RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 6 | Issue 1 | April, 2013 | 51–56

Enhanced yield and fiscal benefit from mango (*Mangifera indica* L.) and guava (*Psidium guajava* L.) through automated drip fertigation

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Received : 01.09.2012; **Revised :** 25.11.2012; **Accepted :** 22.01.2013

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ABSTRACT : Sustainable and increased agricultural productivity emphasize judicious use of water and nutrients accompanied by other factors. This can be achieved by application of water and nutrients through drip fertigation, which is the most advanced and efficient practice of fertilizer application. It has to follow appropriate management strategies to get maximum benefit, which become easy through automatic operation system. Therefore, an automated drip fertigation system was installed in mango (*Mangifera indica* L.) and guava (*Psidium guajava* L.) orchards at the farm of Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh. Irrigation and fertilizers were provided to mango and guava as per crop water requirement and scheduling. The mean fruit yield of guava under automated drip fertigation system was found to be 10.29-13.07 tonnes/ha and increased by 27.03 per cent during the period from 2007-08 to 2009-10. It increased significantly from 15.6 per cent to 23.7 per cent over conventional system during the same period. The pulp content of guava varied between 95.4 - 95.5 per cent and was higher by 1.38-1.60 per cent as compared to conventional system. The mean fruit yield of mango was 8.00-12.80 tonnes/ha and increased to 60.0 per cent under automated drip fertigation. The mean fruit yield of mango significantly increased from 17.6 to 23.1per cent over conventional practices. The pulp content of mango under automated drip fertigation ranged between 74.5 to 74.6 per cent being 3.33-3.47 per cent higher than conventional system during the study period. Total cost of cultivation through automated drip fertigation varied from Rs.1,56,383-Rs.12,17,913 and Rs. 1,73, 775- Rs. 15,65, 774 for guava and mango, respectively for one to 20 hectare area. The benefit cost ratio for mango and guava orchard reached 1.45 and 2.20 for 20 hectare area, respectively. This study indicated that automated drip fertigation system could be techno-economically feasible for use in 5-20 hectares of mango and 3-20 hectares of guava.

KEY WORDS : Mango, Guava, Automated drip fertigation, Increased yield, Techno-economic feasibility, Benefit cost ratio

HOW TO CITE THIS PAPER : Singh, D.K., Singh, R.M. and Rao, K.V.R. (2013). Enhanced yield and fiscal benefit from mango (*Mangifera indica* L.) and guava (*Psidium guajava* L.) through automated drip fertigation . *Internat. J. Agric. Engg.*, **6**(1) : 51-56.

Fruits are diversified and rich source of vitamins, proteins, carbohydrates and minerals. Mango (*Mangifera indica* L.) and guava (*Psidium guajava* L.) are important fruit crops, accounting around one fourth of total fruit production of the country. Mango, called king of the fruits shares around 20.3 per cent of total fruit production of the country. The area under its cultivation has increased from 1.57 million ha to 2.29 million ha with production from 10.02 million tonnes to 15.18 million tonnes, respectively during 2001-02 to 2010-11 (National Horticulture Database, 2011). The mean productivity of mango in the country has increased from 6.4 to 6.6 tonnes/ha during last ten years.

The area under guava has increased from 1,54,600 ha to 2,05,000 ha with production from 1.72 million tonnes to 2.56 million tonnes, respectively during the same period. During last ten years its productivity has raised from 11.1 tonnes/ha to 12.0 tonnes/ha (National Horticulture Database, 2011). But, according to estimates, the per capita consumption of fruits in India is only around half the recommendation by the Indian Council of Medical Research and National Institute of Nutrition, Hyderabad (Srivastava, 2010). At the same time Indian agriculture is facing reduced availability of land and share of water for irrigation along with increasing cost of other inputs including fertilizers. Therefore, enhanced and sustainable fruit production and productivity are important for nutritional and nutraceutical self-sufficiency and security of ever increasing population of the country.

