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Impact of drip irrigation and fertigation scheduling on tomato crop - An overview

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Abstarct: The primary objective of this review study was to determine the best irrigation and fertilizer scheduling practice in order to achieve maximum yield with maximum water and fertilizer use efficiency and highest nutrient uptake. It is found nutrient use efficiency could be as high as 90 per cent in fertigation as compared to 40 to 60 per cent in conventional methods. The amount of fertilizer lost through leaching can be as low as 10 per cent in fertigation whereas it is 50 per cent in the traditional system. It is observed that irrigation and fertigation scheduled at 75% ET and at 75% RDF, respectively could be a good alternate for saving water and nutrients with enhanced nutrient uptake, growth, yield and quality of crops. In this paper, the literature pertaining to the different aspects of fertigation and irrigation scheduling are reviewed.

Keywords: Economics, Quality, Tomato, Water and nutrient uptake, Yield

INTRODUCTION

Tomato is one of the most important and widely grown vegetable crop in the world ranking 2nd in importance after Potato (FAO, 2009). It is very versatile vegetable for culinary purposes. Its fruits are eaten raw or cooked. Tomatoes, asides from being tasty are very useful for our heath as they are a good source of Vitamins A and C. Cooked tomatoes and tomato products are the best source of lycopene, which is very powerful antioxidant and helpful in preventing the development of many form of cancer (Mahajan and Singh, 2006). About 83% of the fresh water resources in India are currently being used for agriculture. However, tomato crop requires 400-800 mm water per total growing period in an open field. So, there is a tremendous pressure on agriculture sector to reduce its share of water and at the same time to improve total production by enhancing productivity with increased water use efficiency (Pandey *et al*., 2012). Although, we know water scarcity is the most common problem in many areas creating problem in growing crops. Water productivity at the all India level is very low and needs to be enhanced through tapping, harvesting and recycling water, efficient on-farm water management practices, micro irrigation, use of waste water and resource conservation technologies. The overall irrigation efficiency of the major and medium irrigation projects in India is estimated at around 38%, says the survey, adding that efficiency of the surface irrigation system can be improved from 35-40% to around 60% and that of groundwater from 65-70% to 75% (Source: thethirdpole.net). Drip irrigation can be very effectively utilized in such land situation of the region. Drip irrigation provides an efficient method of water/fertilizer delivery and allows precise timing and uniform distribution of water and applied nutrients (Pandey *et al*., 2013). Drip irrigation is an effective way to supply water to roots of plant and save water, while maintaining high yield and excellent product quality. It can easily be used for fertigation through which fertilizer is placed to the active root zone and crop requirement can be met accurately (Paramsivam *et al.,* 2001 and Neilsen *et al*., 2004). Optimum yield of crop can be obtained when needed primary nutrients (N, P and K) and others are injected precisely through the drip irrigation system (Godara *et al*., 2013). In fertigation nutrient use efficiency could be as high as 90 per cent compared to 40-60 per cent in conventional methods (Solaimalai *et al*., 2005). Controlled watering through drip and efficient nutrient management through fertigation, not only improves the production but quality as well due to better control over soil and water borne diseases (Singh and Pandey, 2014). Drip fertigation

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optimize the use of water and fertilizer enabling to harness high crop yield, simultaneously ensuring a healthy soil and environment. The drip fertigation technology encompasses the application of solid and liquid mineral fertilizers through drip irrigation system thus, supplying a nutrient containing irrigation water to crops. With the objectives to study the effect of different irrigation-fertigation scheduling and their rates on vegetable crops especially tomato, several literature were studied out and accordingly their results were added in it with an aim to find out the best alternate of water and fertilizer management so that farmer could get more production from lest inputs.

Advantages and disadvantages of drip irrigation are given below (Reddy *et al*., 2017):

Advantages - Maximum use of available water, no water being available to weeds, maximum crop yield, high efficiency in the use of fertilizers, less weed growth and restricts population of potential hosts, low labour and relatively low operation cost, no soil erosion, ready adjustment to sophisticated automatic control, no runoff of fertilizers into ground water, less evaporation losses of water as compared to surface irrigation, improves seed germination, decreased to tillage operations.

Disadvantages - Sensitivity to clogging, moisture distribution problem, salinity hazards, high cost compared to furrow, high skill is required for design, install and operation.

