# Prerequisites for Successful Fertigation

**M. J. RUSAN**
**Jordan University of Science and Technology; Dept of Natural Resources and Environment; PO Box 3030; Irbid, Jordan; Phone: 962 079 5573970 (Mobile); Fax: 962 2 9570069**
**E-mail: mrusan@just.edu.jo**

## ABSTRACT

Fertigation is an attractive method of fertilization for the farmers in today's modern irrigated agriculture and a key-factor in today's intensive irrigated agriculture. This concept became an extremely important to plant nutrition after the introduction of drip irrigation as a new method of irrigation. With drip irrigation, the wetted soil volume and thus the active root zone is reduced under drippers and this small volume will not tolerate the addition of all fertilizers required by the crop. Instead, fertilizers requirement should be applied frequently and periodically in small amount with each irrigation to ensure adequate supply of water and fertilizers in the root zone. Therefore, following the shift from surface irrigation to drip irrigation, fertigation became the most common fertilization practice in irrigated agriculture.

However, to ensure successful fertigation, the following should be considered: the selection of fertilizers and their solubilities and compatibilities with each others, with soil chemical and physical properties and with the quality of the irrigation water, quality of irrigation water, water requirement, method, scheduling and frequency of irrigation. In addition, the irrigation system including the fertigation head should be selected and designed properly and continuously maintained to operate efficiently through out the growing season.

Application of fertilizers with irrigation water is one of several possible ways of fertilizer application. Its applicabilities depend on external conditions such as type of soil & crop, method of irrigation used, water quality, types of fertilizers available, general economics compared to other ways of fertilizer application. Fertigation is more advantageous on coarse-textured, sandy soils (not heavy) esp. for N to avoid possible leaching when adding in large amount. In fertigation small doses of N frequently added prevent leaching. Fertigation is more advantageous in drip irrigation system. Better fertilizer distribution compared to furrow & surface irrigation. Drip also has higher water use efficiency higher fertilizer use efficiency.

The kind of fertilizer to be used has to be chosen very carefully. The quality of irrigation water plays an important role in choosing which kind of fertilizer to use. Improper choice may cause difficulties by clogging irrigation system or by corrosion.

By fertigation, fertilizers are added in synchronization with plant needs, which are different for different periods of growth. i.e. by fertigation the amount and form of nutrient supply is controlled according to the changing demand for physiological stages during the growing season. For example, nitrate:ammonium ratio had a significant impact on the growth and development of the root system. Thus ratio can be different for different physiological and growth stages as well as for different plant species. This also can also be used to control the quality of agricultural products. For example, providing high rates of nitrate through fertigation can reduce the harmful effect of increased levels of chloride ion concentration. On the other hand, supplying high rates of nitrate during the last and preharvest stages may lead to accumulation of undesirable levels of nitrate in the products. Thus reducing their marketability and quality parameters. In addition, by controlling nitrogen fertigation during the last stages of growth one can somewhat control the maturation. High levels of nitrogen are needed in the early stages to stimulate and enhance vegetative growth while high levels of nitrogen should be avoided toward the late and preharvest stages to avoid delay in maturation and avoid accumulation of nitrate in the products. Assimilation of nitrogen toward the end of the growing season is significantly reduced and thus most of the nitrate absorbed during these periods tend to accumulate in the products.

Fertigation is also an efficient method for providing and supplying available forms of immobile elements such as P at a desirable level in the root zone. This is especially important during the very first stages where P is badly needed for developing a good root system.

1. Since with fertigation, fertilizer application can be controlled better, overfertilization and overirrigation at any growth period can be avoided. Thus, by synchronization of water and nutrient supply with the crop demands, both water and fertilizer use efficiencies are improved and the adverse impact of overfertilization on the environment is minimized. The nearer the time of fertilizer application to peak nutrient demand, the higher the utilization efficiency of fertilizers.

2. Drip irrigation has proved to be the most efficient method of irrigation in terms of water saving and yield increase. Conventional fertilization techniques are not suitable under drip irrigation farming system while the fertigation is considered the only appropriate techniques for fertilizer application. In fact, fertigation in many countries has gained momentum since adoption of drip irrigation systems. This is also of extreme important in countries where water resources quantitatively and qualitatively are limited.

3. By fertigation, one can avoid application of large amount of solid fertilizers by conventional methods thus avoiding salt damages of plant roots.

4. By fertigation, one can minimize the losses by leaching and/or volatilization because the nutrients are directly supplied into the root zone in small amount and frequently according to the needs of each growth period.

