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Fertigation in fruit crops

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Abstract
The most effective way to use fertilizers and water is through fertilization. Addressing the vital root zone and so reducing the wetting area, it enables optimal water and nutrient utilization. The cost of both irrigation and fertilizer administration is decreased by incorporating fertilizer into drip irrigation. Fertigation also reduces the amount of nutrients lost through leaching. In this review, various fertigation-related elements are examined, including how it affects fruit quality, yield, development, and soil and leaf nutrition content. In terms of equivalent or higher growth, production, and quality fruit production, microbial enrichment, antioxidant activity, and attaining significant cost savings, it clearly specifies the benefits of the method of fertigation above standard soil fertilization technique.

Keywords: Antioxidant, fertigation, fertilization, quality, NUE, growth, yield

Introduction
Fertigation, is the combined application of irrigation as well as fertilizers in order to establish for measured nutrient release method that meets the needs of crops for both water and nutrients through their development stage while considerably reducing nutrient leaching losses. This approach enables the direct delivery of nutrients at the location of the rhizospheric area and in accordance with crop needs (Sandal *et al*., 2015) [1]. In addition to its poor nutrients and water use efficiency, the conventional method of fertilizer and irrigation treatment has had a negative impact on the soil health and quality of output. The fertigation enhances fruit quality while potentially lowering crop costs. The most crucial inputs that directly impact the growth of plants, development, yield, and quality of produce are irrigation and fertilizers. While fertigation ensures that fertilizers are supplied directly into the location of the active root zone, nutrients applied via the broadcasting approach are ineffectively utilized by plants. Fertigation has enormous potential for more precise and timely crop nutrition, resulting in higher yield and quality as well as significant fertilizer cost savings. Therefore, fertilization is required to boost output and fruit quality. In the peach production system, fertilization has allowed for up to 40% water and 30% fertilizer savings. Some of the main causes of low fruit yield include inadequate nutrition management and a lack of guaranteed irrigation water. When treated using standard ways, the plants under these circumstances do not adequately utilize the available nutritional levels. However, the advantages and disadvantages are mentioned in Figure 1.
Nitrogen is the nutritional ingredient that drip irrigation systems use the most frequently. It is frequently applied as urea/ammonium salt, which increases fruit yield and quality. There aren't numerous studies on nitrogen fertigation by drip systems in peach, plum, cherry, and apple (Ganeshamurthy *et al*., 2019) [2]. Apart for ammonium sulphate (NH_4SO_4), which may result in the resulting precipitation of calcium salt ($CaSO_4$) in hard water, all nitrogen fertilizers are generally appropriate for drip fertigation. Since urea is very soluble, degrades and does not interact with chemicals in the water that makes it as ideally suited for injection by irrigation. Since nitrate salts are typically soluble, drip irrigation is a good application for them.

Effect of Fertigation on Growth
The use of drip irrigation was used to apply nutrients, which not only helped conserve water but also had a favorable impact on plant height, canopy coverage, and its girth. Comparable yields between soil fertilization at 100% of the authorized dose and fertigation at 60% of the acceptable dose indicated that fertigation can save up to 40% on nitrogen.

Apple fertigation produced the best results in terms of improved growth of shoot, bud formation, fruit sets, and cumulative yield (Singh *et al.*, 2017) [3]. Increased-shoot growth was induced by fertilization along with an overabundance of axillary floral buds that dispersed, leaving bare, unproductive wood.

The effects of several fertilization methods on apricot trees (cv. Hacihaliloglu) cultivated in Malatya, Turkey, included nitrogen (N), phosphorus (P), and potassium (K). High N treatment boosted yield, average fruit weight, and vegetative growth, but it decreased total soluble solid content. K fertilization increased total soluble solids and yield but had no effect on vegetative development. Treatments with high levels of phosphorus increased output while slowing vegetative growth. The most effective fertilization rate for apricots (cv. Hacihaliloglu) was determined to be 96-64-256 kg ha^{-1} NPK based on yield, vegetative growth, and fruit attributes (Sharaf MM *et al*., 2015) [4].

The effectiveness of NPK administration through the fertigation process on the development traits of apple cv. Red Chief was investigated in a research study. In regard to shoot length, plant diameter, number of leaves plant, leaf area, fresh weight, and dry weight of leaves, the entire dosage of NPK through drip irrigation produced the greatest vegetative growth of plants was recorded (Corrêa *et al*., 2018) [5].

Efficacy of Fertigation on Quality of Fruits

The findings of numerous experiments showed that drip irrigation and fertigation enhanced watermelon yield more than standard surface watering and fertilizer application to the soil. Watermelon yield was decreased by inadequate irrigation, while the amounts of TSS, lycopene, and ascorbic acid were unaffected. The recommended fertigation amount for watermelon for open precision farming is 70:50:120 NPK ha^{-1} (Khalifa *et al*., 2020) [6]. The plots fertigated with calcium nitrate showed a modest rise in the amount of calcium of apple fruits, but this had no effect on firmness or storage behavior (Motesharezadeh *et al*., 2021) [7]. After fertigation, it was typical to find greater nitrogen concentrations in leaves and fruits, which prevented the appearance of skin colour.

