Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(5): 2557-2560
Received: 02-06-2020
Accepted: 08-07-2020

Govindu Chinnari Sravani
M.Sc. Research Scholar, School of Agriculture, Lovely Professional University, Punjab, India

Lakhwinder Singh
M.Sc. Research Scholar, School of Agriculture, Lovely Professional University, Punjab, India

Manish Bakshi
Assistant Professor, Department of Fruit Science, School of Agriculture, Lovely Professional University, Punjab, India

Corresponding Author:
Govindu Chinnari Sravani
M.Sc. Research Scholar, School of Agriculture, Lovely Professional University, Punjab, India

Performance evaluation of drip irrigation (fertigation) in citrus cultivation: A review

Govindu Chinnari Sravani, Lakhwinder Singh and Manish Bakshi

DOI: https://doi.org/10.22271/phyto.2020.v9.i5aj.12726

Abstract
Efficient use of water and nutrients is required to accomplished sustainable production. The efficient utilization of these inputs need an integrated approach to promote the techniques of nutrients and water management among farmer to achieve the quality and quantity production. This study aims at reviewing the effect of drip irrigation and fertigation in citrus. Water scarcity is one of major problem of citrus cultivation in India. Among the different methods of irrigation, drip irrigation is most efficient form of application of irrigation to the crops which supplies water at optimum time to root zone and increases the growth, yield and quality of crop. Drip irrigation helped the cultivation of plants more profitable than compared to normal traditional watering of plants and increase the water use efficiency (WUE) in agriculture. As the citrus is more water loving crop, installation of drip would be more helpful in a increasing yield as well as gaining fruitful income. Drip irrigation can also be used for the fertigation and increases the nutrient use efficiency (NUE). However, it also delivers many other economic and social benefits to the society. In this article, intensive research works regarding water and nutrient management for citrus has been reviewed and discussed so that a definite perception may be generated for the farmers as well as future researchers.

Keywords: Citrus, drip irrigation, fertigation, growth, yield, quality

Introduction
Citrus generally belongs to the family Rutaceae and is one of most important sub tropical fruit crop cultivated in the world. Citrus is grown across the 146 countries which is highest among the fruit crops. In India few species, such as grape fruit, lemons, limes, sweet oranges, and mandarins are commercially cultivated. Citrus fruits are rich in multiple nutrients such as vitamin C, flavonoids and fiber, reduce inflammation, improve gastrointestinal function and health (Annanekrich, 2020). Citrus is a highly irrigated crop and due to the evergreen perennial nature, it requires water as well as nutrients all the year for greater yield and productivity. The deficiency of water and nutrient in any phase of the harvest reduced the yield and nature of organic products definitely. Water shortage is one of significant worry in the citrus developing districts of the world. The utilization of water and manures through the conventional surface water system is usually adopted in citrus (Singh and Srivastava, 2004) [25]. This leads to substantial loss of nutrients from the rhizosphere zone of the plants due to conventional irrigation techniques which also leads to the contamination of water in surface as well as ground water (Hanson *et al.*, 2006). The ideal utilization of water and manure to increase the crop yield and fruit quality is one of major concern of today criticultural system (Shirgure, 2012) [33]. It is expected that natural sources of water will exhaust soon, so there is a urgent need to adopt the technologies which can save on water use especially in crops. Drip irrigation is a novel approach developed all over the world has given a new way of judicious and efficient use of water which has been a revolution in the horticultural and other crops. This system has been adopted in about thirty five countries out of which India ranked seventh in terms of acreage. Drip irrigation, also synonymous as micro irrigation or trickle irrigation, relies on application of water to the rootzone of the plants usually in the form of droplets. Drip irrigation generally uses less than half the water of furrow irrigation and had higher efficiency exceeds 90%. Drip irrigation does not wet the entire surface of the soil and often preferred over other irrigation methods because of the high water-application efficiency reduced losses, surface evaporation, deep percolation without wetting the plant surface thus making conditions less favorable for many diseases. For appropriate use of composts, fertigation for example application through fluid or dissolvable composts through dribble water system can supplant soil application. The water solvent manures can be utilized for fertigation for improving the yield and quality.

