(DOI): 10.5935/PAeT.V7.N2.12

This article is presented in English with abstracts in Spanish and Portuguese

Brazilian Journal of Applied Technology for Agricultural Science, Guarapuava-PR, v.7, n.2, p.97-107, 2014

Bibliographic Review

Management characteristics of Fertigation considering the salinization process on cultivation in soil and substratum

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Abstract

The increase of the global demand for food is one of the main factors that induce the improvement of techniques applied to agriculture. In this context, the utilization of techniques such as the cultivation in protected environment, integrated management of pests and diseases and the efficient use and management of water and fertilizers, are essential. The aim of this study is to present data and discussion about relevant aspects of the fertigation on cultivation in soil and using substrates, addressing general characteristics of this technique, the use of fertilizers, substratum and details to be considered on the dimensioning and management. The fertigation enables to provide the culture a quantity next to ideal of water and nutrients, through the fractionating and adjustment of quantities applied according the culture's necessity and according to the development phase, improving the nutritional efficiency and water use. In locals that the soil presents natural conditions that prevent or limit the cultivation, the utilization of substratum allows to overcome these limitations and provide the plants conditions next to the ideal for its development. The adoption of adequate techniques of fertigation management allows reaching an elevated productivity, obtaining products of superior quality, minimizing damages to the environment and to the production system.

Keywords: intensive agriculture; salinization; irrigation; drip irrigation

Características de manejo del fertirriego considerando el proceso de salinización de los suelos y cultivo en sustrato

Resumen

El aumento de la demanda mundial de alimentos es uno de los principales factores que conducen a la mejora de las técnicas aplicadas en la agricultura. En este contexto, el uso de técnicas como cultivo protegido, manejo integrado de plagas y enfermedades y el uso y gestión eficiente del agua y de los fertilizantes, son fundamentales. El objetivo es presentar un análisis de aspectos relevantes de la fertirrigación en cultivos en suelo y con el uso de sustratos, considerando características generales de esta técnica, el uso de fertilizantes, sustratos y detalles a tener en cuenta en el diseño y manejo de sistemas. La fertirrigación proporciona ofertar a las plantas la cantidad de agua y nutrientes más cercana a la ideal a través del fraccionamiento ajustando las cantidades de acuerdo a las necesidades del cultivo y la etapa de desarrollo, mejorando la eficiencia nutricional y el uso del agua. En lugares en que el suelo presenta condiciones naturales que impiden o limitan el cultivo, la utilización de sustratos permite superar estas limitaciones y proporcionar a las plantas condiciones cercanas de las ideales para su desarrollo. La adopción de técnicas apropiadas de gestión de la fertirrigación permite lograr una alta productividad, obtener productos de mayor calidad, reduciendo al mínimo los daños al medio ambiente y el sistema de producción.

Palabras clave: agricultura intensiva; salinización; riego; goteo

Recived at: 24/10/13. Aceppted for publication: 12/08/14.

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Características de manejo da Fertirrigação considerando o processo de salinização em cultivos em solo e substrato

Resumo

O aumento da demanda global de alimentos é um dos principais fatores que induzem ao aprimoramento das técnicas aplicadas na agricultura. Nesse contexto, a utilização de técnicas como o cultivo em ambiente protegido, manejo integrado de pragas e doenças e o uso e manejo eficientes de água e fertilizantes, são fundamentais. O objetivo do trabalho é apresentar uma análise de aspectos relevantes da fertirrigação em cultivos em solo e com o uso de substratos, abordando características gerais desta técnica, uso de fertilizantes, substratos e detalhes a serem considerados no dimensionamento e manejo de sistemas. A fertirrigação possibilita fornecer à cultura uma quantidade próxima ao ideal de água e nutrientes, por meio do fracionamento e ajuste das quantidades aplicadas conforme as necessidades da cultura e conforme a fase de desenvolvimento, melhorando a eficiência nutricional e do uso de água. Em locais que o solo apresenta condições naturais que impedem ou limitam o cultivo, a utilização de substratos permite superar essas limitações e proporcionar às plantas condições próximas as ideias para seu desenvolvimento. A adoção de adequadas técnicas de manejo da fertirrigação permite alcançar elevada produtividade, obter produtos de qualidade superior, minimizando danos ao ambiente e ao sistema de produção.