Effect of drip fertigation on growth and yield: Fruit yield and yield attributes an important character to study the effect of water and nutrients application through drip irrigation (Fertigation). Fruit yield plant^{-1} reflects effect on various growth and yield parameters like plant height, number of branches, number of fruits plant^{-1} and average fruit size and weight in a cumulative way in a single parameter. Several researchers have reported the beneficial influence in various vegetable crops given below.

Hebbar *et al.* (2004) recorded that the fertigation with 100 per cent water soluble fertilizer (WSF) increased the fruit yield significantly (79.2 q ha^{-1}) over furrow-irrigated control (52.1 q ha^{-1}). Kadam and Karthikeyan (2006) reported that thirty-day-old seedlings of cauliflower *cv*. Golden 80 were subjected to fertigation with 60, 80, 100, 120 and 140 per cent recommended dose of NPK in a field experiment conducted at Rahuri, Maharashtra, India. Fertigation with 80 per cent of the recommended dose of NPK resulted in the highest average plant survival (98.03%), average plant height (95.9 cm) and crop yield (554 qha^{-1}) compared to other treatments combination. Muralikrishna swamy *et al.* (2006) recorded the significant effect of drip irrigation at 75 per cent PE (pan evaporation) + 100 per cent N and K through fertigation recorded 67.5 per cent pod yield and drip irrigation at 50 per cent PE + 100 per cent N and K through fertigation recorded 65.8 per cent increased pod yield when compared to surface irrigation 0.90 IW/CPE ratio + entire NPK as soil application. Araki and Yamaguchi (2007) concluded that drip fertigation was equally efficient in improving yield and growth parameters with a 30% saving in fertilizer compared with the conventional system of fertilizer application. Shedeed *et al.* (2009) reported that fertigation treatments recorded significantly higher number of fruits and main fruit weight per plant compared to drip and furrow irrigation. Aujla *et al*. (2007) reported that 50% water saving could be achieved through drip irrigation in brinjal while obtaining 4% yield increase as compared to furrow irrigation. Gupta *et al*. (2010) recorded observations for various growths and yield attributes. In case of growth and yield attributes, drip irrigation at 80 per cent ET water along with 80 per cet recommended dose of NPK as fertigation was found significantly superior over all other treatment combinations with maximum fruit yield (366.48 q ha^{-1}). Badr *et al.* (2010) observed that the maximum fruit yield of tomato was recorded with 100% NPK fertigation (74.87 t ha^{-1}) and was associated with a higher number of fruits plant^{-1} and a bigger fruit size than the solid applied fertilizers under both drip and furrow irrigation. Vijayakumar *et al.* (2010) conducted an experiment at Agricultural Research Station, Bhavanisagar during 2007 and 2008 to maximize the water and fertilizer use efficiency in brinjal crop. He noted higher yields (42.33 t ha^{-1} in I crop and 37.90 t ha^{-1} in II crop) and maximum shoot length of 45.2, 82.0 and 111.3 cm at 30, 60 and 90 days after planting (DAP) and number of branches plant^{-1} of 8.3, 12.1 and 16.0 at 30, 60 and 90 DAP, respectively by drip irrigation at 75% of PE with 75% of recommended N and K. Imamsaheb *et al.* (2011) reported that in tomato crop, fertigation with 100 per cent recommended NPK recorded significantly higher number of flowers cluster^{-1} (6.30), number of fruits cluster-1 (4.82), per cent fruit set (78.24%), number of fruits plant^{-1} (40.71), average fruit weight (60.89g), yield 2.36 kg plant^{-1}, 53.65 kg plot^{-1} and 56.98 tones hectare^{-1} respectively as compared to other fertigation levels. Singh *et al.* (2014) reported the highest average fruit weight, fruit yield plant^{-1} and fruit yield with 100% recommended dose of NPK as compared to 2/3rd recommended dose of NPK fertilizer applied through drip irrigation. Pandey *et al.* (2013) showed that drip irrigation enhanced the fruit yield, net income and minimized the time, weeds and diseases of the crop. Fertigation resulted in maximum yield (10.20 kg m^{-2}), minimal disease and saved water and total irrigation time as compared to top dressing. The drip irrigation had significantly increased yield (10.50 kg m^{-2}) and net income (60.30%) as compared to flood irrigation. Singh and Sharma (2013) reported increase in yield of cauliflower, capsicum, tomato and pomegranate by 86.28, 17.80, 35.87 and 41.52 per cent, respectively where micro-irrigation systems were

