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Original Research Paper

Standardisation of fertigation in papaya for higher productivity and profitability

Manjunath B.L.[1*], Gutam S.[2] and Raghupathi H.B.[3]

[1]Division of Fruit Crops, [2]Division of Basic Sciences, [3]Division of Natural Resources
ICAR-Indian Institute of Horticultural Research, Bengaluru - 560089, Karnataka, India
[*]Corresponding author Email: manjunath.bl@icar.gov.in

ABSTRACT

A field experiment conducted to standardize the fertigation in papaya (*Carica papaya* L.) variety Arka Prabhat with 12 treatments in split plot design, indicated that fertigation with 75% recommended fertilizers (250:250:500 g NPK/plant/year) through water soluble fertilizers recorded significantly higher fruit yield (47.34 t/ha), fertilizer use efficiency (20.45 kg fruit yield/kg of nutrient applied) and increase in 31% higher yield over soil application. The TSS of papaya fruit was although not significantly influenced by both doses and sources of fertigation, significantly lower cavity index (3.12%) was observed when RDF was supplied with organics to the soil. Fertigation with 100% RDF through water soluble fertilizers recorded significantly higher soil organic carbon (1.16%). However, fertigation of 75% RDF with inorganic fertilizers was found more economical with higher gross returns (Rs.7.10 lakh/ha), net returns (Rs.4.7 lakh/ha) and benefit cost ratio (2.96).

Keywords : Benefit cost ratio, fertigation, papaya, productivity, profitability

INTRODUCTION

Papaya (*Carica papaya* L.) is a common fruit crop grown in the Southern region of India. The crop is being cultivated in an area of 1,49,000 ha with a production of 57,44,000 MT (Anonymous, 2022). Fertigation combines the application of water and nutrient required for plant growth and development and allows an accurate and uniform application of nutrients to the wetted area in the root zone. Through fertigation, it is possible to supply an adequate quantity and concentration of nutrients to meet the demand of the crop throughout growing season. Further, fertigation is the most efficient method of fertilizers application, as it ensures application of the fertilizers directly to the plant roots (Rajput and Patel, 2002). The scheduling of fertigation for crops will benefit the farmers to increase the yield and improve the quality of produce through efficient use of water and fertilizers. Use of fertigation in fruit crops was reported to save 30-50% of fertilizer doses as well as irrigation (Shirgure *et al*., 2001; Shirgure and Srivastava 2014). Further, it is imperative to achieve the high nutrient use efficiency and reducing the requirement of bulk fertilizers to 25% (Malhotra, 2016).

Fertigation has been substantiated for many crops throughout world. It has been reported that efficiency of nitrogenous fertilizers is 95% under drip-fertigation compared to 30-50% under soil application. When a fertilizer is applied to a soil, nearby water begins to move very gradually toward the area where the fertilizer has been applied. Fertilizer salts begin to diffuse, or move away from the place where they were applied. This dilutes the fertilizer and distributes it throughout a much larger area. If tender plant roots are close to the placement of a fertilizer, water is drawn from these roots, as well as from surrounding soil (Rajput and Patel, 2002). Further, Sathya *et al*. (2008) observed that the availability of N, P and K nutrient was found to be higher in root zone area of drip fertigated plot, while nitrogen and potassium moved laterally from point source up to 15 cm and vertically up to 15-25 cm and P moved 5 cm both laterally and vertically and thereafter dwindled.

Nitrogen promotes vegetative growth, flower and fruit set. High level of phosphorus throughout root zone is essential for rapid root development and good utilization of water and other nutrients by plant. Phosphorous has pronounced effect on the flowering, in combination with N and K improves peel colour, taste, hardiness and vitamin C content and hastens maturity. Potassium tends to increase fruit size, fruit quality and rectifies many disorders. It also helps in decreasing incidence of irregular shaped fruits. However, standardisation of the schedules of fertigation is crucial to decide both the doses and in coinciding the crop nutrient requirement with different stages of the crop. Keeping this in view, a field experiment was carried out to standardize the fertigation in papaya.

MATERIALS AND METHODS

The experiment was conducted during 2020-21 at ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka, which is located at an altitude of 890 m above mean sea level and lies between coordinates of 13° 8' N latitude and 77° 29' E longitude. Soil of experimental field was sandy loam with 6.27 pH, 0.16 dS m^{-1} EC, and 0.78% organic carbon. The soil had an initial nutrient content of 283 kg available N/ha, 42.0 kg available phosphorus/ ha and 246.4 kg available potassium/ha.

