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Effect of fertigation on growth, yield and quality of papaya (*Carica papaya* L.) cv. MADHU BINDU under South Gujarat conditions

■R.V. TANK, N.L. PATEL[1] AND J.R. NAIK[1]

Associated Authors:
[1]Department of Horticulture, N.M. College of Agriculture, Navsari Agricultural University, NAVSARI (GUJARAT) INDIA

Author for correspondence :
R.V. TANK
Department of Horticulture, N.M. College of Agriculture, Navsari Agricultural University, NAVSARI (GUJARAT) INDIA

Abstract : An experiment to study the effect of fertigation on growth, yield and quality of papaya (*Carica papaya* L.) cv. MADHU BINDU under South Gujarat conditions was carried out for two years at the Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsasi, Gujarat in randomized block design with 9 fertigation treatments and a control having surface irrigation @ 1.0 IW/CPE ratio + 100 per cent fertilizer through soil. The results of experiment showed early flowering and maturity of first fruit, shortest bearing height, maximum plant height and stem girth, number of functional leaves and total leaf area were found due to application of fertigation @ 0.8 PEF + N and K_2O @ 100 per cent recommended dose of fertilizer (RD) which remained at par with treatment of fertigation @ 0.8 PEF + N and K_2O @ 80 per cent RD. The higher yield of papaya fruits in above treatments was about 31.90 and 31.07 per cent, respectively over control treatment which was attributed to higher number and weight of fruits. These treatments also maintained its superiority in improving quality of papaya fruits. While total carotenoids contents remained unaffected due to different treatments.

Key words : Papaya, Fertigation, Growth, Yield, Quality

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Papaya (*Carica papaya* L.) belongs to family Caricaceae is an important fruit crops of the tropics and sub tropics and deserves greater attention due to its high nutritive value and production potentiality. The crop is extremely sensitive to collar rot under flood irrigation where water comes in direct contact with the trunk. Application of water and soluble nutrients to growing plants through fertigation is an effective method to obtain higher and quality yield along with saving of water and labour. Fertigation involves not only efficient use of the two most precious inputs like water and nutrients but also ensures their simultaneous availability to plants. Jeyakumar *et al.* (2010) and Sadarunnisa *et al.* (2010) reported positive influence of fertigation on plant growth, yield and quality of papaya. Badgujar *et al.* (2004) also revealed the favourable response of fertigation on yield and yield attributing parameters of Grand Naine banana.

Gujarat is the second largest (14100 ha) state under papaya cultivation in India after Andhra Pradesh (Anonymous, 2009). Warm and humid conditions of South Gujarat make papaya cultivation effective in this region. Hence, the present experiment entitled fertigation studies in papaya (*Carica papaya* L.) cv. MADHU BINDU under South Gujarat conditions was planned and carried out to know the effect of fertigation on growth, yield and quality of papaya.

RESEARCH METHODS

The present experiment was conducted during the year 2007-08 and 2008-09 at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat. The experimental soil was deep black having moderate drainage as well as good water holding capacity with 7.8 pH belongs to great soil group Vertic Ustochrepts under soil series of Jalalpor. Transplanting of papaya was done with healthy seedlings of 60 days age at a distance of 2.1 m x 1.9 m in triangular fashion. The treatments comprised of nine fertigation treatments *viz.*, drip irrigation @ 0.4 PEF + N and K_2O @ 60 per cent RD (T_1), drip irrigation @ 0.4 PEF + N and K_2O @ 80 per cent RD (T_2), drip irrigation @ 0.4 PEF + N and K_2O @ 100 per cent RD (T_3), drip irrigation @ 0.6 PEF + N and K_2O @ 60 per cent RD (T_4), drip irrigation @ 0.6 PEF + N and K_2O @ 80 per cent RD (T_5), drip irrigation @ 0.6 PEF + N and K_2O @ 100 per cent RD (T_6), drip irrigation @ 0.8 PEF + N and K_2O @ 60 per cent RD (T_7), drip irrigation @ 0.8 PEF + N and K_2O @ 80 per cent RD (T_8), drip irrigation @ 0.8 PEF + N and K_2O @ 100 per cent RD (T_9), in addition to soil application of 100 g phosphorus at 1½ month and at 3 months after transplanting and a control having surface irrigation at 1.0 IW/CPE ratio + 100 per cent RDF of N, P_2O_5 and K_2O at 2, 4, 6 and 8 months after transplanting through soil (T_{10}). The recommended doze of fertilizer was 200 g N, 200 g P_2O_5 and 250 g K_2O per plant. In case of fertigation, N and K_2O applied through drip in form of urea and muriate of potash, respectively in twelve equal splits at 15 days intervals starting from 45 days after transplanting.

