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FERTIGATION: AN EFFICIENT TECHNIQUE FOR ACHIEVING HIGH NUTRIENT USE EFFICIENCY IN CROP PRODUCTION SYSTEM

M.R. Yadav*[1], Rakesh Kumar[1], Hardev Ram[1], Vinod Yadav[2] and Brijesh Yadav[3]

[1]ICAR- National Dairy Research Institute, Karnal-132 001

[2]Rajasthan College of Agriculture, Udaipur-

[3]ICAR-Indian Agricultural Research Institute, New Delhi- 110 012

*Corresponding Author Email: raomaluydv@gmail.com

Fertigation

The practice of supplying crops in the field with fertilizers through irrigation water is called fertigation. Fertigation is a modern agro-technique which, provides an excellent opportunity to enhanced yield and minimize environmental pollution by minimizing fertilizer application, increasing fertilizer use efficiency and increasing net returns on the fertilizer invested (Hagin *et al.*, 2002). In fertigation, timing, amounts and concentration of fertilizers applied are easily controlled. It enables the application of water soluble fertilizer and other chemicals along with irrigation water more efficiently in the active root zone of crop.

Needs for Fertigation

In the present situation water is the most precious natural resources in the world. The availability of fresh water for the mankind is very limited. Demand for water among agricultural sectors and non-agricultural sectors are increasing; demand for food is equally increasing with increasing the population density (Sne, 2006). So in this critical situation of water scarcity it is the challenge to the agriculturist to adopt new technologies to improve the crop production and productivity as well as mention the quality of crops to supply the sufficient foods to the nations. So, the basic needs of fertigation are:

1. Uneven growth in fertilizer consumption resulting in state-wise, crop-wise variation in consumption.
2. Mining of nutrients from the soil at alarming rate (Soil fertility depletion due to inadequate and imbalanced fertilizer use).
3. Decline in crop response to fertilizer.
4. Stagnation in fertilizer production.
5. Increase dependence on fertilizer import (mostly for P and K).
6. Weakening relationship between fertilizer use and food grain production.

Advantages of Fertigation

1. **Eliminates manual application:** Manual application requires labour and time and is less efficient compared to the advanced fertigation methods. The fertigation eliminates this manual operation.
2. **Higher water and nutrient use efficiency:** Nutrient use efficiency by crops is greater under fertigation compared to that under conventional application of fertilizers to the soil.

3. **Higher resource conservation:** Fertigation helps in saving of water, nutrients, energy, labour and time.
4. **Less water pollution:** Intensification of agriculture led by use of irrigation water and indiscriminate use of fertilizers has led to pollution of surface and groundwater's by nutrients. Fertigation helps in reducing pollution of water-bodies through leaching of nutrients nitrogen (N) and Potassium (K).
5. **Uniformity of application:** Since the drip or micro-sprinkler irrigates a limited area of active root zones and fertilizers are placed directly in this active root zone, there is very high uniformity in the application of fertilizers.
6. **Efficient delivery of micronutrients:** Application of micronutrients solely is a very difficult task, but fertigation gives the opportunity for efficient use of compound and ready mix nutrient solutions containing small concentrations of micronutrients.
7. **Stage wise availability:** In fertigation fertilizers can be given every day and the quantity given is based on the crop nutrient requirement. Hence, nutrients are available as and when the crop requires it.
8. **Help in effective weed management:** Use of plastic mulch along with fertigation through drip system allows effective weed control in widely spaced crops.
9. **Effective use in undulating soil:** Undulating soil can be used under cultivation using micro irrigation system.
10. **Improved soil structure:** Due to reduce traffic movement on the surface soil under micro irrigation system during irrigation and nutrient application it helps to reduce sub-surface soil compaction.

Fertigation Methods:

Based on the crop, soil type and management practices fertigation methods has classified into two groups viz. quantitative dosing and proportional dosing (Sne, 2006):

1. **Quantitative dosing:** In this method a calculated dose of fertilizer is injected into the irrigation system. Fertilizers are applied once in a pulse and mainly highly water soluble solid fertilizers are used for quantitative dosing. Fertilizer dose is expressed as kg/m^3 or g/l.
2. **Proportional dosing:** In this process, a constant ratio between irrigation water and fertiliser solution is maintained, in such a fashion that nutrient concentration in the irrigation water will be constant. Fertilizer dose is expressed as kg/m^3 or g/l.

Criteria for Evaluation of Fertilizers for Fertigation:

Based on the physiochemical characteristics a wide range of solid as well as liquid chemical fertilizers are suitable for fertigation. For large scale application solid fertilizers are cheaper and offer a good alternative to the commonly available liquid fertilizers. While selecting fertilizers for the purpose of fertigation following key factors should be considered:

1. **Solubility**

Solubility of a chemical fertilizer indicates the relative degree to which given fertilizer dissolves in water. Solubility of the subjected chemical fertilizers is most important factor while preparing stock solutions for fertigation. Based on their relative degree of being soluble in water, following chemical fertilizers were identified for efficient fertigation and their comparative performance is given in Table 1.