It could be realised by using improved production

techniques including efficient water and nutrient management techniques such as drip fertigation coupled with improved varieties and crop protection measures. Efficient water and nutrient management can be achieved through use of drip irrigation system for application of water and nutrients (Singh and Biswas, 2000). The nutrient status of soils of India shows widespread deficiencies of fertilizers (India Fertilizer Resource Centre, 2012). Fertilizer is costlier input and judicious use has great significance in agriculture. Fertilizer, in general, applied manually have low application efficiency of 20-50 per cent. With drip fertigation fertilizer use efficiency of 45- 95 per cent can be achieved.

The application of fertilizer through this system is the most advanced and efficient practice of application of fertilizer, which combines two main factors in plant growth and development *i.e.*, water and fertilizer. In fertigation, fertilizer application is made in small and frequent doses fitting within scheduled irrigation intervals matching the plant water use to avoid leaching. Significant savings in the use of fertilizers and increase in yield of many crops have been observed through fertigation (Kumar, 2001; Patel and Rajput, 2001 and 2002; Singh *et al.*, 2010). Also, drip fertigation in guava managed manually has been found techno economically feasible (Singh *et al.*, 2012).

Fertigation through drip irrigation has to follow appropriate management strategies to get maximum benefit, which become difficult through manual operation of fertigation system. Therefore, the automation of the fertigation system is the need of the time to accomplish above. A study on water application through automated drip system installed in guava orchard indicated its excellent performance (Singh *et al.,* 2012). Therefore, a study was conducted and presented on enhanced production and benefit from mango and guava under automated drip fertigation system for sustainable fruit production.

METHODOLOGY

The study was carried at research Farm of Central Institute of Agricultural Engineering (CIAE), Bhopal, Madhya Pradesh, India during 2007-10. The soil of farm area was black vertisols. The texture and other physical properties of the soil are given in Table A.

Details of experiment :

An automated drip fertigation system was designed and installed for irrigation and fertigation of a six year old orchard of guava and mango. The guava variety Lucknow -49 was planted at both plant to plant and row to row spacing of 6m x 6m. The mango variety Amrapali was planted at both plant to plant and row to row spacing of 5m x 5m. The experiment was replicated for four times. It was compared with controlled treatment including conventional irrigation and fertilizer application system. The schedules of irrigation and fertilizer for mango and guava was based on their water requirement and recommended dose of fertilizer (Srinivas, 2001; Rajput and Patel, 2002; Singh *et al*., 2004). The irrigation was provided at 80 per cent of crop evapotranspiration and fertilizer at 75 per cent of recommended fertilizer doze (Bhandarkar *et al.*, 2002).

Components of automated fertigation system :

The components of automated fertigation system consisted of drip irrigation system, controller, solenoid valves, fertilizer injector, semi-automatic sand filter and screen filters, rain sensor, voltage stabilizer, relay and toggle switch, electrical conduit and connecting wire along with other fittings and accessories required.

The system had capability of being operated using computer and controller as well. The controller consisted of 32 output port digital, and 14 analog inputs, it has provision

Table A: Physical properties of soil at experimental site

Sr. No.	Properties	
1.	Soil texture:	
	Clay	49.7 - 53.7 %
	Silt	27.9 - 29.6 %
	Sand	8.2 - 20.8 %
	Gravel	2.9 - 3.8 %
2.	Soil structure	Sub angular blocky
3.	Bulk density	1.39 -1.75 g/cc
4.	Porosity	38.0 – 40.0 %
5.	Water holding capacity	33.0 – 36.0 %
6.	Field capacity	28.5 – 31.0 %
7.	Permanent wilting point	19.0 - 19.5 %
8.	Infiltration rate,	0.011 m/h

for independent and sequence programming for valves and backwash programming for sand filter. It has capacity to run independent fertilizer injector either on time basis or volumetric basis fertigation with programming facility for water before and after fertigation event. The capacity of fertilizer injection pump was 250 litres per hour. Flow rate of solenoid valves of 10 cm diameter ranged from 1- 300 litres per minute at operating pressure of 0.25 to 6 kilogram per square centimetre (kg/ cm^2). The flow capacity of semi-automatic sand filter was 25 cubic meter per hour (m^3/hr) at 1 kg/cm^2 operating pressure.

