Journal Crop and Weed, 11(1):33-37(2015)

Integrated effect of irrigation methods and nutrient management practices on yield and water use efficiency of papaya (*Carica papaya* L.)

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Received:11-11-2014, Revised: 09-02-2015, Accepted:10-02-2015

ABSTRACT

An experiment was conducted at the Regional Research Technology and Transfer Station, Chiplima, Sambalpur during 2009, 2010 and 2011 to study the response of papaya to different irrigation methods and nutrient management practices. The experiment was comprised with three irrigation methods (I_1 - Drip irrigation, I_2 - Basin irrigation with straw mulch and I_3 - Basin irrigation without straw mulch) in the main plots and three levels of nutrients management practices such as N_1 - 100% inorganic source (RDF-100:80:120g of $N:P_2O_5:K_2O$ plant^{-1} year^{-1}), N_2 - 100% organic source (FYM 15.0 t ha^{-1} + vermicompost 5.0 t ha^{-1} + neemcake 0.5 t ha^{-1}) and N_3 - integrated nutrient management (75% inorganic source + 25% organic source) in the sub-plots with four replications in a split plot design. Pooled analysis of three years'data indicated that basin irrigation with straw mulch (I_2) recorded highest fruit yield of 23.17 t ha^{1} with water requirement of 205.43cm and water use efficiency of 112.78 kg ha-cm^{-1}. Integrated nutrient management practice comprised of 75% inorganic source + 25% organic source (N_3) recorded the highest fruit yield of 22.31t ha^{-1}. The basin irrigation with straw mulch and exploitation of integrated nutrient tactics comprised of 75% inorganic+25% organic source produced maximum papaya fruit yield of 24.32 t ha^{-1} due to better soil health.

Keywords : Basin irrigation, drip irrigation, microbial respiration, straw mulch, water use efficiency

Papaya (*Carica papaya* L.) is essentially a tropical fruit and commercially grown in tropical and subtropical areas (Yadava *et al*.,1990). It is one of the important fruit crops which find an important place in homestead garden under diverse eco-climatic condition (Singh *et al.*, 2012). It is rich in carotene, vitamin A, thiamin, riboflavin, minerals and a number of proteolytic enzymes. It can be consumed as ripen fruit as well as vegetable. Its area under cultivation is increasing with time due to its high nutritious value and high yield potential. In India, 90 thousand ha area is covered under papaya with an annual production of 3.67mt. In Odisha, total area under papaya is 11 thousand ha with an annual production is 0.22 mt where as productivity is 20 t ha^{-1}. It provides higher fruits per hectare and income next to banana (Singh, 1990). In Odisha, productivity of papaya is very low because of poor nutrition and deficiency of water particularly during summer and winter seasons. Generally this crop is irrigated by basin method which has resulted impounding of more water in the root zone and loss of more water and nutrients through leaching. On the other hand, drip irrigation can save lot of water and reduces the leaching of nutrients (Narayanamoorthy, 2004). Straw mulch can check the evaporation from the basin. Papaya is one of the nutrient exhaustive fruit crops because of its quick growth, continuous fruit bearing habit and heavy fruit yield. Continuous applications of huge amount of chemical fertilizers hamper the soil health and biological environment (Nambiar and Abrol,1989; Tandon, 2000). The continuous and imbalanced use of conventional fertilizers leads to reduction in crop yield. Problems like leaching, volatilization, de-nitrification of nitrogen and in soil are also the results of heavy use of chemical fertilizers (Maurya and Beniwal, 2003). The use of manures as organic source occupy an important place as they provide a scope for reduction in use of costly chemical fertilizers which can pollute soil in long term use (Sharma, 2005). The integrated nutrient management is the better way to overcome these problems. The present study was aimed to find out suitable irrigation methods and nutrient management practices (organic, inorganic and INM systems) for better productivity of papaya which can improve farm economy and farmers livelihood in Odisha.