Palavras-chave: agricultura intensiva; salinização; irrigação; gotejamento

Introduction

The growing need for food has been demanding a fast development of techniques for agriculture, increasing its complexity and leading to the intensification of cultures, where it is aimed to produce and increment the production per area unit, with the quality desired by the consumers and searching the maximum techno-economic efficiency. The utilization of protected cultivation, integrated management of pests and diseases, irrigation and efficient use and handling of water and fertilizers are factors of great importance in this context (FACTOR et al., 2008; JADOSKI et al., 2010).

Irrigation is essential for the development of crops according to its water necessities and characteristics of different edaphoclimatic situations of cultivation (SCOTT et al., 2004). To KAFKAFI (2008) the scarcity of available fresh water in the world has stimulated men to constantly develop systems for a better use of this resource, creating, thus, opportunities for the developing of new technologies.

The application of fertilizers via fertigation, normally by drip irrigation, can decrease the water and nutrient loss in the soil, enabling to adjust the quantity of nutrients applied to the needs of each development phase of the crop (GENUNCIO et al., 2010; CARDOSO and KLAR, 2012) and improve the efficiency of water use, nitrogen and other applied nutrients (VÁZQUEZ et al., 2006). It provides a decrease of the soil compaction (TEIXEIRA et al., 2007), presents generally a high uniformity of distribution of the fertilizer in field conditions, reduces manpower and enables greater parceling of the fertilizations, increasing, consequently, the efficiency on the utilization of fertilizers by the plants (DUENHAS et al., 2002; ELOI et al., 2007; SOUSA et al., 1999; HOU et al, 2009), though such results will only be achieved if the movements and reactions of the nutrients are well comprehended and managed (RAVIKUMAR et al., 2011).

The handling techniques of fertigation must always tend to the conservation and increment of the production capacity of the soils, aiming the elevation of productivity (SOUSA et al., 1999). Potential environmental problems are associated to the fertigation, standing out the contamination of the superficial sub-superficial water and by fertilizer leaching (CAUSAPÉ et al., 2004; DARWISH et al., 2011) and the accumulation of salts in more superficial soil layers (DIAS et al., 2005; FACTOR et al., 2008); such problems are normally associated to inadequate handling of the irrigation and to elevated doses of applied fertilizers (SILVA et al., 2013).

The aim of this study is to present data and discussion about relevant aspects of fertigation on cultivation in soil and with use of substrates, addressing general characteristics of this technique, use of fertilizers, substratum and details to be considered on the dimensioning and management.

General aspects about fertigation

The benefits of intensive and technified production on agriculture, where the fertigation is routinely used, point out for a sustainable production (JADOSKI et al. (2010). In this context, VILLAS BOAS (2003) indicates that in function of a global concern in relation to the management of resources such as soil and water, associated both to the productivity and food quality, the fertigation is inserted as an efficient technique, reflecting favorably on the reduction of harm to the environment, though DIAS et al. (2005) and FACTOR et al. (2008) report the existence of several potential problems that may occur in fertigated areas, which requires a technical knowledge and conscious activity.

The inadequate management of water in the soil brings problems related to nutrient loss by leaching and, though the fertigation offers a series of advantages, its efficiency depends on the knowledge and study of several factors, among them the fertigation management associated to water handling in the soil-water-plant-atmosphere system (PEIXOTO et al., 2006). The fertigation allows the application of fertilizers as many times as it is necessary, without raising the costs of manpower. However, for better efficiency on the application, the ideal is to follow the absorption curve of nutrients of the crop, in a way of fractioning rationally the elements during the cycle, according to the necessity (SOUSA et al., 2011).

The capacity of providing an exact quantity of nutrients and water to a plant in a specific moment offers many advantages. To COSTA et al. (1986), there is a work economy, reduction of machinery traffic that causes soil compaction, and also the necessary water volume, decreasing wastage. These advantages made this system viable in different production scales. However, KAFKAFI (2008) points out that in function of the demand for products of better quality and quantity in more regular supply, the areas with fertigated production has been expanding in locals that generally present most elevated manpower costs and higher scarcity of water, as in the cases of the greenbelts of big cities.

PAULINO et al. (2011), analyzing the situation of the irrigated cultivation in Brazil, according to the agricultural census of 1996 and 2006, found an increase of approximately 1.3 million acres, going from 3.1 million to 4.4 million acres in 10 years, resulting in a pace of 130 thousand acres per year. Following the pace reported, Brazil must currently have approximately 5.4 million irrigated acres. There is no precise information about how much of this area fertigation is used, though the data indicate the potential of expanding the technique in the country, and its possible impacts on the national production.