Yield of fruits :

The yields of the mango and guava during 2007-08 to 2009-10 were recorded on per plant basis and converted to area basis from four replications. The pulp content of both the fruits was also measured. The pulp of mango was separated from peel and stone and that of guava separated from seeds. The weight of pulp of mango excluded the weight of stone and peel, while that in case of guava excluded the weight of seeds. The pulp content was found by dividing the weight of pulp to the total weight of fruit and converted to per cent basis. The t-test was used to establish the statistical significance of automated drip fertigation system over conventional system of irrigation for enhancing the mean yield.

Techno-economic feasibility of automated fertigation :

The techno-economic feasibility study of automated fertigation system for mango and guava orchard was evaluated based on the yield and net profit fetched. It was assumed that the system would last for 15 years. The interest rate being 10 per cent and salvage Rs. 10,000/-. The rate of mean market sell price of mango and guava was taken as Rs. 15 per kilogram of each produce. The installed automated drip fertigation system is capable for irrigation upto 20 hectare. The cost of controller and head unit of automated system would remain same irrespective of increase in irrigated area. The cost of field unit laterals and emitters, control valves, pressure gauges and submains would increase with area or increase in number of blocks. Also, to accommodate the year to year fluctuation in average market price of fruits as well as for unbiased analysis the B:C was evaluated at varying rate of fruit price (Singh *et al.,* 2009).

■ RESULTS AND DISCUSSION

The yield of the mango and guava from year 2007-08 to 2009-10 has been presented in Table 1. The t-test was used to establish the statistical significance of automated drip fertigation system over conventional system of irrigation for enhancing the mean yield from four replications. It may be observed that during all the three years of the study both the crops performed well under automated drip fertigation.

Yield of guava :

The mean fruit yield of guava under automated drip fertigation system increased to 27.03 per cent over period of three years during 2007-08 to 2009-10. While, it increased to 18.7 per cent during the same period under conventional practices. The mean yield of guava under automated drip fertigation during 2008-09 and 2009-10 crossed the national average productivity of 11.1 and 11.7 tonnes/ha (National Horticulture Database, 2011). Increase in fruit yield of guava under automated drip fertigation system over conventional practice was higher during each consecutive year (Fig. 1).

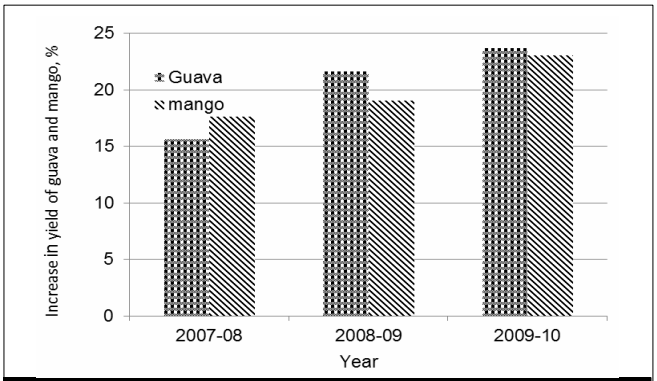

Fig. 1: Increase in yield of mango and guava under automated drip fertigation over conventional practice during 2007-08 to 2009-10

Table 1: Yield attributes of mango and guava under automated drip fertigation system

Crop	Year	Crops under conventional practices		Crops under automated fertigation system		Increase in fruit yield over conventional practice, %
		Mean fruit yield per plant (kg)	Mean fruit Yield (t/ha)	Mean fruit yield per plant (kg)	Mean fruit yield (t/ha)	
Guava	2007-08	32	8.90	37*	10.29*	15.6
	2008-09	37	10.29	45*	12.51*	21.6
	2009-10	38	10.56	47*	13.07*	23.7
Mango	2007-08	17	6.80	20*	8.00*	17.6
	2008-09	21	8.40	25*	10.00*	19.0
	2009-10	26	10.40	32*	12.80*	23.1

*Significant at $t_{0.05, 6} = 2.44$

The yield of guava under automated drip fertigation significantly increased from 15.6 per cent to 23.7 per cent as compared to conventional system during 2007-08 to 2009-10, respectively. The enhanced yield of guava under automated drip fertigation may be attributed to uniform distribution and availability of nutrient to plant as compared to conventional practice. It may be well supported that increased yield in many crops has been observed due to drip fertigation (Kumar, 2001; Patel and Rajput, 2001 and 2002, Singh *et al.,* 2010). The pulp content of guava under automated drip fertigation varied between 95.4 to 95.5 per cent during the study period (Table 2). Though, the same was little bit higher by 1.38 to 1.60 per cent over conventional practice but not statistically significant.