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MATERIALS AND METHODS

An experiment was conducted at the Regional Research Technology and Transfer Station, Chiplima, Sambalpur during 2009, 2010 and 2011. The experimental site was located at 20°212 N latitude and 80°552 E longitude with an altitude of 178.8 m above mean sea level. The soil of the experimental field was clayey with acidic in reaction (pH 5.48), organic carbon 0.47% and available N, P and K content was 232, 14.0 and 189 kg ha^{-1}, respectively with poor drainage facility. The per cent N, P_2O_5, and K_2O content of FYM were 0.56, 0.40 and 0.63, for vermicompost were 1.2, 0.68 and 0.9 and for neem cake were 4.8,1.0 and1.5, respectively The moisture content at field capacity and permanent wilting point was 19.4 and 8.4%, respectively. Nine treatments comprised of three irrigation methods (I_1- drip irrigation, I_2- basin irrigation with straw mulch and I_3- basin irrigation without straw mulch) as the main plots and three levels nutrients management practices such as N_1- 100% inorganic source (RDF- 100: 80: 120 g of N-P_2O_5-K_2O plant^{-1} year^{-1}), N_2- 100% organic source (FYM 15.0 t ha^{-1} + Vermicompost 5.0 t ha^{-1} and Neemcake 0.5t ha^{-1}) and N_3- Integrated Nutrient Management (75% inorganic + 25% organic) as sub-plots were tested in split plot design with four replications. Total precipitation during crop growth period was 1207.3 mm, 1239.6 mm and 1381.0 mm during 2010, 2011 and 2012, respectively. Each planting pit measuring 50×50×50cm was treated with 20g mancozeb powder. In organic and integrated nutrient management, pit was filled with FYM and neem cake as per treatment. One 45 days old healthy seedling of papaya cv. CO-2 was planted in a pit at a spacing of 2.5×2.5m every year. Full quantity of phosphorus and half of the potassium were applied as basal while N was applied at one, three and six months after planting in three equal splits as per treatment. Recommended cultural operations were adopted to raise papaya for experimentation. The volume of irrigation water in each plant was calculated by multiplying the depth of irrigation and effective area. The circular distance from the plant is 30 cm in case of basin and drip irrigation. Irrigations to a depth of 5 cm were given for basin irrigation with and without mulch at 50% depletion of available soil moisture (DASM). Measured quantity of irrigation water was applied with the help of irrigation modules. In drip irrigation, drip was operated every day and equal quantity of irrigation water was applied based on pan evaporation information. Observations on yield and yield parameters were recorded. Water requirement (WR) was calculated by adding effective rainfall during crop growth period, the amount of irrigation water applied and soil profile contribution. Water use-efficiency was calculated by dividing fruit yield to the water requirement for each treatment. From the pooled data, economics was worked out on the basis of prevailing market price of the produce and inputs used in the experiment. The recorded data for various parameters were statistically analyzed (Panse and Sukhatme, 1978).

RESULTS AND DISCUSSION

Yield attributes

Pooled data of three years' experimentation on yield attributing characters of papaya as influenced by different irrigation methods and nutrient management practices are presented in table-1. Irrespective of nutrient management practices, basin irrigation with straw mulch (I_2) produced maximum plant height of 62.13 cm which was statistically *at par* with drip irrigation alone (I_1). The number of fruits per plant was significantly maximum in basin irrigation with straw mulch being, 24.76 and found superior to drip irrigation alone and basin irrigation without mulch. Highest fruit weight of 677.67g was observed with basin irrigation with straw mulch, which was statistically *at par* with drip irrigation alone and significantly different from basin irrigation without mulch. Irrespective of irrigation methods, the nutrient management practices indicated that maximum plant height of 63.11cm was observed with 100% inorganic sources (N_1) which was statistically *at par* with integrated nutrient management practices (N_3). Number of fruits was observed significantly highest with integrated nutrient management practices being, 25.40 plant^{-1}. Highest average fruit weight of 690.22g was observed with integrated nutrient management (N_3), which was statistically *at par* with 100% inorganic source and significantly different from 100% organic source.