Uniform and well-developed 45 days old seedlings of papaya var. Arka Prabhat were planted at a spacing of 1.8 m x 1.8 m on raised beds during July 2020 and the treatments were imposed with the crop establishment. The crop was managed with recommended package of practices except for irrigation. The experiment was carried out in split plot design with 12 treatment combinations consisting of three doses of fertilizers, *viz*., M_0: 100% RDF (250 g N + 250 g P_2O_5 + 500 g K_2O per plant/year), M_1: 125% RDF, and M_2: 75% RDF as main plot and four sources of nutrients, *viz*., S_0: fertigation through inorganic sources (urea, MKP and SOP) S_1: fertigation through organic sources (humic acid and vermiwash), S_2: soil application of only organic sources (FYM, vermicompost, neem cake, *Sesbania* and *Glyricidia* loppings), and S_3: soil application of FYM+ RDF (urea, SSP and MOP) as control as sub-plot treatments. Each treatment was replicated four times and each replication had five plants.

Observations were recorded on various parameters of plant growth and physiology, root growth, soil fertility, yield, and TSS and fruit cavity index after 240 days after planting. The physiological parameters were measured using IRGA portable photosynthesis system. The horizontal and vertical root growth was measured for the longest spread, and the root volume was calculated based on the displacement of water technique at the end of the crop season on a destructive mode. The dry weight of roots was calculated by carefully uprooting the roots with soil, washing with water and drying with hot air oven. Soil samples were collected at the end of the crop from 0-30 cm at 30-40 cm away from the base of the plant. Soil chemical and fertility parameters such as pH, organic carbon, available phosphorus (P) and potassium (K) were analysed as per standard procedures described by Jackson (1973). The fruit cavity index (%) was calculated by fruit cavity volume divided by fruit volume and multiplied by 100. Plant canopy volume was calculated using the formula $2/3\pi H$ (A/2 x B/2)], where H stands for plant height, A and B stands for EW and NS plant canopy spread (Thome *et al*., 2002). Fertilizer use efficiency was calculated based on the fruit yield obtained and the fertilizer nutrient used in each of the treatment. All the experimental data were statistically analysed as per Panse and Sukhatme (1985), and the differences in means were compared at 5% level of significance.

RESULTS AND DISCUSSION

Plant growth parameters

The plant height in papaya was significantly influenced by fertilizer doses and fertigation sources (Table 1). Significantly higher plant height (1.19 m) was recorded with 125 % RDF and among the sources, fertigation with RDF through inorganics recorded higher plant height (1.20 m).

Number of leaves were significantly higher with 125% RDF (20.63/plant) as compared to other sources, and further application of water soluble fertilizers recorded significantly higher number of leaves (20.6/plant) differing from other sources. Among the interactions, soil application of organic sources meeting 125 % RDF recorded significantly more number of leaves (21.5/plant). The plant girth in papaya differed significantly both due to doses and sources of nutrients although their interactions were non-significant. Significantly higher plant girth (26.28 cm) was recorded with application of 75 % of RDF, and among the sources, fertigation with inorganic sources recorded more plant girth (26.92 cm). Canopy volume in papaya was not significantly influenced by the fertilizer doses and their interaction with various sources. However, fertigation with water soluble fertilizers recorded significantly higher (1.64 m^3) canopy volume differing from rest of the sources.

Table 1 : Mean plant growth parameters in papaya as influenced by fertilizer doses and fertigation sources

Treatment	Plant height (m)	No. of leaves/plant	Stem girth (cm)	Canopy volume (m^3)
Main plot				
M_0	1.00	15.66	20.56	0.95
M_1	1.19	20.63	25.78	1.18
M_2	1.10	18.63	26.28	1.16
Subplot				
S_0	1.20	20.63	26.92	1.64
S_1	1.05	16.67	22.42	1.00
S_2	1.03	17.33	22.71	0.81
S_3	1.11	18.59	24.79	0.93
Interaction				
M_0S_0	1.10	21.00	24.75	1.44
M_0S_1	0.95	13.75	20.00	0.75
M_0S_2	0.90	12.00	17.00	0.65
M_0S_3	1.07	15.88	20.50	0.96
M_1S_0	1.32	21.00	26.75	1.78
M_1S_1	1.13	19.00	23.38	1.34
M_1S_2	1.15	21.50	27.50	0.87
M_1S_3	1.15	21.00	25.50	0.74
M_2S_0	1.18	19.88	29.25	1.71
M_2 S_1	1.06	17.25	23.88	0.92
M_2S_2	1.05	18.50	23.63	0.91
M_2S_3	1.12	18.88	28.38	1.10
S Em ± Main	0.02	0.65	0.37	0.07
Sub	0.03	0.66	0.80	0.21
Main x Sub^{-1}	0.05	1.19	1.25	0.32
C.D (P=0.05) Main	0.07	2.31	1.30	NS
Sub	0.08	1.93	2.33	0.60
Main x Sub^{-1}	NS	3.69	NS	NS