Yield of mango :

The mean fruit yield of mango increased to 60.0 per cent under automated drip fertigation and 52.9 per cent under conventional practices during the same period. Higher values of increased yield of mango during the period may be attributed to the relatively lower yield of mango (8.00 tonnes/ha) as compared to the guava (10.29 tonnes/ha) in initial years. Also, during end of the period the yield of mango (13.60 tonnes/ha) reached just beyond that of guava (13.34 tonnes/ha). Also, the mean yield of mango under automated drip fertigation during the period of study reached beyond average national average productivity of 6.4 -6.5 tonnes/ha (National Horticulture Database, 2011).

It may be observed that increase in yield of mango under automated drip fertigation over conventional practices could reached from 17.6 to 23.1 per cent during the same period (Fig. 1). The enhanced yield of mango may be attributed to more uniform distribution and availability of nutrient to plants with automated drip fertigation system as compared to conventional practice. Pulp content of mango under automated drip fertigation was between 74.5 to 74.6 per cent during the study period. The same was higher over conventional practice by 3.33 to 3.47 per cent but not statistically significant.

Techno-economic feasibility of automated fertigation :

The analysis of total cost, benefit and benefit cost ratio (B:C) for irrigation of guava and mango through automated drip fertigation has been presented in Fig. 2 and 3. Total cost of cultivation of guava through automated drip fertigation was Rs. 1,56,383 to Rs.12,17,913 only for one to 20 ha area, respectively. The yield of mango varied from Rs. 1,73775 to Rs. 15,65,774 for cultivation in one to 20 ha. The yield of mango and guava (based on crop data) were taken as 12.8t/ha and 13 t/ha, respectively with market price Rs. 15/kg for each. The net benefit fetched was around Rs. 38,617 to Rs. 26, 82,087/- with guava and Rs. 18,225 to Rs.22,74,253 with mango cultivated under automated drip fertigation system in an area of one to 20 ha, respectively.

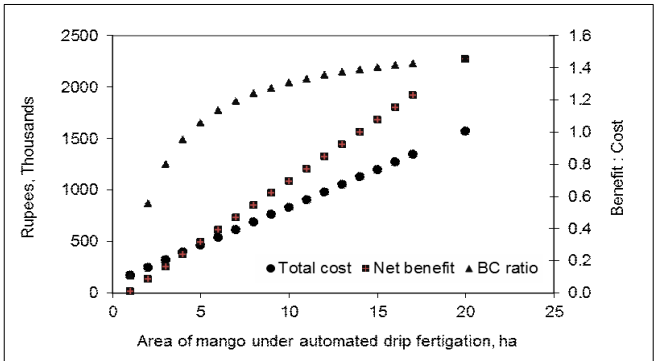

Fig. 2: Total cost, net benefit and benefit cost ratio for irrigation of mango through automated drip fertigation

Table 2 : Pulp content of mango and guava under automated drip fertigation system

Crops	Year	Pulp content of fruits under automated fertigation system (%)	Pulp content of fruits under conventional system (%)	Increase in pulp Content (%)
Guava	2007-08	95.4	94.1	1.38
	2008-09	95.5	94.0	1.60
	2009-10	95.5	94.2	1.38
Mango	2007-08	74.5	72.0	3.47
	2008-09	74.6	72.1	3.47
	2009-10	74.5	72.1	3.33

Table 3 : The B:C ratio of mango and guava with automated drip system at varying market price of fruits