The spray irrigation system is considered efficient for water distribution, however not so much for product application via fertigation. It is considered that it was with the arrival of localized irrigation by micro sprinkling and dripping that the fertigation spread through the world. What distinguishes these irrigation methods is the possibility using an automatic system, with distribution lines and little emitters of water and solution, filters, fertilizer injectors, registers and valves responsible for regulation pressure and output (MAGEN, 2008; TRANI et al., 2011).

To SOUSA et al. (2011), the fertigation fits better to the drip irrigation system than to the micro aspersion system, because in the drip irrigation the root system of the crop matches the regions of higher humidity values of the wet volume, generated by one or more drippers, optimizing the fertilizer usage, and in the micro aspersion, the same occurs when it is used one micro sprinkler by plant or when it is used a continuous wet track.

Characteristics of the most used fertilizers

The fertilizer industry provides to the producer a great variety of products, both solid and liquid. However, for the application via fertigation it is indispensable to consider the fertilizer compatibility, avoiding the formation of precipitates and also the corrosion of metallic components of the system. To BLANCO and FOLLEGATI (2002), it is important to consider the adequate balance of water quantity for irrigation and the quantity of solid fertilizer that can be dissolved, besides the concentration of liquid fertilizer (HAGIN, 2003), for thorough maintenance of characteristics such as pH and electric conductivity (Ce) in ranges considered adequate.

Although the fertigation is being used on some irrigated areas in Brazil, the lack of information, mainly about dosages, most recommended fertilizer type, prevention of formation of precipitates, form and time of application, reflects the need of conducting researches in this area, taking in consideration the diverse conditions of the country (PEIXOTO et al., 2006).

According to VILLAS BOAS and SOUZA (2008), the expectation of great productions with the use of fertigation can be frustrated if the executor does not present knowledge to act adequately.

RAVIKUMAR et al. (2011) described that areas of knowledge such as irrigation system, fertilizer sources, vegetal physiology, nutrition, soil fertility or characteristics of the substrates are essential so it is possible to achieve a high productivity. Still according to VILLAS BOAS and SOUZA (2008), a very common mistake is the application of fertilizer in excess and the use of "recommendation packages", without taking in consideration soil analyses and climate conditions of the local where the fertigation is being performed.

Over the past few years, it was found an increase in terms of companies and options regarding fertilizers, with adequate characteristics for fertigation. Although the current legislation about fertilizers do not contemplate aspects of solubility and pureness, essential to the use in fertigation, several companies started to provide more purified fertilizers and at more competitive costs. The products found in the market are simple fertilizers or mixture (formulated) (VILLAS BOAS and SOUZA, 2008).

There are different sources of fertilizers used in fertigation, and each product must be chosen in function of the irrigation system, the culture, the soil type, the solubility of the product and its cost, whereas the fertilizers to be used in fertigation can be liquid, commercialized in solution ready for application, or solid, that must be dissolved before the application and present high solubility, in order to avoid clogging in the emitters and differences on the applied concentration. The pureness of the fertilizer can interfere on its solubility in water, since it is calculated from pure products and the tabulated values must be applied only to fertilizers with high degree of purity (MANTOVANI et al., 2006).

The fertilizers rich in nitrogen, potassium and micronutrients are, majorly, soluble in water and do not present problems of usage. Whereas for the phosphorous, for being majorly insoluble in water and present slow availability, when applied in the soil, are more problematic to be used in fertigation. Although there are some soluble phosphorous fertilizers, such as the ammonium phosphate, some of them presents danger if used with water with high level of calcium, because there can be precipitation, such as calcium phosphate, which is insoluble, leading to obstructions in the pipes and emitters (PINTO, 2001).

In Table 1, we listed the main traditional fertilizers used in fertigation and its characteristics.

Fertigation on cultivation in soil

In conventional cultivation systems, the soil quality is critical, being conditional when it is aimed to achieve maximum productivities. This must be aerated, have good water retaining capacity, rich in nutrients and free of pathogens. Many times there is no availability of soils with these characteristics. To PAPADOULOS (1991), too sandy soils have low capacity of water retaining and nutrient absorption, and a bad formation of wet bulb, when irrigated by dripping. Whereas soils considered clayey hinder

Table 1. Main traditional fertilizers used in fertigation and its characteristics.