Table.1. Specification of some commercial fertilizers used for fertigation

Fertilizer	Grade ($N:P_2O_5:K_2O$)	Solubility (g/L)	pH (g/L at 20°C)
Urea	46-0-0	1100	5.8
Ammonium nitrate	34-0-0	1920	5.7
Ammonium sulphate	21-0-0	750	5.5
Calcium nitrate	16-0-0	1290	5.8
Magnesium nitrate	11-0-0	-	5.4
Potassium nitrate	13-0-45	133	7
Potassium sulphate	0-0-50	110	3.7
MAP	12-61-0	230	4.9
Potassium chloride	0-0-60	340	7
Orthophosphoric acid	0-52-0	457	2.6

(NCPAH, 2012)

2. Compatibility

Mixing of multiple fertilizers for the purpose of fertigation may sometimes leads to formation of solid precipitate. The prime cause of this problem is non-compatibility of the subjected chemical fertilizers with each other in the final solution. To avoid this problem while preparing fertilizer solutions for fertigation, farmers should consider the following compatibility chart of different commonly used fertilizers.

Table.2. Compatibility chart of different water soluble fertilizers:

Fertilizer	Urea	Ammonium nitrate	Ammonium sulphate	Calcium nitrate	MAP	Mono potassium phosphate	Potassium nitrate
Urea		C	C	C	C	C	C
Ammonium nitrate	C		C	C	C	C	C
Ammonium sulphate	C	C		LC	C	C	LC
Calcium nitrate	C	C	LC		NC	NC	C
MAP	C	C	C	NC		C	C
Mono potassium phosphate	C	C	C	NC	C		C
Potassium nitrate	C	C	L	C	C	C	

C-Compatible; LC-Limited Compatible; NC-Not Compatible (Mantig, 1997)

From the above table it is quite clear that Phosphorus and Potash containing fertilizers are generally non-compatible with calcium containing chemical fertilizers.

3. Precipitation

Water sources that contain high quantity calcium, magnesium and bicarbonates are generally known as hard water and reaction of these water sources is alkaline in nature with pH values 7.2 to 8.5 or more. When water soluble fertilizers are mixed with these alkaline water sources, the interaction can leads to a wide of problems, such as formation of precipitates in the fertilizer tank and clogging of the drippers and filters of micro-irrigation systems. This problem mostly observed with phosphorus fertilizers because presence of high

calcium and magnesium ions and high pH values of these fertilizers in the irrigation system and fertilizer tank as well lead to the precipitation phosphorus as calcium and magnesium phosphates. To avoid this while preparing the fertilizer solutions the solubility and compatibility of the mixing fertilizers should be considered.

Fertigation Systems:

Fertigation method should suit to irrigation system and the crop in question. Inappropriate choice of the fertigation equipment can cause damage to the irrigation system and may affect not only the operation of the irrigation system but also reduce the efficiency of the nutrients. In market a wide range of fertilizer injector is available for this purpose with specified pressure and flow range. Fertilizer injectors available in the market are able to operate automatically to convert injector pulses into electric signals. Flow regulators controls injection rate through chemically resistant ball valves or by electronic or hydraulic control units and computers. For fertigation normally two type of system are in practice:

1. VENTURI INJECTOR

Venturi injectors work is based on suction principle. It utilises the pressure induced by the flowing water to suck the fertilizer solution from the fertilizer tank into the irrigation line (Fig 1.a.). For this purpose conical constriction in the pipe is created to induce an increase in the water flow velocity and simultaneously decrease in external pressure to an extremely low value, which helps in fertilizer suction from the supply tank through a tube into the irrigation system. Filter screens are used in between. An adjustment valve is used to control the difference between the water velocities across the valves.

(a) Venturi injector (b) Fertilizer tank

Fig.1. Fertigation equipment

2. Fertilizer Tank:

This system of fertigation is based on the principle of a pressure differential. In which a valve, elbows or pipe friction in the mainline are used to create pressure difference. The resulted pressure difference in the mainline forces the water to enter through a by-pass pipe into fertilizer tank, and to go out again, carrying a varying amount of dissolved fertilizer (Fig 1.b.). In this system, the fertilizer concentration is more during starting period of irrigation and decreases with time. This results in uneven distribution of fertilizers in the field.

Constraints in Fertigation:

1. Initial high cost and required highly skilled labour to maintain the fertigation system.

2. A high range of different graded chemical fertilizers are needed.
3. If the pH of irrigation water and fertilizer sources are high there will be chances of clogging of emitters are also high.
4. Insoluble fertilizers like super phosphate are not fit for fertigation.
5. Higher cost and locally unavailability of liquid fertilizers in the market.
6. Less popular in closer spaced grain crops.
7. Lack of information in respect of its rate/method of application, fertilizer to water ratio used and its scheduling further restricted its adoption.
8. Chances of crop injury will more if proper dose/time of application not follow.

Conclusion:

Indiscriminate use of water for agriculture, industries and domestic purpose resulted into water scarcity throughout the world. The application of chemical fertilisers along with irrigation water through micro-irrigation technology has advantages mainly to meet nutritional need as per requirement of crops. It is an efficient method of applying fertilizers, in which the irrigation system is used as the carrier and distributor of the nutrients to the crop. Fertigation system is useful in achieving higher input use efficiency, crop yield as well as net returns to the farmer. Thus, fertigation has opened a new window for efficient use of water and nutrient supplies in crops and provides a viable option for sustainable crop production and quality produce.

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