installed. Likewise, net returns of the farmers from the respective crops increased by 105.08, 24.54, 22.91 and 38.09 per cent respectively, when compared to the conventional methods of irrigation. Chauhan *et al.* (2013) concluded drip irrigation at 1.0 Et, an optimum irrigation schedule for brinjal. It gave 30.95 per cent higher fruit yield of brinjal and saved 24.62 per cent irrigation water over conventional surface irrigation. Under drip irrigation application of 80% of recommended dose of N and K fertilizer gave significantly higher fruit yield of brinjal. Kumar *et al*. (2015) reported average increment in the height (137, 106 and 81.6%) and total yield (8.4, 6.1 and 5.2 kg) of fertigated tomato plants at flow rate of 2, 4 and 8 L/hr were estimated and respectively. Ughade *et al.* (2016) conducted an experiment to study the effect of fertigation levels and schedules on growth, yield and quality of tomato under poly house including 3 fertigation levels (F_1-60%, F_2-80%, and F_3-100% of RDF) and 3 fertigation schedules (S_1-6 equal splits of RD of NPK at every 18 days interval, S_2-9 equal splits of RD of NPK at every 12 days interval, S_3-12 equal splits of RD of NPK at every 9 days interval). The results indicated that fertigation of 100% RD of NPK in 12 equal splits at every 9 days interval up to 120 DAT was found significantly superior in case of growth, yield attributes and fruit yield of tomato. Gupta *et al.* (2015) carried out research to improve yield, quality and water/ fertilizer use efficiency in tomato hybrid SH-TH-1 under drip irrigation and fertigation technology at the experimental farm of Division of Olericulture, SKUAST-K, Shalimar, Srinagar. Drip irrigation at 80% ET and fertigation with 60% recommended NPK significantly enhanced fruit yield (989.3 q/ha), higher water use efficiency (49.9 q ha^{-1} cm^{-1}) and fertilizers use efficiency (10.9, 18.3 and 27.4 q kg^{-1} N, P & K, respectively). Average fruit weight, fruit length and fruit diameter also exhibited higher values (53.0 g, 4.48 cm and 4.75 cm, respectively with the same treatment combination. Ankush *et al*. (2017) revealed that among the treatment combination, maximum plant height (67.43 cm), number of branches (12.33), average fruit weight (98.62 g), average fruit yield per plant (3.49 kg) and fruit yield (201.25 q ha^{-1}) was achieved with the application of 75 % PE through drip irrigation + 75 % RDF through fertigation + 2 foliar spray of 1 % urea phosphate.

Effect of drip fertigation on nutrient uptake: Kohire and Das (2015) obtained higher NPK content in plant (2.18, 0.34 and 2.17 per cent NPK), in fruit (1.19, 0.190 and 1.36 per cent NPK) and total nutrient uptake *i.e.* 2.12.62, 42.16 and 186.96 kg/ha with the application of 100% EpR + 75% RD of N and K through drip. The higher nutrients content under the drip irrigated treatments over the surface irrigation might be done to frequent application of irrigation and fertilizer in drip with low concentration, for which the nutrients were effectively utilized as these were direct contact with root system with negligible loss through leaching beyond the deeper depth of the soil profile. Ughade *et al*. (2016) conducted a 2 year experiment to study the response of irrigation and fertigation schedules on tomato and he recorded significantly higher total nitrogen uptake (226.26 and 218.42 kg/ha), phosphorus uptake (74.64 and 69.26 kg/ha) and potassium uptake (302.05 and 291.02 kg/ha) by tomato plant with 100% RDF as compared to rest of the fertigation levels. Ankush *et al*. (2017) conducted an experiment under Udaipur region regarding response of drip fertiagation scheduling to tomato and revealed that NPK content in plant (1.88 %, 0.42 %, 1.94 %) and in fruit (2.55 %, 0.61 % and 2.72 %) was significantly increased with the application of drip irrigation upto100 % PE. Also, nutrient content in plant i.e. nitrogen (1.91 %), phosphorus (0.43 %) and potassium (1.95 %) and in fruit i.e. nitrogen (2.56 %), phosphorus (0.63 %) and potassium (2.78 %) was significantly higher under 100 % RDF through fertigation. Total nutrient uptake by tomato i.e. nitrogen (166.83 kg ha^{-1}), phosphorus (41.59 kg ha^{-1}) and potassium (183.08 kg ha^{-1}) was also found significant higher under treatment combination of 75 % PE through drip + 75 % RDF through fertigation + 2 foliar spray of 1 % urea phosphate.