5. Compared to soil application, fertigation can save time, energy, labor and overall application cost.

6. Frequent application of small doses of fertilizers with fertigation keeps the amount of fertilizers in the soil at any time low enough to minimize losses by leaching and runoff during heavy rainfall or excessive irrigation. This regulates nutrient uptake, minimize losses and increase fertilizer use efficiency.

7. Fertigation give us the possibility of incorporation of fertilizers with pesticides and other chemicals, given they are chemically compatible. This reduces the time, labor, energy and application costs.

8. With fertigation it is more convenient to apply small doses of micronutrient fertilizers especially for basic and calcareous soils where most micronutrient fertilizers have low solubility.

9. With fertigation marginal lands, like sandy soils, rocky soils, shallow soils and salt affected soils can be cultivated and crops can grow successfully. Under these conditions, control of irrigation water and fertilizers in the root zone is critical and can be achieved successfully with fertigation. In addition, with fertigation and drip irrigation, marginal water can be successfully used for irrigation by keeping root zone wet all times, thus keeping salts away from the roots. With surface irrigation, soil varies from saturation to wilting point between irrigation.

10. Benefits of fertigation include reduction in soil compaction and mechanical damages to the crops due to reduced use of tractors and other heavy machines in the fields.

11. Fertilizers can be applied to the soil when crops and soil conditions are inconvenient (wet soil surface, crops are growing, etc) for labors or equipment to enter the field to apply fertilizers by conventional methods.

12. By fertigation, immobile nutrients such as phosphorus and micronutrients will be supplied right into the root zone and the nutrients therefore are not widely mixed with the soil. Thus less soil volume is fertilized and less fixation, sorption or precipitation are taking place and fertilizer use efficiency is improved.

Prerequisites for successful fertigation

1. Water and nutrient requirements must be known.

Amount of fertilizer applied depends on the amount of irrigation water. Application rates should be estimated for each crop according to their water and nutrient requirements. All factors affecting the recovery of applied fertilizers should be considered in estimating the application rates. These factors include mobility of the nutrients in the soil, soil moisture and other physical characteristics, chemical characteristics, crop species and genotypes and other factors.

2. Fertigation scheduling (management).

Irrigation scheduling should be well understood to ensure successful fertigation program because irregular irrigation leads to poor fertigation. By fertigation, fertilizers can be supplied to the crops in amount, forms and at times when they are mostly needed. So one can schedule nutrient application to a crop by following the crop demand during the growing season. This can generally means, an application of low rates during the early growth periods, and then increasing the application rates during the vigorous growth rate periods; and finally decreasing again the rate toward the end of the growing season. This means that fertigation scheduling should follow and reflect the growth rate of the crops.

3. Frequency of application.
Should the fertigation be continuous?
Fertilizers can be applied into irrigation water in various frequencies. The frequency of application depends mainly on crop type, system design constraints, soil type and on grower preference. The frequency of application through irrigation water can be every day or once every several days or once every week and so on. This should be determined for each crop and for each cropping system in a site-specific basis. The following consideration should be taken into account while deciding on frequency of injection of fertilizers:

a. Continuous injection of fertilizers would reduce the chance of leaching below root zone during heavy rains and excessive irrigation compared to injecting larger amount on a less frequent basis.

b. To ensure uniform application to the soil, the drip irrigation systems should always be brought up to operating pressure prior to start injecting any fertilizers. Injection of fertilizers should start only after the system has been fully pressurized. Besides, after finishing fertilizer injection, the drip system should be operated for a period of time to flush out any remaining fertilizers from the irrigation system.

c. It is also not uncommon that fertilizers are sometimes are added preplanting as a starter. This is important especially during rainy seasons where fertigation cannot be operated due to continuous rainfall for a long period of time and for nutrients, which are required relatively at higher rates to early growth stages.

d. The constant and continuous rate of fertigation may result in underfertilization during the stages of higher growth rate or overfertilization during the early and preharvest periods of growth, which are characterized by lower growth rates. Therefore, fertigation should be scheduled efficiently according to the variable growth rates of the various growth stages.