The measure of manure applied through the fertigation at any time is small and particularly around the root zone to meet the crop nutrient demand which improves the quantity and quality of crop. The trickle water system and fertigation has better water and manure use proficiency just as well as different focal points like sparing in labor, water and power, greater orchard uniformity, better soil water plant relationship, rooting environment, better yield and quality in citrus. Besides these advantages the main issue realted to drip irrigation is the economic viability and the farmers are often reluctant to adopt these methods due to their weak resource base. This review is aimed at summarizing the efforts of researchers in highlighting the effects of drip or trickle irrigation and how it affects the growth, quality and yield attributes in citrus species.

Impact of trickle water system and fertigation on vegetative growth and development:

Fertigation is an important aspect of fruit culture in current scenario. Fertigation not only ensures savings on irrigation water but also ensures prolonged availability of fertilizers in the root zone thereby enhancing the performance of the plant. Kinnow mandarin is a nutrient responsive crop and application of 120% recommended dose of fertilizers (600:288:288g/plant/year) through fertigation method ensures enhanced growth characters in Kinnow mandarin crop (Sinha *et al.*, 2019). Kinnow plants supplied with fertigated nutrient solutions responded with increased plant height, stem girth, canopy volume and yield under high density planting system as compared to 100%, 80%, 60% of RDF. *Citrus sinensis* cv. Mosambi showed significant effects on phenology and physiology of the plants when supplied with fertigation levels such as 120%,100%,80%,60%,40% RDF (Nirgude *et al.*, 2016). Fertigation with 120% RDF had significantly higher plant height, trunk girth, canopy volume, leaf area index and growth of present season shoot. The tree physiological parameters *viz*. total chlorophyll (2.65 mg/g), net photosynthesis rate (6.83 µmol CO_2 / m^2/sec), stomatal conductance (0.18 mol/m^2/sec) and area of leaf (31.9 cm^2) were also higher under 120% RDF through fertigation. Drip irrigation at 90% ER (effective rainfall) and fertigation level of 80% RDF had significantly maximum plant height, plant spread, and canopy volume as compared to other irrigation and fertigation levels in sweet orange (Jogdand and Jagtap, 2018). Fertigation with 100% RDF in *Citrus sinensis* had significantly higher plant height (0.61 m), stem girth (5.51 cm), plant spread (0.63 m) and canopy volume (12.59 m^3) as compared to the soil application of RDF (Goud *et al*., 2017). Trials on *Citrus nobilis* at Ahmednagar to evaluate the combined effect of nutrient levels at different level of irrigation confirmed that drip irrigation at 90% ER and fertigation with 80% of RDF recorded significantly maximum plant height (4.54 m) and canopy volume (34.87 m^3) (Dalal *et al.*, 2019). Higher leaf area per cm^2 was observed under drip irrigation in Kagzi lime at 100% ET as compared to the basin method of irrigation (Balaganvi and Kumathe, 2004)

Impact of trickle water system and fertigation on yield

Yield of a fruit plant is directly correlated with availability of irrigation and nutrients. Physiologically, nutrients help in synthesizing fruit tissues and irrigation plays a pivotal role in cell expansion thereby leading to increase in size. Also moisture stress is related to flower and fruit drop in fruit crops especially in citrus which is a very sensitive fruit crop. Nagpur mandarin, the premier mandarin of India reported to have achieved 65% more yield over basin irrigation with band placement of fertilizers (Panigrahi and Srivastava, 2017). Drip irrigation keeps the root zone moist thereby limiting any stress signals that might originate from moisture stress. Drip method of irrigation produced significantly higher yield, higher number of fruit per plant, fruit retention percentage and fruit weight in Mosambi sweet orange as compared to the basin method of irrigation (Ghosh and Pal, 2010). Significant higher fruit yields to the tune of 150 kg/plant were achieved under drip irrigation system in Kinnow orchard as compared to the 115 kg/plant achieved in conventional irrigated orchard (Bhagat and Yadav, 2019).