Fertilizers	N (%)	P (%)	K (%)	Other Nutrients (%)	Solubility (g L^{-1} – water 20°C)	Acidity / alkalinity index
Ammonium Nitrate	33.5	-	-	-	1180	62
Calcium Nitrate	15	-	-	20% Ca;	1220	-20
Ammonium Sulfate	21	-	-	24% S	710	110
Urea	45	-	-	-	1030	71
Potassium Nitrate	13	-	44	-	320	-115
Phosphoric Acid	-	54	-	-	460	110
Monoammonium Phosphate	11	60	-	-	380	58
Monopotassium Phosphate	-	51	33	-	230	0
Dipotassium Phosphate	-	40	53	-	1670	-
Potassium Chloride	-	-	60	-	347	0
Potassium Sulfate	-	-	48	16% S	110	0
Magnesium Nitrate	11	-	-	9% Mg	720	
Magnesium Sulfate	-	-	-	9.5% Mg; 12 % S	710	-

Source: CAMACHO FERRE (2003); TRANI et al. (2011).

the water drainage. The two types of soils can be artificially improved with the addition of organic matter or drainage systems, for example. What is expected in the end is to provide a way of cultivation with a certain balance between air, water and nutrients, which will ensure the good development of the plant.

Only with the knowledge of the chemical and physical conditions of the soil it is possible to use the fertigation in conditions compatible to the local reality. JADOSKI et al (2010), highlight among the main aspects the pH, electric conductivity, levels of exchangeable calcium and magnesium, organic matter and capacity of cation exchange (CTC), besides textural characteristics. MANTOVANI et al. (2003) also add the importance of the availability of the water retaining curve in the soil.

One of the main problems on handling the soil with the use of fertigation is the salinization. It naturally occurs mostly in semiarid regions all over the world, due to the climatic conditions and irrigated agriculture. The water quality or salt excess in the soil solution increases its osmotic pressure, being able to reach a level where the plant will not have sufficient force to overcome it and absorb water, even in apparently wet soils (physiological drought). Depending of the salinity degree, the plant can lose water to the soil, in an action called plasmolysis, and it occurs when a highly concentrated solution is put in contact with the vegetal cell (DIAS and BLANCO, 2010).

The application of nutrients with the irrigation without adequate handling makes the fertigation a potential system for the growth of areas with high salt concentration. Several are the negative effects of salinization, being able to affect even the soil structure, because high levels of sodium cause the dispersion of clay fractions, decreasing its permeability. For this reason, it is estimated that about 10 million acres throughout the world are abandoned annually due to salinization (LIMA JUNIOR and SILVA, 2010).

Fertigation with the use of substrates

With the modernization and expansion of protected cultivation systems over the past few decades of the XX century, the plant cultivation has been changing the traditional system, from the use of soil to without soil, based on other ways of cultivation and with the use of fertigation (DIAS et al., 2005). To ROMANINI et al. (2010), this change, associated with the protected cultivation, aims to achieve higher qualitative and quantitative yields, standardizing cultivation techniques and decreasing the environmental impact. The intensive cultivation, with the use of plasticulture, substrates and fertigation is an alternative to the traditional techniques of cultivation, due to a better control that is possible to have from the inputs (BERJON and MURRAY, 1999), also being an option for producing in regions where the soil is not appropriate for cultivation (NICOLA et al., 2005; MIRANDA et al., 2011).

Besides the difficulty on the expansion of cultivation areas, the soil, frequently, presents limiting conditions that prevent good agronomic results. For this reason, the practice of substituting the natural soil by substrates of various origins is becoming common, due to the possibility of overcoming some nutritional and hydro-physical limitations and, reaching a situation next to ideal for the plant's development (MARTINEZ and ROCA, 2011).

The production by this method became important for the agribusiness in Brazil, which ended up driving the substrate industry to develop products according to the new demand, increasing the production scale and the search for new sources of raw material to meet the market (KÄMPF, 2004). MARTINEZ and .BARBOSA (1999) highlight the importance of sources such as turf, coal, sawdust, rice husk, tree bark, coir, bagasse, pearlite, among others, whose use scale depends on the culture specificities and local availability.