Fruit yield

Experimental results revealed significant influence of irrigation methods and nutrient management practices on the fruit yield of papaya (Table 2). During 2010, the mean maximum fruit yield of 22.85 t ha^{-1} was obtained from basin irrigation with straw mulch (I_2) which was significantly higher than that of basin irrigation without straw mulch (I_3) and drip irrigation (I_1). Integrated nutrient management practice (N_3) resulted mean maximum fruit yield of 21.64 t ha^{-1}, which was significantly higher than that of 100% organic source (N_2) and statistically *at par* with100% inorganic source (N_1). Fruit yield of 20.59 t ha^{-1} was observed with 100% organic source (N_2) which was less than that of 100% inorganic source (N_1). During 2011, the mean maximum fruit yield of 24.08 t ha^{-1} was observed with basin irrigation with straw mulch (I_2) which was significantly higher than that of basin irrigation without straw mulch (I_3) and drip irrigation (I_1). Integrated nutrient management practice (N_3) resulted maximum papaya fruit yield of 23.36 t ha^{-1}, which was significantly higher than that of 100% organic source (N_2) and statistically *at par* with100% inorganic source (N_1) but both treatments such as 100% organic source (N_2) and 100% inorganic source (N_1) were statistically significant with each other. Basin irrigation with mulch with INM practices recorded maximum yield of green and marketable papaya fruits. Supply of nutrients through 100% organic source along with basin irrigation without mulch recorded lowest yield. Interaction effect of irrigation methods and nutrient management practices was non-significant with respect to papaya yield. During 2012, significantly highest mean fruit yield of 22.58 t ha^{-1} was observed with basin irrigation with straw mulch (I_2) whereas lowest fruit yield (15.25 t ha^{-1}) was observed with basin irrigation without straw mulch (I_3). Among the nutrient treatment highest fruit yield of 21.93 t ha^{-1} was observed with integrated nutrient management practice (N_3) whereas the yield due to different treatments are statistically *at par*.

Pooled analysis of papaya fruit yield for three years, irrespective of nutrient management practices indicated that maximum fruit yield of 23.17 t ha^{-1} was observed with basin irrigation along with straw mulch (I_2) whereas, lowest value of 18.31 t ha^{-1} was observed with basin irrigation without straw mulch (I_3). The maximum fruit yield with respect to basin irrigation with straw mulch may be attributed to favorable hydro-thermal regime, improved physical properties such as bulk density, soil aggregates, porosity along with chemical properties like organic carbon content and availability of different nutrients and biological properties. These results are in agreement with the findings of Srinivas (1996) and Suresh and Saha (2004). They found that 30% and 37% increase in fruit yield of papaya with drip

Table 1: Effect of irrigation methods and nutrient management practices on yield attributing characters of papaya (pooled)

Treatments	Plant height at initiation of flowering (cm)	Fruits plant^{-1} (Number)	Fruit weight (g)
Irrigation methods			
I_1 : Drip irrigation	61.35	23.43	630.11
I_2 : Basin irrigation with straw mulch	62.13	24.76	677.67
I_3 : Basin irrigation without straw mulch	57.50	20.55	585.78
SEm(±)	**1.18**	**0.30**	**18.94**
LSD(0.05)	**3.50**	**0.88**	**56.84**
Nutrient management practices			
N_1 :100% inorganic Source	63.11	22.91	641.78
N_2 : 100% organic Source	55.18	20.43	561.56
N_3 : Integrated Nutrient Management Practices (75% inorganic source + 25% organic source)	62.70	25.40	690.22
SEm(±)	**1.15**	**0.41**	**27.40**
LSD (0.05)	**3.25**	**1.17**	**77.55**

Table 2: Effect of irrigation methods and nutrient management practices on yield and water use efficiency of papaya (pooled)

Treatments	Fruit yield (t ha^{-1})				Water requirement (cm)	Water useefficiency (kg ha cm^{-1})
	2010	**2011**	**2012**	**Pooled**		
Irrigation methods						
I_1 : Drip irrigation	19.01	21.38	20.76	20.38	159.80	127.53
I_2 : Basin irrigation with straw mulch	22.85	24.08	22.58	23.17	205.43	112.78
I_3 : Basin irrigation without straw mulch	18.29	18.40	18.25	18.31	244.31	74.94
SEm (±)	**0.59**	**0.74**	**0.60**	**0.37**		
LSD (0.05)	**2.03**	**2.58**	**2.08**	**1.11**		
Nutrient management practices						
N_1 : 100% inorganic source	20.59	21.87	20.40	20.95	208.30	100.57
N_2 : 100% organic source	17.92	18.62	19.26	18.60	183.72	101.24
N_3 : Integrated nutrient management practices (75% inorganic + 25% organic)	21.64	23.36	21.93	22.31	201.13	110.92
SEm (±)	**0.60**	**0.76**	**0.76**	**0.24**		
LSD (0.05)	**1.78**	**2.24**	**NS**	**0.69**		