Acid lime, a heavy bearing citrus responds well to rhizoshpere moisture saturation. 90% RDF as fertigation at 1005 ET in acid lime cv. Phule Sharbati resulted in maximizing growth and yield (Taru *et al.*, 2020). Response of Sweet Orange cv. Sathgudi was studied over a period of 8 years to precisely determine the effect of nitrogen and potassium fertigation on growth, yield and quality of fruits borne by the plant (Ramana *et al.* 2014). Fertigation with 75% RDF of N and K had significantly higher number of fruits per tree and final cumulative fruit yield. Fertigation to compensate the evapo-transpiration was tried in Kinnow mandarin plants (Desai *et al.* 2014). Maximum fruit yield was observed at 80% of ET and 700 g K/plant/year. Different drip irrigation regimes and RDF levels were tested for growth, quality and yield analysis in Kinnow mandarin (Sharma, 2017). The interaction of 0.8 volume of water and 80% RDF through drip irrigation recorded significantly highest number of fruits per plant (515.9) and yield per hectare (258.7 quintals). In sweet orange, maximum fruit yield (14.18 t/ha) was observed with the drip irrigation scheduled at 90% ET combined with 70% RDF fertigation with saving of 10-30% in water and fertilizers (Lakashmi *et al.*, 2019) [21]. Grape fruit is another important member of citrus family in which fertigation has been evaluated for yield and yield components with four treatments *viz*. 50%, 75%, 100% and 125% of urea recommended dose applied through fertigation. The highest number of fruit per tree and yield was observed in 125% of urea recommended dose, while the lowest was obtained for 50% of urea recommended dose (Khalifa *et al.*, 2018). In sweet orange, drip irrigation at 90% ER (effective rainfall) and fertigation level of 80% RDF had significantly higher number of fruits, weight of fruit, fruit yield kg/plant and t/ha as compared to other irrigation and fertigation levels (Jogdand and Jagtap, 2018). Significantly higher fruit yield was obtained by fertigation with 100% RDF as compared to the soil application of RDF (Goud *et al.* 2017). Drip irrigation at 90% ER and fertigation with 80% of RDF recorded significantly highest number of fruits (286.49 fruits $tree^{-1}$), weight of fruit (238.69 g) and yield (68.20 kg $tree^{-1}$) with the substantial saving of water and fertilizers (Dalal *et al.*, 2019). Drip irrigation with 100% crop ET recorded significantly higher yield/tree as compared to traditional check basin irrigation (Balaganvi and Kumathe, 2004).

Impact of trickle water system and fertigation on fruit quality: Fruit quality is a major attribute that commands the acceptability and price in the market. Though fruit quality depends upon various factors, moisture availability coupled with nutrient management is the basics of having a good harvest. Under the All India Coordinated Research Project on Fruits at Maharashtra, evaluation of different irrigation levels and fertigation regimes was carried out on sweet orange (Hendre *et al*,. 2020) [18]. Drip irrigation with 100% ET along

with 100% RDF through water soluble fertilizers had significantly higher fruit quality parameters such as juice, TSS, higher ascorbic acid, reducing sugars, non-reducing sugars and total sugars in comparison to other different treatments. Fertigation with 100% RDF had higher juice content and TSS as compared to the soil application of RDF (Kuchanwar *et al.*, 2017). Fruit quality attributes of *Citrus sinensis* Osbeck cv. Mosambi were evaluated using fertigation and it was observed that TSS (9.40° Brix), total sugar (7.43%) and total acidity (0.33%) and other compounds of bioactive & antioxidant compounds *viz.* ascorbic acid (51.74 mg/100g), phenolics in total (156.4 µg GAE) as well as flavonoids (13.3 mg/100g) was obtained @ 120% RDF which was significantly higher than 100% soil application of RDF with drip irrigation (Nirgude *et al.*, 2016). Fertigation with 75% RDF of N and K had significantly higher fruit quality such as Juice content (38.98%), as well as TSS (9.67) and Brix and acidity (0.85%) compared to 50%RDF,100%RDF through fertigation and 100% in RDF soil application (Ramana *et al.*, 2014).