According to KAFKAFI and TARCHITZKI (2011), the chemical properties of the substrates interfere in the fertigation regime, since the substrates of organic and mineral origins have very different characteristics. Inorganic and inert substrates have very low CTC, with decreased buffering capacity and, most times, are not able to provide any kind of nutrient, making the plants to require a fertigation similar to the hydroponic systems; conditions on which the fertilizers and doses must be thoroughly balanced and provided.

PEREIRA and MARTINEZ (1999) describe that substrates of organic origin have colloidal properties that guarantee a high CTC and a more stable pH. However, the interaction between water and substrate will only provide a partial control over the solution composition. This can be an advantage, because this type of mean of culture is capable of maintaining certain nutrient concentrations during system fails. ANDRIOLO et al., (2009), emphasize that for this reason, it is common the association between substrates of organic and inorganic origin, in a way that it is possible to obtain vantages from each of them.

Considerations about the Fertigation management and the salinization process

The solute concentration, applied via fertigation, is considered an indispensable factor for the development and productivity of the cultures and, according to DIAS et al (2003), it is a preponderant factor to aggravate the salinity problems of the soils. To ABRAHAO et al. (2011) the irrigated agriculture can modify the water balance of the local and have influence over the water and soil qualities, being the most relevant problems the water and soil salinization, and the water contamination by nitrates. YANG et al. (2007) consider that probably one of the most important sources of diffuse contamination is the nutrient loss by superficial outflow and leaching.

The intensive cultivation system and the inadequate handling practices are considered the main sources of salinization and contamination by nitrates (DARWISH et al., 2011). According to BRAVO et al. (2011), the nitrate leaching is normally associated with excessive application of nitrogen and water. VÁZQUEZ et al. (2006) report that the continuous application and without control of the irrigation, normally conducted in vegetables in the establishment of the cultures, to guarantee the survival of the seedlings, usually causes the nutrient leaching beyond the wet bulb and, consequently, can lead to water contamination by nitrates.In relation to the risks of leaching and salinization, GARCÍA-GARIZÁBAL et al. (2009) verified that an adequate handling of the irrigation can significantly decrease the quantities of lost salts and nitrates. GHEYSARI et al. (2009) stated that it is possible to control the levels of leached nitrate from the root zone with an adequate handling of the irrigation and fertilization. LIANG et al. (2014) and CUI et al. (2010) demonstrate that in some cases it is possible to decrease the nitrogen fertilization without damages to the production, though the balance point is very delicate.

BRAVO et al., (2011) considered that for an efficient handling of the nitrogen, it is necessary to conduct the fractionated application, according to the necessities of each development phase of the culture, and also, it must be considered the availability of nitrogen in the soil, mineralization of organic matter and biological fixation.

The fertigation, similar to the conventional mineral fertilization, can salify the soil (DUARTE et al., 2007). The phenomenon of salinization has been increasing throughout the world, mainly in arid and semiarid regions, due to climatic conditions or, according to VILLAS BÔAS et al. (2001), to irrigation without the adequate management. DIAS et al., (2005) and SILVA et al., (2007) corroborate that the salinization can come from the use of already salty water for fertigation, however, the increase of salinity in most cases is due to the excess of fertilizer, when there is no precipitation and to high temperatures.

The process of salinization, which consists on the accumulation of soluble salts in the root portion of the soil, can be due to the soluble salts present in the irrigation water, the ascent of salts present in the soil by the process of evapotranspiration, or, more commonly, to both, making the salt to deposit in the root zone (JADOSKI et al., 2010). To SILVA et al. (2007), besides the characteristics of the soil and of the soluble salts applied, the salinization is accelerated by the use of water with high level of chlorides, sulfates, carbonates and sodium bicarbonate, calcium and magnesium and of sources, without taking in consideration the qualitative properties of the water. According to DIAS et al. (2006) and SILVA et al (2013), waters of this nature can cause toxicity to the plants and physically weaken the soil, accelerating the soil degradation.

SILVA et al., (2013) highlight that the effects of excessive accumulation of soluble salts over the plants can be caused by difficulties of water absorption, specific ion toxicity and by the interference of salts in the physiological processes (indirect effects), reducing the growth and development of the plants. To FAGERIA (1998), the adverse effect of the salinity on the absorption and utilization of nutrients is related to the increase of the osmotic pressure in the soil solution, with the accumulation of certain ions in the vegetal tissue, in toxic concentrations and reduction on the root system growth. DIAS et al. (2003) emphasize that the negative effects of salinity are directly related to the growth and yield of the plants and, in extreme cases, on the total loss of the culture.