Effect of drip fertigation on nutrient and water use efficiency: The beneficial influences of irrigation and fertigation on treatments alone or in combination have been reported by various researchers on vegetable crops. These are summarized below:-

Veeranna *et al.* (2001) conducted an field experiment to investigate the effects of broadcast applications and fertigation of normal and water soluble fertilizers at 3 rates through drip and furrow irrigation. Fertilizer use efficiency of 5.28 was obtained in drip fertigation with 80 per cent WSF was effective in producing about 31 and 24.7 per cent higher chilli fruit yield over soil application of normal fertilizers at 100 per cent recommended level in furrow and drip irrigation methods respectively with 20 per cent of fertilizers saving. Solaimalai *et al.* (2005) reported that drip fertigation recorded higher use efficiency of water and fertilizers, minimum losses of N due to leaching, supplying nutrients directly to root zone in available forms, control of nutrient concentration in soil solution and saving in application cost. Gupta *et al.* (2010) reported that the highest water use efficiency (29.40 q ha^{-1}-cm) was observed with the treatment combination of 60% ET through drip + 80% recommended NPK through fertigation. The fertilizer use efficiency was found maximum (NUE-4.89 q kg^{-1} N, PUE-6.53 q kg^{-1} P and KUE -9.79q kg^{-1} K) with the treatment combination of 80% ET through drip + 60% recommended NPK through fertigation. Kadam *et al.* (2006) reported that the higher WUE (18.95 q ha^{-1}-cm) and FUE (230.9 kg ha^{-1}) with 80 per cent of the recommended dose of NPK

rates through fertigation as compared to other treatments. Muralikrishnasamy *et al.* (2006) reported the mean WUE ranged between 2.3 kg ha^{-1}-mm to 6.5 kg ha^{-1}-mm. The higher water use efficiency *i.e.* 6.2 kg ha^{-1}-mm and maximum water productivity *i.e.* Rs. 5.4 m^{-3} was recorded in drip irrigation at 50 per cent PE. Goswami *et al*. (2006) reported superior fruit yield in drip irrigation with fertigation in Brinjal and saved 37-49% water as compared to surface irrigation. Zotarelli *et al.* (2009) reported higher total plant N accumulation for surface drip irrigation (SUR) and subsurface drip irrigation (SDI) *viz:* 12–37% than fixed time irrigation. Moreover, at the intermediate N-rate SUR and SDI systems reduced NO_3–N leaching to 5 and 35 kg ha^{-1}, while at the highest N-rate corresponding values were 7 and 56 kg N ha^{-1}. Badr *et al.* (2010) observed that application of nutrients through fertigation treatments improved NPK recovery and fertilizer use efficiency (FUE) resulted in lesser leaching of NO_3^--N and K to deeper soil layers. Vijayakumar *et al*. (2010) reported the highest water use efficiency *i.e.* 111.5 kg ha^{-1}-mm and N and K use efficiencies were recorded with drip irrigation at 75% pan evaporation and 75% N and K fertigation. Vjekoslav *et al.* (2011) observed 28% more WUE in drip irrigation in comparison with treatment with conventional application of fertlilizer and drip irrigation and 87% more than the treatment with furrow irrigation and conventional application of fertilizers. Kumari and Kaushal (2014) conducted an experiment on drip fertigation in sweet pepper which results in saving of fertilizer up to 25 per cent, water to 40 percent significant increase in yield and water use efficiency. Ughade and Mahadkar (2014) reported maximum field water use efficiency (FWUE) *i.e.* 46.91 q ha^{-1}-cm in treatment combination of plant spacing S3 (17550×50 cm) with 60% ET and 100% RDF through drip.

Effect of drip fertigation on tomato quality: Quality of tomato is an important characteristic *viz.* TSS, reducing sugar, non reducing sugar, vit-c, ascorbic acid etc. which determines the grading of produce and their respective economics (prices) in the market which is the result of amount of water and nutrients that plants uptake in adequate amount and at the right time. Several researchers have made their contribution in field of drip fertigation in tomato crop as given below:

Machado *et al. (*2005) reported non-significant pH with respect to different irrigation regimes [4.36 for 0.6 (DI), 4.37 for 0.9 (DII) and 4.32 for 1.2 ETc (DIII)]. Neither drip irrigation nor fertigation treatments does have any significant effect on fruit pH as its reported by Sanders *et al.* (1989). Favati *et al.* (2009) studied the effect of different irrigation regimes on tomato quality in the years 2002 and 2003 and concluded higher mean value of soluble solids in both years was 5.78 °Brix for the lowest water irrigation level applied for tomato cultivation and 4.30 °Brix for the largest water application. Gupta *et al.* (2015) carried out research for improving yield, quality and water/fertilizer use efficiency in tomato hybrid SH-TH-1 under drip irrigation and fertigation technology at the experimental farm of Division of Olericulture, SKUAST-K, Shalimar, Srinagar. He concluded higher TSS (4.92^0 brix) and Total sugar (3.77%) under I_2F_2 treatment *i.e* 80% ET through drip irrigation + 80% RFD through drip irrigation. The improved quality with conjunctive use of drip irrigation and fertigation might be due to the facts that drip fertigation permits better use of water and nutrients, lower leaching losses and more controllable application of nutrients and plants complete their metabolic process at right times. Nangare *et al.* (2016) reported improved TSS considerably with deficit irrigation and is higher with $RDI_{0.6}$ (5.5° Brix).

Effect of drip fertigation on economics: Net returns and Benefit cost ratio are the most important economic parameters to access the profitability of any treatment. The ultimate goal of any treatment is to achieve profit in terms of net return and B: C ratio.

Under drip fertigation system, highest benefit cost ratio (2.17) in chilli was achieved with the application of 100 per cent recommended NPK (Tumbare and Bhoite, 2002). Highest additional net income of Rs. 1,23,679 and B: C of 3.30 in chilli was obtained with drip irrigation at 100 per cent WRc with 100 per cent RDF which was closely followed by drip irrigation at 80 per cent WRc with 100 per cent RDF registering an additional net income of Rs. 1,19,488 and BCR of 3.23 over surface irrigation (Selvakumar, 2006). Narayanan *et al*. (1994) conducted an experiment to evaluate the economic benefits of drip irrigation and reported that maximum gross return was obtained with drip irrigation compared to furrow irrigation. It was reported that the net profit per ml of water used in tomato crop under drip irrigation and conventional system were 278.43 and 66.47, respectively. Muralikrishnasamy *et al.* (2006) reported the mean Benefit: Cost ratio was 1.87 in drip irrigation at 75 per cent PE +100% N and K through fertigation. Irrigation scheduling to chilli at 50% PE through drip irrigation coupled with 100 per cent N and K application as fertigation improved the yield and quality of the produce. Singh *et al.* (2006) stated that under unlimited water supply, drip irrigation in cauliflower-hybrid chilli sequence gave a net return of Rs. 37565 ha^{-1} against Rs. 18618 ha^{-1} in check basin method of irrigation. However, under limited water supply or in water hunger areas, drip irrigation boosted the net return to the tune of Rs. 1,00,077 due to increase in yield resulted from additional area covered under irrigation. Brahma *et al*. (2010) studied on fertigation efficiency and economics of cultivation and reported that fertigation with 100 per cent recommended dose of N and K was the most efficient treatment with Fertigation efficiency of 43.24 per cent and cost: benefit ratio of 1:2.28. Vijayakumar *et al.* (2010) con-

ducted an experiment at Agricultural Research Station, Bhavanisagar during 2007 and 2008 to maximize the water and fertilizer use efficiency in brinjal crop. He noted maximum benefit-cost ratio in drip irrigation at 75% of PE with fertigation of 75% of recommended N and K (2.9 and 2.5, respectively) in both the years of study. Ankush and Singh (2017) also studied the effect of drip fertigation on economics of tomato and obtained maximum net return (220115.43 Rs/ha) and B: C ratio (2.40) with 75% PE through drip irrigation and application of 75% RDF through drip fertigation + 2 foliar spray of 1% urea phosphate.

Conclusion

In drip fertigation system, water falls onto the soil surface drop by drop and fertilizers can also be applied along with water. From the review study of different literature, it should be concluded that if water and nutrients are applied according to crop demand in adequate amount and at right time then plant can grow much better in a congenial environment without more losses. At the rate of 75% ET_c through drip irrigation and 75% RDF through fertigation could help in attaining more yield with higher uptake and nutrient use efficiency thus enhanced the quality of the produce and we get more economic returns. However, it is very difficult to obtain maximal water use efficiency and maximal yield simultaneously because reduction in the amount of irrigation water results in higher water use efficiency; but at lower irrigation rate higher yield can't be achieved. Thus, higher water use efficiency is achieved at lower irrigation rate.

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