Economics of cultivation using fertigation

Economic feasibility of a process is the most important aspect of cultivation as the combined value of inputs should not exceed the output gained through cropping. Any increase in the cost of fertigation due to increased amount of fertilizer application is compensated with the increased fruit quality and cumulative yield. Laws of economics must confirm to the return structure of a process otherwise it becomes a no gain intervention. Researchers have worked on the economic aspect of fertigation also and have consented to the profitable nature of fertigation. Although it may involve higher inputs but the incremental returns in the form of high yield coupled with enhanced quality of the produce suffice the input costs. Fertigation with 75% RDF of N and K had the top C: B ratio @ 1:2.29 as compared to 50%RDF,100%RDF through fertigation and 100% RDF through soil application (Ramana *et al.*, 2014). Maximum cost benefit (B: C) ratio of 3.84 was observed in irrigation schedule @ 90% combined ER with fertigation level @ 60% of RDF as compared to remaining treatment combination (Lakashmi *et al*., 2019) [21].

Impact on Water use productivity

Drip irrigation has seen that 40.46% higher yield and higher water use efficiency (4.85 kgm^{-3}) and saves upto 55% of water on irrigation in comparison with traditional flood irrigation method of Kinnow plant (Raza *et al*., 2020). Drip fertigation results in higher yield, WUE and water productivity with the additional benefit of saving fertilizers cost and higher return than the soil application of recommended dose (Barua, 2013). With the utilization of water system level @ 80% ET and fertigation at 80% RD of fertilizers was discovered acceptable in improving water profitability and N use productivity (Goramnagar *et al.*, 2017). Impact of various water system and fertigation levels on nutrient uptake efficiency were evaluated and it was found that irrigation at 100% ET recorded significantly higher NUE (99.47, 105.9 and 102.69 kg fruit kg^{-1} N), PUE (265.26, 282.4 and 273.83 kg fruit kg^{-1} P), KUE (132.63, 141.2 and 136.91 kg fruit kg^{-1} K) which has observed to be a part with fertigation at 80% RDF (Hendre *et al.*, 2020) [18]. Higher WUE (3.9 kg m^{-3}) @ FUE (87.3 kg kg^{-1}) has been observed in drip irrigation at 75% ET and 75% RDF as compared irrigation through basin with band implication of fertilizers (Panigrahi and Srivastava, 2017).

Impact of Fertigation on Supplement up-take

Fertigation is an effective technology whereby the nutrients are made available to the plants in readily absorbable form. Total N recovery and N use efficiency is fundamentally more through dribble water system framework as contrasted with irrigation by flood system. Total recovery of N in soil plant system was 93% & 85.4% in drip irrigation (Quinones *et al.*, 2007). Individually, N-use productivity was essentially higher with drip irrigation 75.1% more with flood irrigation 62.7%. The uptake efficiency of N in the plant was significantly higher with drip irrigation (75%) than with flooding irrigation system (64%) and seen that drip irrigation systems was more effective and beneficial for improvement in water use and uptake of N from fertilizers in plants, along with reduced leaching loss. When drip irrigation system and flood irrigation systems were compared in citrus in relation to the response of trees for nutrient status, it was observed that N compost admission was 25% more prominent in trees of DI-F while contrasted with the treatment of FI-B; the fine roots and organic product produce of DIF trees aggregated 2.1 and 1.4-crease more noteworthy manure N, accordingly, while contrasted with the particular pieces of FI-B trees. They also found that Potential nitrate leaching (PNL) was more in flood irrigation (14%) as compared with drip irrigation (5%) (Belen *et al.*, 2012).

References

1. Asif M, Ahmad M, Mangrio AG, Akbar G, Memon AH. Design, evaluation and irrigation scheduling of drip irrigation system on citrus orchard. *Pak. J. Met.* 2015; 12(23):39-40.
2. Bastida F, Torres IF, Abadía J, Romero-Trigueros C, Ruiz-Navarro A, Alarcón JJ, Nicolás E. Comparing the impacts of drip irrigation by freshwater and reclaimed wastewater on the soil microbial community of two citrus species. Ag. Water Mgt. 2018; 203:53-62.
3. Battikhi AM, Abu-Hammad AH. Comparison between the efficiencies of surface and pressurized irrigation systems in Jordan. *Irrigation Drainage Sys.* 1994; *8*(2):109-121.
4. Bilal A. *The evaluation of irrigation performances for a drip irrigation system in a citrus orchard in Adana-Yakapınar district* (Doctoral dissertation, M.Sc. Thesis, Univ. of Çukurova, Institute of Science, Agric. Structure and Irrigation Dep. Adana), 1997.
5. Bucks DA, Nakayama FS, Warrick AW. Principles, practices, and potentialities of trickle (drip) irrigation. In: *Advances in Irrigation* 1982; 1:219-298. Elsevier.
6. Carr MKV. The water relations and irrigation requirements of citrus (Citrus spp.): a review. *Exp. Agric.* 2012; *48*(3):347.
7. Castel JR. Response of young Clementine citrus trees to drip irrigation, I, Irrigation amount and number of drippers. Journal of Horticultural Science 1994; 69(3):481-489.
8. Chauhdary JN, Bakhsh A, Ahmad N, Mehmood K. Optimizing chlorine use for improving performance of drip irrigation system under biologically contaminated water source. Pak. J. Agri. Sci. 2015; 52(3):829-835.
9. Consoli S, Stagno F, Roccuzzo G, Cirelli GL, Intrigliolo F. Sustainable management of limited water resources in a young orange orchard. Agric. Water Mgt., 2014; 132:60-68.
10. Cooper HJ, Smith EA, Martsolf JD. Spray irrigation effects on surface-layer stability in an experimental citrus