The required quantity of water was applied at alternate day on the basis of evaporation under drip irrigation treatments except rainy days. In case of control treatment required quantity of water was applied on the basis of IW/CPE ratio using 15 cm throat size parshall flume. High density polyethylene pipes (HDPE) of 75 mm diameter was directly connected from a 3 HP submersible pump to head unit of the drip irrigation system. The head unit consisted of screen filter (40 m^3/hr), pressure gauge, fertigation tank (90 litres), by pass assembly and control valve. Polyvinyl chloride (PVC) pipes of 75 mm and 50 mm diameter were used as main and sub main, respectively. Lateral of 16 mm diameter of low density polyethylene pipe (LDPE) was laid out at the distance of 2.1 m in the every plot and two 8 lph capacity drippers were placed at 30 cm on the either side of the plant trunk. Each lateral was provided with lateral cock in order to deliver desired quantity of water and fertilizer to each treatment. The system was operated at alternate day and the optimum pressure of 1.2 kg/cm^2 was maintained in the drip system with the help of control valve. The observations on growth, yield and yield attributing characters and fruit quality were recorded and analysed statistically.

RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads:

Growth parameters:

The measurements on growth parameters (Table 1) of the plant revealed the significant influence of fertigation in papaya. Among all the treatments, the plants which received drip irrigation @ 0.8 PEF + N and K_2O @ 100 per cent RD (T_9) resulted in bearing height at lower level and minimum days to flowering and days to maturity of first fruit after transplanting. The shortest flowering height was noted in treatment T_8. It might be due to effective utilization and accurate placement of fertilizers in soluble form at the active root zone area resulting in vigorous growth which ultimately resulted in early flowering and bearing (Madhumathi *et al.*, 2004). The maturity was delayed in the treatment T_{10} (Surface 1.0 IW/CPE ratio

Table 1 : Effect of fertigation on growth parameters (Pooled data)

Treatments	Height at first flowering (cm)	Bearing height (cm)	Days to flowering	Days to maturity of first fruit	Plant height (cm)	Stem girth (cm)	No. of functional leaves/plant	Total leaf area/plant (m^2) at 240 DATP
					At 300 DATP			
T_1	83.28	92.08	91.27	278.00	150.39	31.22	37.13	4.49
T_2	75.78	83.67	83.17	268.07	160.14	33.09	39.97	5.14
T_3	72.45	79.92	80.97	263.13	166.68	34.17	41.10	5.46
T_4	76.94	84.72	86.63	272.90	160.36	32.31	39.33	4.92
T_5	71.04	77.94	78.67	261.80	170.85	35.51	42.50	5.79
T_6	63.99	73.26	75.33	259.07	179.89	36.97	44.30	6.30
T_7	70.40	77.49	78.63	263.27	171.27	34.72	41.70	5.38
T_8	60.45	68.34	71.37	253.57	184.81	38.84	46.60	6.58
T_9	62.65	67.94	69.10	249.00	189.02	40.18	48.73	6.88
T_{10}	74.71	83.74	81.50	267.07	164.00	34.27	41.53	5.28
S.E. ±	2.62	2.39	1.81	3.81	4.78	1.26	1.24	0.28
C.D. (P=0.05)	7.48	6.82	5.18	10.94	13.62	3.62	3.52	0.80
C.V. %	9.68	8.07	5.50	3.54	7.68	8.81	7.97	13.46

+ 100 per cent of N, P_2O_5 and K_2O through soil) as compared to higher level of fertigation treatments (T_9 and T_8). This might be due to moisture stress experienced between the irrigation intervals and competition of nutrients with weeds which was also reported by Agrawal and Agrawal (2005) in banana. The results of present investigation are in confirmation with those of earlier workers Sharma *et al.* (2005) and Sadarunnisa *et al.* (2010).