In order to identify soils that were affected by salts, there is a series of observations and studies in the area, such as the observation of visible characteristics in the field and the conducting of analyses, which involves laboratory and field methods (D'ALMEIDA et al., 2005). Each method presents advantages and disadvantages, whereas the use of extractors per porous cup is, currently, one of the most recommended, aiming the good relation cost/precision of the method (SILVA et al., 2000), and also, due to the fact that the CE obtained by this method demonstrates the real conditions on which the plant develops (DIAS et al., 2005). The monitoring of the soil CE in this production system becomes essential, allowing adequacies that prevent the occurrence of salinization processes of the soil and losses on the quality and quantity of the production (QUEIROZ et al., 2009).

The concentration of the solution applied on the fertigation is a factor that has great influence on the development and production of cultures (FARIA et al., 2009). The recovery of soils affected by salts has as main objective the concentration reduction of the soluble salts and the exchangeable sodium in the soil profile, at a level that does not damage the development of cultures. The decrease of the salinity level involves a process of solubilization and the consequent removal by percolating water, while the reduction of the exchangeable sodium level involves its displacement from the exchange complex by the calcium, before the process of leaching (BARROS et al., 2004).

The total salinity of the soils is a result of the sum of the irrigation water, the fertilizer solution and the residual salinity of the soil, however, the CE may not present good correlation with the sum of salts, in function of the different elements present and its properties (FARIA et al., 2009). BURGUEÑO (1996) emphasizes that when the electric conductivity of the soil solution presents inferior values to the maximum tolerated by the culture, without decrease on the relative yield, and superior to the maximum necessary for its nutrition, the salinization is understood as controlled.

The fertigation management is conducted through prearranged quantities of fertilizer, parceled according to the culture and, normally, there is no monitoring of the concentration of ions on the soil solution, neither of the nutritional state of the plant (JADOSKI et al (2010). Thus, it is more viable to rationalize the fertigation management by determining the electric conductivity and/or the partial concentration of ions on the soil solution (BARROS et al., 2012). DIAS et al., (2007) describe that one of the methods used to help on the experiments with fertigation handling and the plant's tolerance to salinity is the method of artificial salinization curves of the soils by adding an excessive volume of fertilizers.

Each plant species has variable tolerance levels regarding the salinity, which predisposes necessity and handling of the salt leaching in the soil to be specific for each culture (FOLEGATTI and BLANCO, 2000). DIAS (2003) highlights that the salinity must be thoroughly controlled, though when it exceeds the culture tolerance threshold, it is necessary to take drastic measures, such as stopping the cultivation temporarily and initiate the process of salt removal by recovery practices involving essentially drainage. In this sense, BARROS et al. (2012) alert that the irrigation system associated to the drainage for washing the soil when necessary is a fundamental tool on the salinity control in irrigated areas, though they also point out that the process requires criteria, because the drainage can carry contaminants that end up damaging the quality of the water bodies and restraining its future use of water resources.

In a general context, it is observed that the use of fertigation in crops is considered as a handling process that gauges advantages to the irrigators. However, it is common to have salinity problems and nitrate leaching that cause reduction of the production and loss of the productive potential of the soil. This way, it is evident that the use of fertigation must always be conducted with handling criteria that reduces the risks of salinization, keeping the productive potential high.

Concluding remarks

The fertigation is a management alternative for irrigated cultivation that offers the advantage of providing higher control of the fertilizer use, enabling the fractionated application according to the culture needs on different stages of the cycle;

Although it is a recent technique in relation to irrigation, the fertigation has been demonstrating to be one of the most efficient ways of using water and inputs with capacity of generating greater productivities for the culture, being currently most used in vegetable and fruit cultivation.

Though it may be considered as an efficient tool on modern agricultural management, the fertigation must be used with control criteria in relation to the offer and extraction of the used salts, due to the risk of occurrence of soil salinization and nitrate leaching, with potential risk of contaminating the underground areas.

The use of fertigation, whether in soils or in substrates, requires a greater technical knowledge of plant nutrition and soluble salts handling. Besides, for the production of substrates, it is important to highlight the importance of the use of adequate material regarding water retention and availability of invested nutrients, and mainly that they are derived from renewable sources, following patterns of environmental sustainability.

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