orchard during winter freezes J App. Met. 1997; 36(2):155-166.
11. Dasberg S, Or D. Practical applications of drip irrigation. In *Drip Irrigation* Springer, Berlin, Heidelberg. 1999, 125-138.
12. Dhawan BD. Drip irrigation: Evaluating returns. *Economic and Political Weekly*, 2000, 3775-3780.
13. Falivene S, Giddings J, Hardy S, Sanderson G. Managing citrus orchards with less water. *New South Wales DPI, Primefact*. 2006; *427*:1-10.
14. Franco L, Motisi A, Provenzano G. Identifying the threshold of soil water content for the precise irrigation scheduling of a Citrus orchard under subsurface drip irrigation. In Geophysical Research Abstracts, 2019, 21.
15. García-Tejero I, Jiménez-Bocanegra JA, Martínez G, Romero R, Durán-Zuazo VH, Muriel-Fernández JL. Positive impact of regulated deficit irrigation on yield and fruit quality in a commercial citrus orchard [*Citrus sinensis* (L.) Osbeck, cv. Salustiano]. Agric. Water Mgt. 2010; 97(5):614-622.
16. Grieve AM. Water use efficiency, nutrient uptake and productivity of micro-irragated citrus. Aust. J Exp. Agric. 1989; 29(1):111-118.
17. Harrison DS, Smajstrla AG, Zazueta FS. An economic analysis of irrigation systems for production of citrus in Florida. In: Proceedings of the Florida State Hort. Soc. 1983; 96:7-11.
18. Hendre PD, Ranpise SA, Pawar PS. Effect of different irrigation and fertigation levels on fruit quality parameters in sweet orange (*Citrus sinensis* L. Osbeck) cv. Phule Mosambi. J Pharmacognosy and Phytochem. 2020; 9(3):503-507.
19. Hoffman GJ, Oster JD, Alves WJ. Evapotranspiration of mature orange trees under drip irrigation in an arid climate. Transactions of the ASAE. 1982; *25*(4):992-0996.
20. Hondebrink MA, Cammeraat LH, Cerdà A. The impact of agricultural management on selected soil properties in citrus orchards in Eastern Spain: A comparison between conventional and organic citrus orchards with drip and flood irrigation. *Sci. Total Environ.* 2017; 581:153-160.
21. Lakashmi LM, Venkataramana KT, Shirgure PS, Srivastava AK, Patil P. Integrated water and nutrient management in Sathgudi sweet orange (*Citrus sinensis*). Ind. J Agric. Sci. 2019; 89(11):1932-6.
22. Levy Y, Lifshitz J. Field screening of citrus rootstocks using trickle linear salinity gradient. In *XXV International Horticultural Congress,* Part 1: Culture Techniques with Special Emphasis on Environmental Implications. 1998; 511:197-204.
23. Levy Y, Columbus D, Sadan D, Lifshitz J. Trickle linear gradient for assessment of the salt tolerance of citrus rootstocks in the orchard. Irrigation Sci. 1999; 18(4):181-184.
24. Li J, Hong T, Feng R, Yue X, Chen S. Development of automatic control device for integrated water and fertilization drip irrigation of citrus orchard. Trans. Chinese Soc. Agric. Eng. 2012; 28(10):91-97.
25. Luhach MS, Khatkar RK, Singh VK, Khatry RS. Economic analysis of sprinkler and drip irrigation technology in Haryana. Agric. Eco. Res. Rev. 2004; 17(347-2017-3183):107-113.
26. Morinaga K, Sumikawa O, Kawamoto O, Yoshikawa H, Nakao S, Shimazaki M *et al*. New technologies and systems for high quality citrus fruit production, labor-saving and orchard construction in mountain areas of Japan. J Mountain Sci. 2005; 2(1):59.