Crop	B:C ratio at varying market price of fruits, Rs./ kg			
	10	15	20	25
Mango	0.65	1.45	2.27	3.09
Guava	1.13	2.2	3.27	4.34

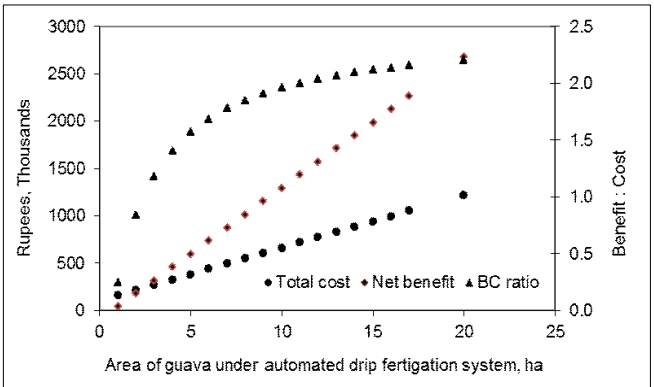

Fig. 3: Total cost, net benefit and benefit cost ratio for irrigation of guava through automated drip fertigation

The benefit cost ratio was well above unity for five hectare of mango and three hectare of guava cultivation. It indicated that at least five hectare of mango and three hectares of guava may be cultivated to make automated drip fertigation economically beneficial. The B:C for mango and guava increased exponentially with area (A) upto 20 hectares and R^2 values of 0.9574 and 0.9718, respectively (Equation 1 and 2). But, the rate of increase of B:C for both crops was reducing with increase in area (Fig. 2 and 3). Total cost and net benefit followed linear relationship with R^2 values of unity for area in between one to 20 hectare (Equation 3- 6). Both followed increasing trend with increasing area of both the crops. Net benefit increased higher as compared to the total cost for both the crops but faster in case of guava (Fig. 2 and 3).

$$B:C_{Mango} = 0.4297\ln(A) + 0.2807 \quad (1)$$

$$B:C_{Guava} = 0.638\ln(A) + 0.4409 \quad (2)$$

$$\text{Total cost}_{Mango} = 73262A + 100513 \quad (3)$$

$$\text{Total cost}_{Guava} = 55870A + 100513 \quad (4)$$

$$\text{Net benefit}_{Mango} = 118738A - 100513 \quad (5)$$

$$\text{Net benefit}_{Guava} = 139130A - 100513 \quad (6)$$

It was found that B:C of guava was higher than that of mango because the yield of guava was higher than mango for same age of plant during the period of study (Table 1). The B:C for guava under automated drip fertigation became 2.0 for 11 ha area, while that for mango reached upto 1.22 for the same area. It reached 1.45 and 2.20 for 20 hectare area, respectively for mango and guava orchard. Therefore, automated drip fertigation system could be used for 5-20 hectares of mango and 3-20 hectares of guava to make it techno economically feasible.

The benefit cost ratio of automated drip fertigation at varying fruit price :

The B:C of installed automated drip fertigation to its full capacity for nine year old orchard of guava and mango using varying price of fruits has been presented in Table 3. It could accommodate the year to year fluctuation in average market price of fruits. The market price of fruits of both mango and guava has been taken as Rs.10, Rs. 15, Rs., Rs. 20 and Rs. 25 per kilogram for unbiased analysis (Singh *et al.*, 2009). It was found that B: C of guava under automated drip fertigation varied from 1.13-4.34 and that for mango 0.65-3.09. It may be observed that B:C is very much dependent upon prevailing market price of both the fruits. The B:C improved with the increasing market price of fruits between Rs. 10 to Rs. 25 per kilogram.