irrigation over surface methods. Similar results was observed by Sivanappan (1994) indicated that the increase in yield could be 45% with drip irrigation over basin irrigation

Pooled analysis of fruit yield for three years, irrespective of irrigation treatment, maximum fruit yield of 22.31t ha^{-1} was observed with integrated nutrient management practices (N_3) which was significantly higher than that of 100% organic source(N_2) and 100% inorganic source (N_1). Addition of 100% inorganic source (N_1) recorded fruit yield of 20.95 t ha which was significantly higher than the fruit yield (18.60 t ha^{-1}) due to application of 100% organic source (N_2). This result corroborates the finding of Reddy *et al.* (2010). They observed that crop growth and fruit yield of papaya were higher in inorganic fertilizer treated plot (55 t ha^{1}) as compared to organic treatments (26.9 to 38 t ha^{-1}).

The interaction effect both irrigation methods and nutrient management practices for the three years revealed that basin irrigation with straw mulch along with integrated nutrient management practices produced highest fruit yield of 24.32 t ha^{-1} which was significantly higher than any other combination of irrigation methods and nutrient management practices.

Water requirement (WR) and water use efficiency (WUE)

Irrespective of nutrient management practices, water requirement of different irrigation treated plots varied

Table 3: Interaction effects of irrigation methods and nutrient management practices on fruit yield of papaya (pooled)

Irrigation methods	Fruit yield (t ha^{-1}) Nutrient management practices			
	N_1	N_2	N_3	Mean
I_1	20.20	17.54	23.41	20.38
I_2	23.35	21.84	24.32	23.17
I_3	19.32	16.41	19.20	18.31
Mean	20.96	18.60	22.31	
SEm(±) I × N		**0.51**		
LSD(0.05) I × N		**1.43**		

Table 4: Interaction effects of irrigation methods and nutrient management practices on soil properties at root zone as measured after first harvest in every year (pooled)

Irrigation methods	Fruit yield (t ha^{-1}) Nutrient management practices			
	N_1	N_2	N_3	Mean
	Soil bulk density (g cc^{-1})			
I_1	1.45	1.42	1.42	1.43
I_2	1.37	1.39	1.43	1.40
I_3	1.51	1.55	1.47	1.51
Mean	1.44	1.45	1.44	1.45
LSD (0.05) I × N		**NS**		
	Soil organic carbon (%)			
I_1	0.64	0.61	0.63	0.63
I_2	0.62	0.64	0.68	0.65
I_3	0.55	0.57	0.62	0.58
Mean	0.60	0.61	0.64	0.62
LSD (0.05) I × N		**NS**		
	Microbial respiration (mg CO_2 g^{-1} soil day^{-1})			
I_1	0.37	0.33	0.39	0.36
I_2	0.51	0.51	0.43	0.48
I_3	0.36	0.42	0.41	0.40
Mean	0.41	0.42	0.41	0.41
LSD (0.05) I × N		**NS**		

from 159.8 to 244.3 cm. (Table 2). The highest water requirement of 244.3 cm was observed with basin irrigation without straw mulch (I_3) whereas, lowest value of 159.8 cm was observed with drip irrigation (I_1). Irrespective of irrigation treatments, water requirement of different nutrient management plot varied from 183.72 to 208.30 cm. The highest water requirement of 208.30 cm was observed with 100% inorganic source (N_1) whereas, lowest value of 183.72cm was observed with 100% organic (N_2).

Irrespective of irrigation schedule, water use efficiency (WUE) for different nutrient management treatments varied from 100.57 to 110.92 kg $ha^{-1}cm^{-1}$.

