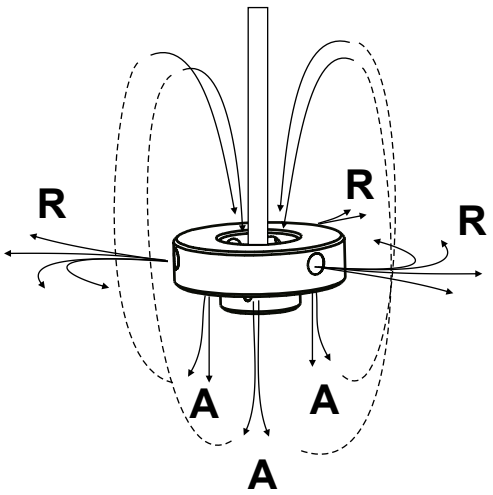
Analysis of the turbulence generated in the fluid

- Turbine agitator:

The design of the turbine is based on the same principle as centrifugal pumps, where the liquid is driven from a smaller diameter to a larger one thanks to the rotation of the turbine. In this way, energy is imparted to the fluid, increasing its speed at the rate of the square of the variation in diameter. Fluid jets

Fertilizer dissolution process

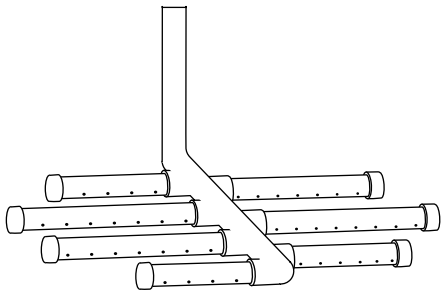
are produced due to the axial and radial distribution of the outlets, axially towards the bottom of the tank in order to drag any particles that may be present, and radially in order to impart rotation to all the liquid in the tank. Since the agitator is offset from the centre of the tank, the formation of a vortex is avoided, and turbulence is generated due to the jets bouncing off the bottom of the tank colliding with the radial ones imparting rotation, thus facilitating the dissolution of the salt .



Turbine agitator with axial and radial jets

- Air compressor (blower)

Comprising an air compressor located externally and connected to a PVC pipe which branches throughout the bottom of the tank so that it covers the

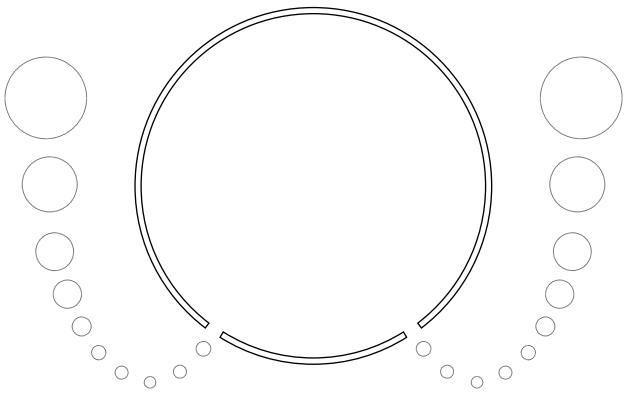


Structure of pipes at the bottom of the tank

With the blower, solids can remain undissolved at the bottom since the stirring effect is very small, much less than the mixing capacity of the turbine agitator.

entire surface area, with 4 mm holes distributed in its lower part through which air is injected .

The air in the form of bubbles is driven out of the orifices on the underside of the tubes. The pressurized air comes out of the orifices in the form of bubbles. These bubbles contain a volume of air subjected to a pressure of 1 meter, which is the height of the liquid above them. As they rise, the pressure is lower, which makes them increase in size. The larger the size, the greater the stirring capacity, since the volume of liquid displaced by each one is greater. The visual effect from the surface is of great agitation, but at the bottom of the tank the agitation is very slight, and the effect on any solids deposited on the bottom may be insufficient.



As the bubbles rise, the pressure is lower, which makes them increase in size.

Conclusions

- Dissolution efficiency. With the blower, solids can remain undissolved at the bottom since the stirring effect is very small, much less than the mixing capacity of the turbine agitator. A blower is not recommended for dissolving solid fertilizers, but may be right for liquid fertilizers

- Energy cost. For a given tank, the compressor needs a motor three times more powerful than the turbine agitator. But the mixing speed is the same in both cases, so that for preparation of a finished fertilizer solution the turbine agitator will have consumed a third as much energy as the compressor.

- Installation cost. The unit costs are similar. The blower can be installed so that a single unit is connected to several tanks, with valves being used to select which tank is to be stirred. It is not possible to stir more than one tank at a time since the flow of injected air, and therefore the agitation efficiency, would be reduced.

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