In Navel oranges, total seasonal nitrogen treatment early in the growing season led to quicker fruit maturity or higher fruit size. Both the soluble solids and acid levels in Valencia oranges were decreased by fertigation. Comparing the use of partial fertigation to the use of dry fertilizer alone, little difference was shown in fruit output. The process of fertilization led to improvements in fruit quality, leaf mineral content, chlorophyll content, phytochemical effectiveness, photosynthesis and nutritional status. Combining these two treatments increased fruit yield per square meter of canopy as well as N, P, K, and other fruit quality indicators.

Effects of various fertigation and soil fertilization rates on strawberry (*Fragaria ananassa* Duch.) growth, fruit quality, yield, and leaf content of nutrients were studied where the findings showed that fertigation with the suggested NPK dosage significantly increased the plant's height, leaf area, and yield of fruit when compared with fertigation with the 1/2 and 1/3 of the recommended NPK dose and soil fertilization, but was found to be comparable to 3/4 of the recommended dose of NPK fertilization treatment. In fertigation with the full advised dose of NPK, the maximum fruit length, fruit breadth, and fruit weight were additionally recorded (Kachwaya *et al*., 2015) [8]. Additionally, the plants that had received the full dose of NPK fertilizer had leaves that were 60% more nutrient dense than those that had only received soil fertilization.

Effect of Fertigation on Leaf Nutrient Status

Pineapple development in response to NPK fertigation with or without mulching showed that all treatments had significant effects by varied amounts of fertigation. In terms of production and other biometric parameters in main and ratoon crops, complete RDF through fertigation and mulch performed better than 80% RDF through fertigation and mulch. In regards to growth and other vegetative parameters in pineapple crop, it is established that fertigation done at 80% RDF with mulching can generate results comparable to those obtained from 100% RDF treatment using drip fertigation or soil without mulch (Reddy *et al*. 2017) [9].

This study will be conducted in the Kemantren Village, Tulangan District, Sidoarjo Regency, from July through September 2020, with the goal of determining the impact of N fertilizer on the quantity of chlorophyll and the nutritional value of tomato fruit (*Lycopersicon esculentum*). Through the use of a randomized block design, the experiment was set up in a single factor. Analysis of variance will be used to test the research data, and if actual or very real results are found, the 5% BNJ test will be run. The findings demonstrated that all observation variables, including total chlorophyll (mg/l), vitamin C content (%), fruit weight (g), fruit volume (ml), fruit hardness (Pa), and the number of fruits per plant, could not be accurately predicted by the dosage utilized for N fertilizer.

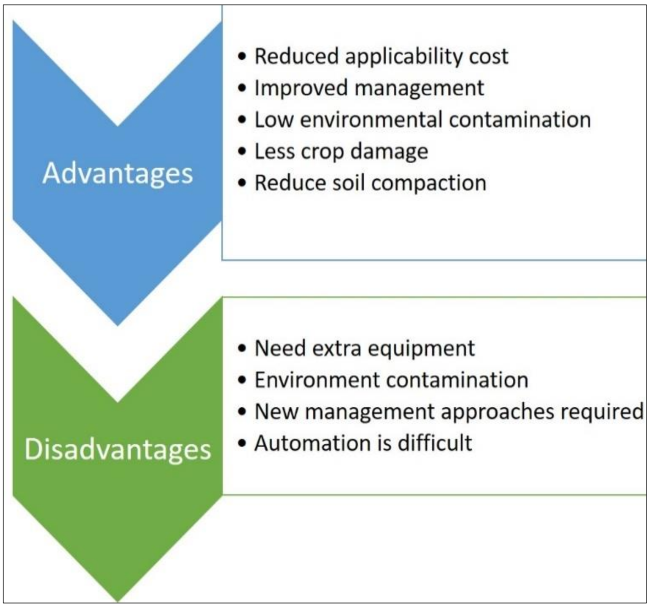

Fig 1: Advantages and Disadvantages of fertigation Effect of Fertigation on Soil Nutrient Status

In comparison to no fertilization, fertilization increased the amount of P, N and K that was accessible in the soil. When RDF was applied in full, the levels of P, N and K in the soil tended to rise. It is possible to speculate that the large change in the mineral content of the soil over time at various irrigation rates, especially at 75% and 100% of RDF, aids in the accumulation of nutrients. It can be said that, when soil N levels were higher, N treatment via drip fertigation had a greater impact on copra output than soil application via the ring basin approach did. As a result, fertigation can sustain soil nutrient availability at a higher level than soil application of fertilizers using flood or ring basin irrigation. Fertigation makes it possible to apply fertilizers consistently and more effectively (Das *et al*., 2015) [10]. As has already been documented for onions, the fertigation method keeps the applied nutrients as well as water in the root zone of coconuts, which raises the soil's nutrient status. Split-dose fertilization combined with drip irrigation in coconuts reduces N and K leaching losses, promotes P fixation in the soil, and raises soil nutrient levels.