It is not uncommon, the fertigation is practiced based on what is known as "quarter-half-quarter rule" where fertilizers are injected only during the middle half of the irrigation cycle. This non-continuous fertigation is recommended in particular when large doses of corrosive chemicals are to be applied. This shorten the contact of the fittings and emitters of the irrigation system with the chemicals, thus preventing the damages of these fittings. In addition, application of fertilizers only during the half period of the irrigation cycle will assure that the irrigation system was already brought up to the operation pressure. So, the water and fertilizers will be discharged and applied uniformly. Besides, by not injection the fertilizers during the last quarter of the irrigation cycle, one would facilitate the flushing out of the remaining fertilizers from the irrigation system by the fertilizer free irrigation water during the last part of the irrigation cycle. On the other hand, one should consider the possibility of leaching fertilizers from the root zone during the last quarter period of the irrigation cycle. This is mainly more important to consider when fertigation is practiced in coarse textured soils.

**Note** "When flushing out the chemicals from the irrigation system is required, it is important to estimate the travel time of these chemicals from the injection point to the final application point. This travel time can be calculated for each pipe segment in the system. Since any system would include different segments and of different length with different flow rates, determination of the travel time becomes practically complicated. Therefore, it is suggested to estimate the travel time simple by continuous sampling the irrigation water at the farthest irrigation outlet in the system and then measure the electrical conductivity, which serve as a detector or indicator for the arrival of fertilizers to this outlet. The use of EC meters will not work if fertilizers injected into the irrigation water are chemically uncharged such as urea and others".

4. Discharge and distribution uniformities.
The irrigation system should be designed properly and maintained to operate efficiently through out the growing season. Watch for any defect in the system, precipitation problem and water quality. Precipitation can clog the emitters and irrigation lines and change their discharge rate.

5. Solubility and compatibility of fertilizers.
Fertilizers must be water soluble and compatible with each others and with irrigation water. Fertilizer solutions are rather concentrated salt solution therefore, they may become supersaturated causing the salts to form crystals and precipitate out of solution.

Applicability of fertigation depends on several factors such as type of soil and crop, method of irrigation, water quality, type of fertilizer, and economics compared to other ways of fertilizers application.

Soil characteristics influencing the efficiency of Fertigation
a. Soil texture.
Fertigation is most suitable for coarse textured soil and sandy soils where permeability is high and where conventional application methods could result in nutrient leaching. On heavier soil, by contrast, the advantages of split application of fertilizers and of fertigation are less evident. In coarse-textured soil, leaching potential is high so we recommend to split application to minimize leaching and increase use efficiency by plant. The texture of the entire profile is important in consideration of NO3 movement below root zone. Texture influences the retention of phosphorus fertilizer. Phosphate ions are immobile nutrients in the soil and it is fixed in fine-textured soil and less in coarse-textured. So phosphate fixation less if applied by fertigation in coarse soil. Therefore with fertigation we apply small amount or doses several times during the growing season. On the other hand, in fine-textured soil we tend to add on or few based application and the crop response still be suitable. Under these condition fertigation my not have advantage over the other methods.

b. Method of irrigation
Method of irrigation is also an important factor determining the efficiency of fertigation. With surface irrigation, the water distribution and thus the fertilizer distribution in the soil are not uniform. By management we may improve fertilizers distribution by adding fertilizers in the second or third of the H2O applied. With surface flooding irrigation there is a chance for overirrigation and thus overfertilization and nutrient leaching. This will decrease the water and fertilizer use efficiencies. Sprinkler and drip irrigation on the other hand, provide a more uniform distribution of irrigation water and thus a relatively more even distribution of fertilizers in the root zone. The dissolved nutrients accompany the water wherever it goes. However,

unsatisfactory distribution of nutrients can occur under some conditions, with some forms and types of fertilizers and with low rates of fertilization.

With fertigation, less nitrate leaching is observed than with broadcast fertilization. In general, heavy doses of fertilizers are applied with broadcast applications to cover the crop nutrient requirement through the growing season. Thus, higher doses application keep the nutrient at higher concentration than needed by the crops and remain subject to leaching with heavy rainfall and excessive irrigation. With fertigation, the fertilizers are applied in small amount and just to meet the crop demand at a time of application, Therefore, there is never a high concentration of the nutrient in the soil solution and the potential for leaching is minimal.

Distribution of nutrients applied through irrigation water

Nutrients applied in irrigation water are distributed in about the same manner as water. However, distribution of nutrient is different according to irrigation system. In furrow irrigation, the water tends to percolate more at the head of a run than at the tail. Since N concentration is uniform in water, so N more in head since more water there. To offset this problem nutrients are withheld from water during the first part of the irrigation thus avoiding an accumulation of nutrients. And use short furrows. In sprinkler systems nutrient distribution will also be according to the manner of water distribution