The growth parameters *viz.*, plant height, stem girth; number of functional leaves and leaf area were significantly influenced due to different treatments. Application of drip irrigation @ 0.8 PEF + N and K_2O @ 100 per cent RD (T_9) and drip irrigation @ 0.8 PEF + N and K_2O @ 80 per cent RD (T_8) in addition to soil application of 100 g P_2O_5 each at $1^1/_2$ month and 3 months after transplanting to papaya plants resulted in taller plants with thicker girth, maximum number of functional leaves and leaf area. The increase in plant height, stem girth, number of functional leaves and leaf area might be due to the higher uptake and accumulation of nutrients in leaf tissues which in turn ensure photosynthetic efficiency causing greater synthesis, translocation and accumulation of carbohydrates (Ghanta *et al.,* 1995). Similar findings were reported by Srinivas (2000). The better performance of papaya crop in terms of plant height and girth was observed under drip irrigation largely due to adequate supply of water and reduced weed growth (Rungsimanop *et al.,* 1987). The vigorous growth was earlier reported by Sharma *et al.* (2005), Sadarunnisa *et al.* (2010) and Jeyakumar *et al.* (2010) in papaya due to fertigation.

Fruit characteristics:

Fruit characteristics like fruit length, circumferences, volume, pulp thickness and firmness were influenced significantly and found maximum (Table 2) in the treatment T_9 and T_8. But fruit cavity volume and index noted minimum in these treatments. It might be due to production of more photosynthates due to more number of leaves and leaf area besides enhanced physiological traits might have resulted in better transfer to the sink, developing fruit with thicker pulp and low cavity index in fertigated plants (Jeyakumar *et al.,* 2010). The increase in fruit volume could be ascribed to bigger size of fruits under optimum dose of fertilizer through drip irrigation. Lower cavity index is beneficial in papaya as it relates with more pulp thickness (Muthulakshmi *et al.,* 2007). Among the different treatments under study, treatments T_9 and T_8 resulted in low cavity index due to the increase in the volume of the fruit with a corresponding increase in pulp thickness. Similarly, Jeyakumar *et al.* (2010) also noted low cavity index in papaya under fertigation. The increase in fruit characteristics in papaya with fertigation was reported by Singh and Singh (2006) and Jeyakumar *et al.* (2010).

Yield and yield attributes:

The positive influence of higher levels fertigation (T_9 and T_8) on growth attributes and fruit characteristics ultimately reflected in maximum number of fruits per plant, average fruit weight and yield of papaya (Table 3) in these particular treatments in present study. This might be due to the increase in growth traits which helped to increase the synthesis of carbohydrates which utilized for the development of fruits. In the present study, the plant receiving treatment T_9 recorded higher number of fruits per plant, average fruit weight and fruit yield over rest of the treatments but, it was at par with treatment T_8. The

Table 2 : Effect of fertigation on fruit characteristics (Pooled data)

Treatments	Fruit length (cm)	Fruit circumferences (cm)	Fruit volume (cc)	Fruit cavity volume (cc)	Fruit cavity index (%)	Pulp thickness (cm)	Fruit firmness (kg/cm^2)
T_1	18.55	36.93	1027.44	321.51	31.23	2.91	3.40
T_2	19.33	40.04	1116.15	311.04	27.88	3.00	3.50
T_3	20.53	41.40	1169.71	288.99	24.81	3.16	3.46
T_4	19.11	39.89	1082.00	313.10	29.07	3.04	3.40
T_5	19.79	41.90	1240.15	285.52	23.11	3.34	3.47
T_6	21.64	43.24	1301.57	257.91	19.83	3.65	3.63
T_7	19.95	42.33	1226.44	281.23	23.31	3.53	3.46
T_8	23.81	46.66	1337.45	244.51	18.31	3.94	3.74
T_9	24.23	45.09	1357.95	232.21	17.09	4.05	3.91
T_{10}	19.76	42.04	1159.11	297.81	25.73	3.27	3.44
S.E. ±	0.67	1.11	41.93	11.93	1.20	0.14	0.12
C.D. (P=0.05)	1.90	3.16	120.26	34.00	3.45	0.40	0.33
C.V. %	8.69	7.07	8.50	11.29	12.30	11.14	8.57