The spatial distribution arrangement of the available P and potassium in arecanut was examined using an experiment that included varying fertilizer treatment rates and frequencies. The amount of P and K was observed to be at its highest at the dripping position and tended to gradually decrease as distance increased from the dripping point. Similarly, the largest quantities of minerals were discovered below the emitter in an additional experiment on the dispersion of nutrients under drip irrigation in olives, particularly in the 0-20 cm range.

Effect of Fertigation on Soil Microbial Activity

When different quantities of N fertilizer were applied over an extended period of time, distinct numbers of soil bacteria OTUs fell in response. Wheat yields were also strongly connected with the average relative richness of Patescibacteria and Bacteroidetes. It was discovered that short-term N fertilizer input affected the prevalent bacterial species by changing the soil NO_3 concentrations (Zhang *et al*., 2021) [11]. By altering the pH of the soil, long-term N fertilizer can have a considerable impact on the majority of the dominant soil bacterial species. A long-term N fertilization-induced fall in soil pH can be detected by the abundance of actinobacteria. Additionally, we discovered that the soil environmental variables we studied (pH, C/N ratio, and NO_3) and the N fertilizer appeared to have no impact on the microbial communities in the phyla Proteobacteria and Gemmatimonadetes.

The requirement for more food must be met by higher food production, which requires greater fertilizer application to agricultural regions to maximize crop yield. In this regard, various fertilizing techniques found favour with farmers. We looked examined the impact of the three primary types of fertilization-conventional, organic, and biological-on the variety, activity, and community makeup of soil microbes. Studies show that using inorganic fertilizers too frequently reduces soil pH, changes soil osmolarity, damages soil, interferes with the taxonomic diversity and metabolism of soil microbes, and promotes the accumulation of extra elements in the soil, particularly phosphorus (P). Contrarily, organic fertilizers boost the amount of organic carbon (OC) in the soil, which greatly promotes the development of heterotrophic bacteria (Zhaoxiang *et al*., 2020) [12]. Application of organic fertilizer vermicompost increases soil's general microbial population by giving plants and bacteria readily available nutrients. Most recently, the utilization of beneficial bacteria as biofertilizer in the soil has caught the attention of experts due to their importance in long-term environmentally friendly agriculture. Research showed that biofertilization has a positive impact on the soil's microbial Shannon, Chao, and ACE diversity indices. An extensive analysis of the literature led to the conclusion that while each of the three fertilization techniques has a unique manner of providing nutrients to the soil, biofertilization ensures the long-term viability of croplands. When combined with organic fertilizers, it improves soil quality for microbial activity and growth, increases microbial diversity, and supplies micronutrients to the soil for a longer period of time.

Effect of fertigation on antioxidant enzymes

The production of crops is hampered by a number of environmental factors. Among these instances, salt stress is a major factor in reducing the growth as well as yield of agricultural crops that are significant commercially. Exogenous fertigation of mineral and vitamin compounds, however, might be used as a "shot-gun" strategy to counteract the negative effects of salts found in the rhizosphere. In order to measure the impact of aerial fertigation of zinc (Zn) and ascorbic acid (vitamin C) on the physio-biochemical characteristics of barley (*Hordeum vulgare* L. Genotype B-14011) cultivated in a saline environment. While there was a considerable increase in Na^+ and Zn^{2+} during salinity stress, there was a significant reduction in biological yield and a decline in chlorophyll pigment. Likewise to the way the activity of antioxidative enzymes (SOD, POD, CAT, APX, and proline) were dramatically increased under salinity stress, so were the levels of total soluble proteins, total free amino acids, lipid peroxidation, and H_2O_2 (Ashraf *et al*., 2019) [13]. Additionally, salinity had a deleterious impact on plant ion uptake and yield parameters. Foliar fertigation with Zn, on the other hand, improved harvest index, photosynthetic pigments, synchronized ion absorption, enzymatic and non-enzymatic antioxidant synthesis, and vegetative development. This study suggests that the effect of foliar fertigation with the AsA+0.03% Zn combination increased salt stress tolerance as well as yield characteristics, which will help to increase the yield of barley seeds and is a step toward addressing the issue of malnutrition through agriculture.

'Skeena' and 'Cristalina', two varieties of sweet cherry, were studied to determine the impact of irrigation frequency and phosphorus (P) the fertigation process on the quantities of phenolic substances present. The impact of various irrigation and fertilization practices on phenolic component levels yielded less encouraging results. Both extreme and modest water stress did not appear to have a significant impact on cherry' rising phenolic component levels. Furthermore, the lowest annual concentration of phenolic compounds and a decrease in fruit size that was unacceptably small economically were both related to 2012's extreme water stress. Phosphorus fertigation improved the phosphorus status of cherries by steadily raising leaf and fruit P concentrations, however, these fruits had decreased phenolic content (Ross *et al*., 2018) [14].

Conclusion

According to the findings of this study, fertigation increased growth and production while using around 30% less irrigation water than standard fertilization. Some of the main obstacles preventing the widespread use of drip irrigation technology in the nation are a high initial investment and the average Indian farmer's relative lack of technical proficiency. However, growing water shortages and rising fertilizer costs could encourage more widespread use of this technology, particularly in fruit crops.

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