27. Panigrahi P, Srivastava AK, Huchche AD. Optimizing growth, yield and water use efficiency (WUE) in Nagpur mandarin (*Citrus reticulata*) under drip irrigation and plastic mulch. Ind. J Soil Conservation. 2010; *38*(1):42-45.
28. Quiñones A, Belén MA, Francisco L. "Influence of irrigation system and fertilization management on seasonal distribution of N in the soil profile and on N-uptake by citrus trees. Agric. Ecosystems Env. 2007; 122(3):399-409.
29. Robles JM, Botía P, Pérez-Pérez JG. Subsurface drip irrigation affects trunk diameter fluctuations in lemon trees, in comparison with surface drip irrigation. Agric. Water Mgt. 2016; 165:11-21.
30. Sepaskhah AR, Kashefipour SM. Evapotranspiration and crop coefficient of sweet lime under drip irrigation. Agric. Water Mgt. 1995; 27(3, 4):331-340.
31. Shimazaki M, Nesumi H. A Method for High-Quality Citrus Production Using Drip Fertigation and Plastic Sheet Mulching. Japan Agric. Res. Quarterly: JARQ, 2016; 50(4):301-306.
32. Shirguire P, Srivastava AK, Singh S. Effect of drip, microjets and basin irrigation method on growtii, soil and leaf nutrient chance. Ind. J Soil Cons, 2001; 29(3):229-234.
33. Shirgure PS. Effect of pulse irrigation scheduling with hybrid station controller on fruit yield and quality of Nagpur mandarin (*Citrus reticulate* Blanco). Sci. J Crop Sci. 2012; 1(5):76-82.
34. Shirgure PS. Yield and fruit quality of Nagpur mandarin (Citrus reticulata Blanco) as influenced by evaporation based drip irrigation schedules. Sci. J. Crop Sci. 2013; 2(2):28-35.
35. Shirgure PS, Srivastava AK, Huchche AD.). Water requirements in growth stages and effects of deficit irrigation on fruit productivity of drip irrigated Nagpur mandarin (*Citrus reticulata* Blanco). Ind. J Agric. Sci. 2014; 84(3):317-22.
36. Stevens RM, Douglas T. Distribution of grapevine roots and salt under drip and full-ground cover microjet irrigation systems. *Irrigation Sci.* 1994; 15(4):147-152.
37. Stibbe E. A comparison between the gross energy requirements of different irrigation systems in Israel. *Irrigation Sci.* 1986; 7(3):213-223.
38. Swietlik D. Yield, Growth, and Mineral Nutrition of YoungRay Ruby'Grapefruit Trees under Trickle or Flood Irrigation and Various Nitrogen Rates. *J. Am. Soc. Hort. Sci.* 1992; *117*(1):22-27.
39. Tejero IG, Zuazo VHD, Bocanegra JAJ, Fernández JLM. Improved water-use efficiency by deficit-irrigation programmes: Implications for saving water in citrus orchards. *Sci. Hort.* 2011; 128(3):274-282.
40. Tuzcu Ö, Çevik B, Kaplankiran M, Kirda C. Influence of different irrigation methods on nutrient uptake of lemon trees. *Adv. Hort. Sci.* 1988, 79-83.
41. Villalobos FJ, Testi L, Moreno-Perez MF. Evaporation and canopy conductance of citrus orchards. Agric. Water Mgt. 2009; 96(4):565-573.
42. Zhang X, Fan Y, Jia Y, Cui N, Zhao L, Hu X *et al*. Effect of water deficit on photosynthetic characteristics, yield and water use efficiency in Shiranui citrus under drip irrigation. Trans. Chinese Soc. Agric. Eng. 2018; 34(3):143-150.