Conclusion :

The mean fruit yield of guava under automated drip fertigation system was found to be 10.29-13.07 tonnes/ha and increased by 27.03 per cent during period from 2007-08 to 2009-10. It increased significantly from 15.6 per cent to 23.9 per cent over conventional system during the same period. While, pulp content varied between 95.4 - 95.5 per cent and was higher by 1.38-1.60 per cent as compared to conventional system. The mean fruit yield of mango obtained was 8.00-12.80 tonnes/ha and increased to 60.0 per cent under automated drip fertigation. The same increased by 52.9 per cent under conventional practices during the stated period. The mean fruit yield of mango significantly increased from 17.6 to 23.1per cent over conventional practices. Pulp content of mango under automated fertigation varied between 74.5 to 74.6 per cent with 3.33-3.47 per cent higher than conventional system during study period. Total cost of cultivation of guava and mango through automated drip fertigation varied from Rs.1,56,383 to12,17,913 only and Rs. 1,73,775 to Rs. 15,65,774, respectively for one to 20 ha area. The benefit cost ratio for mango and guava orchard reached 1.45 and 2.20 for 20 ha area, respectively. It increased with increasing area and the market price of fruits. Study indicated that automated drip fertigation system could be techno economically feasible for use in 5-20 ha of mango and 3-20 ha of guava.

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REFERENCES

Bhandarkar, D.M.,Nimje, P.M.,Reddy, K.S., Garg, Vijay, Mathankar, S.K. Singh, R.M., Rao, K.V. R. and Lal, S.B. (2002). Performance characteristics of drip irrigation system in vertisols. Final Report of Ad-hoc scheme, pp. 1-29.

Kumar, A. (2001). *Status and issues of fertigation in India.* Micro irrigation, CBIP, publication, pp. 418-427.

Patel, Nelam and Rajput, T.B.S. (2001). *Effect of fertigation on growth and yield of onion.* CBIP publication. 282. pp. 451-454.

Patel, Neelam and Rajput, T.B.S. (2001). Fertigation of okra using commercially available granular fertilizers. Proceedings of International symposium on importance of potassium in nutrient management for sustainable crop production in India held at New Delhi from Dec. 3-5, pp. 270-273.

Patel, Neelam and Rajput, T.B.S. (2002). Yield response of some vegetable crops to different level of fertigation. Paper presented in National conference on Agriculture in changing global scenario, organized by ISAS, New Delhi held at IARI, New Delhi from Feb. 21-23, 2002.

Rajput, T.B.S. and Patel, Neelam (2002). *Fertigation: theory and practice.* Publication No. IARI/WTC/2002/2.

Singh, D.K., Rao, K.V.R. and Singh, R.M. (2009). Development/ adoption and evaluation of automatic fertigation system for mango and guava. Final Report of Research Project No.505. Central Institute of Agricultural Engineering (ICAR), BHOPAL (M.P.) INDIA.

Singh, G.B. and Biswas, P.P. (2000). Balanced and integrated nutrient management for sustainable crop production. *Fertilizer News.* **45**(5):55-60.

Singh, P.K., Singh, K.K. and Shukla, K.N. (2004). Fertigation scheduling of young mango crops. Proceedings of international conference on Emerging technologies in Agricultural and Food Engineering, NREM, held at IIT, Kharagpur,Dec.14-17.PP:273-277.

Srinivas, K. (2001). *Micro irrigation and fertigation in fruit crops. Micro irrigation*, CBIP, publication: 253-255.

Singh, D.K. Singh, R.M. and Rao, K.V.R. (2012). Water application performance of automated drip system installed in guava orchard in vertisols. *Environ.& Ecol.,* **30**(1):7-10.

Singh, R.M., Singh, D.K. and Rao, K.V.R. (2010). Fertigation for increased crop yield and fertilizer saving. *Agric. Engg. Today*, **34**(2): 12-16.

Singh, R.M., Bhandarkar, D.M., Singh, D.K., Reddy, K.S,. K.V.R. Rao, Mathankar, S.K. (2012). Techno-Economic Feasibility of Drip Fertigation in Guava (*Psidium guajava* L.). *Environ. & Ecol.,* **30** (2): 271-274.

■ WEBLIOGRAPHY

India Fertilizer Resource Center–India agronet, 2012. *http://www.indiaagronet.com*//indiaagronet/Technology_Upd/fert_research.htm Accessed 21 June, 2012.

Srivastava, Anubhav (2010). Horticulture sector in India – Opportunities and challenges. *http://www. policyproposalsforindia. com*/article. php? article _id = 101 & languageid =1. Accessed 21 June, 2012.

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