increase in yield was largely as a consequence of higher fruit number and fruit weight. Apart from this, drip irrigation restricts the fluctuations in soil water potential within a narrow range and maintained favourable water regime leading to higher yield (Bresler, 1977). The adoption of fertigation might have maintained congenial moisture regime and better nutrient availability through out the crop growth period than surface method of irrigation. Differences in yield between fertigated plants and plants under conventional method of irrigation might be due to constant and continuous supply of water and nutrients in soluble form to the wetted area of the root zone ensuring better availability of nutrients (Mahalakshmi *et al.,* 2001 and Kavino *et al.,* 2004). The increased in yield parameters and yield through fertigation were reported by Sharma *et al.* (2005).

Quality:

Fertigation had significant influence on quality parameters by recording higher levels of TSS, total sugars, reducing sugars, non-reducing sugar, and ascorbic acid (Table 4). However, total carotenoids content in fruit was remain unchanged. An improvement in the quality parameters under the higher level of fertigation treatments (T_9 and T_8) could be due to better availability of water and nutrients through out the plant growth period. The quality improvement was due to involvement of K in carbohydrate synthesis, breakdown and translocation of starch, synthesis of protein and neutralization of physiologically important organic acids which has been noted by Tisdale and Nelson, (1966). The superiority of fertigation treatments in improving the quality of papaya also been reported by Jeyakumar *et al.* (2002), Jeyakumar *et al*. (2010) and Sharma *et al.* (2005).

Table 3: Effect of fertigation on yield and yield attributes (Pooled data)

Treatments	Number of fruits/plant	Average fruit weight (kg)	Fruit yield (kg/plant)	Fruit yield (t/ha)
T_1	19.77	0.931	18.44	41.48
T_2	21.23	1.032	21.89	49.24
T_3	22.60	1.107	24.99	56.24
T_4	21.13	1.045	22.03	49.56
T_5	23.80	1.173	27.92	62.82
T_6	24.73	1.221	30.24	68.03
T_7	23.97	1.194	28.62	64.39
T_8	28.37	1.240	35.05	78.87
T_9	28.43	1.252	35.48	79.83
T_{10}	22.87	1.057	24.16	54.36
S.E. ±	1.19	0.036	1.50	3.38
C.D. (P=0.05)	3.42	0.103	4.31	9.69
C.V. %	12.34	7.84	13.69	13.69

Table 4 : Effect of fertigation on fruit quality (Pooled data)

Treatments	TSS (^{0}Brix)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Ascorbic acid (mg/100 g pulp)	Total carotenoids (mg/100 g pulp)
T_1	8.90	7.62	6.71	0.92	27.22	2.33
T_2	9.67	8.50	7.31	1.20	29.07	2.30
T_3	10.07	8.94	7.65	1.28	30.32	2.29
T_4	9.52	8.25	7.14	1.11	28.19	2.28
T_5	9.95	8.93	7.63	1.30	30.69	2.26
T_6	10.50	9.58	8.19	1.40	33.11	2.22
T_7	10.15	8.77	7.57	1.20	31.15	2.20
T_8	10.98	9.90	8.45	1.45	35.07	2.20
T_9	11.22	10.05	8.55	1.50	35.86	2.17
T_{10}	9.75	8.61	7.44	1.17	29.04	2.21
S.E. ±	0.27	0.28	0.27	0.07	1.04	0.12
C.D. (P=0.05)	0.78	0.81	0.76	0.19	2.98	NS
C.V. %	6.60	8.57	9.32	14.47	8.23	9.10

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