The mean WUE was highest (110.92 kg $ha^{-1}cm^{-1}$) with integrated nutrient management practices (N_3). Irrespective of nutrient management practices, mean highest WUE value of 127.53 kg $ha^{-1}cm^{-1}$ was observed with drip irrigation (I_1). It might be due to application of water to the root zone of the crop in smaller droplets which reduces water loss through seepage and deep percolation during conveyance of water indirectly improving water use efficiency. These results are in agreement with the findings of Sivanappan (1998). He reported that 68% savings in water at Coimbatore due to adoption of drip irrigation compared to basin irrigation (2280 mm). Adoption of drip irrigation resulted in water savings of 25-45% in papaya compared to surface basin irrigation (Padmakumari and Sivanappan, 1983). Srinivas (1996) observed water saving of 50-60 % with drip irrigation method than furrow irrigation (3510 mm) in papaya at Bangalore.

Changes in soil properties

Pooled result of three years' experimentation revealed that root zone soil was influenced by irrigation methods with respect to bulk density and soil organic carbon. Treatment combination of basin irrigation + paddy straw mulch maintained better soil health with more porosity and organic matter. It also maintained highest microbial activity (0.48 kg CO_2 g^{-1} soil day^{-1}) as measured in terms of microbial respiration. The treatments were *at par* with respect to nutrient management practices.

Therefore, adoption of basin irrigation and straw mulch along with integrated nutrient management practices (75% inorganic +25% organic) could maximize fruit yield of papaya maintaining highest microbial activity of soil.

ACKNOWLEDGEMENTS

Authors are grateful to the Directorate of Water Management (ICAR), Bhubaneswar and OUAT, Bhubaneswar for providing facilities for carrying out the research work.

REFERENCES

Mauyra, P.R. and Beniwal, S.V. 2003. Use of biofertilizers in horticultural crops. *Newsl. Agrobios*, **1:** 12-13.

Nambiar, K.K.M. and Abrol, I.P.1989. Long term fertilizer experiments in India: An area view. *Fert. News,* **34**: 11-26.

Narayanamoorthy, A. 2004. Drip Irrigation in India: Can it Solve Water Scarcity? *Water Policy,* **6:** 117-30.

Padmakumari, O. and Sivanappan, R. K. 1989. Drip irrigation for papaya. *Proc. 11th Int. Conf. Agril. Eng.*, Sept. 4-8, Dublin, Ireland, pp. 134-36.

Panse, V. G. and Sukhatme, P. 1978. *Statistical Methods for Agricultural Workers.* ICAR, New Delhi.

Reddy, Y. T. N., Kurian, R. M., Ganeshamurthy, A. N. and Pannerselvam, P. 2010. Effect of organic nutrition practices on papaya (cv. Surya) fruit yield, quality and soil health. *J. Hort. Sci.,* **5:** 124-27.

Sharma, A. K. 2005. The living soil. In Biofertilizers for Sustainable Agriculture, *Newsl. Agrobios*, Jodhpur, pp. 1-19

Singh, I.D. 1990. *Papaya*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, pp. 186-87.

Singh, V. K., Kumar, V. and Bahuguna, A. 2012. Impact of fertilizer on yield of papaya under indo-gangetic conditions. *J. Crop Weed*, **8:** 74-76.

Sivanappan, R.K.1998. Low cost micro irrigation system for all crops and all farmers. *Proc. of Workshop Micro Irrigation and Sprinkler Irrigation Systems,* April 1998 at New Delhi. , pp. 15 -20.

Srinivas, K. 1996. Growth, yield and water use of papaya under drip irrigation. *Indian J. Hort.*, **53**:19-22.

Suresh, R. and Saha, D. P. 2004. Effect of mulching and drip irrigation on papaya in calcareous soil of North Bihar. *Prog. Hort.*, **36:** 76-81.

Yadava, U.L., Janice,A., and Mc Gary, D. 1990. Papaya: A Potential annual crop under middle Georgia conditions. In. *Advances in New Crops* (Janick, J. and Simons J.E.,Eds.) Timber Press, Portland, pp: 364-66.