Physiological parameters in papaya

Although, the fertigation sources found to have non-significant impact on different physiological parameters recorded, the doses of fertilizers influenced the photosynthesis, respiration and stomatal conductance significantly (Table 2). Application of either 75% or 100% recommended fertilizers recorded significantly higher photosynthetic rate (16.34 µ mol m^{-2} s^{-1} and 16.24 mol m^{-2} s^{-1}, respectively), the former also recorded significantly higher stomatal conductance (0.14 mol H_2O m^{-2} s^{-1}) and transpiration rate (3.07 mol m^{-2} s^{-1}). Among the interactions, application of recommended fertilizers through fertigation (M_0S_0) recorded significantly higher photosynthetic rate (17.53 µ mol m^{-2} s^{-1}), which was followed by application of 75% RDF with organic sources of fertigation (M_2S_1), the latter also recording higher transpiration rate (3.14 mol m^{-2} s^{-1}). Application of 75% RDF through fertigation (M_2S_0) recorded significantly higher stomatal conductance (0.16 mol H_2O m^{-2} s^{-1}) also. Better physiological parameters in fertigated plants may be attributed to the higher nutritional status (N, P and K content), leaf N and K contents and physiological efficiency (Shirgure *et al.,* 2001), fertigated papaya plants recorded higher physiological efficiency (especially total chlorophyll content), photochemical efficiency, stomatal conductance and net photosynthesis, water use efficiency and relative water content compared with plants not subjected to fertigation.

Table 2 : Physiological parameters in papaya as influenced by fertilizer doses and fertigation sources

Treatment	Photosynthetic rate (μ mol m^{-2} s^{-1})	Stomatal conductance (mol m^{-2} s^{-1})	Transpiration rate (mol m^{-2} s^{-1})
Main plot			
M_0	16.24	0.09	1.94
M_1	12.61	0.07	2.32
M_2	16.34	0.14	3.07
Sub plot			
S_0	14.70	0.11	2.52
S_1	14.25	0.09	2.23
S_2	15.82	0.10	2.55
S_3	15.48	0.10	2.47
Interaction			
M_0S_0	17.53	0.11	2.54
M_0S_1	15.15	0.08	1.85
M_0S_2	16.26	0.09	1.58
M_0S_3	16.00	0.08	1.77
M_1S_0	9.69	0.05	1.91
M_1S_1	10.35	0.04	1.71
M_1S_2	16.10	0.09	3.01
M_1S_3	14.29	0.09	2.67
M_2S_0	16.88	0.16	3.11
M_2 S_1	17.26	0.14	3.14
M_2S_2	15.09	0.11	3.06
M_2S_3	16.15	0.13	2.97
S Em ± Main	0.20	0.01	0.15
Sub	0.41	0.01	0.15
Main x Sub^{-1}	0.64	0.01	0.27
C.D (P=0.05) Main	0.80	0.03	0.60
Sub	NS	NS	NS
Main x Sub^{-1}	1.98	0.04	0.89

Root growth

The impact of fertigation treatments on root growth parameters indicated that both the lateral and vertical root growth in papaya was significantly influenced by the doses and sources of fertigation although the root volume showed non-significant differences (Table 3). The vertical growth of the roots was significantly higher with application of 100 % RDF (84.1 cm) and especially with soil application of organic sources (97.5 cm) both of which differing significantly from other treatments. Although, the horizontal growth of roots was significantly influenced both by the fertilizer doses and the fertigation sources, their interaction was non- significant. In general, application of 75 % of RDF (163.8 cm) and among the sources, soil application of nutrients (174.5 cm) showed significantly higher lateral spread of roots. Root dry weight in general was significantly higher with 125 % RDF, and among the sources soil application of RDF shown significantly higher root dry weight (641.2 g $plant^{-1}$) differing significantly from rest of the fertigation sources.

Soil fertility

The pH of soil was influenced significantly both by the doses and sources of fertigation under papaya. Lowering the dose of fertilizers to 75 % RDF recorded pH 6.06 as compared to pH 5.96 in 100 % RDF. Among the sources, soil application of FYM and RDF recorded relatively better soil pH (6.11), while, among

Table 3 : Root growth in papaya as influenced by fertilizer doses and fertigation

Treatment	Root length (cm)	Root breadth (cm)	Root volume (cm^3 plant^{-1})	Root fresh weight (g plant^{-1})	Root dry weight (g plant^{-1})
Main plot					
M_0	84.1	109.9	1222.5	1606.9	395.9
M_1	65.6	154.8	1530.6	2378.1	594.4
M_2	50.0	163.8	1332.5	2556.3	554.8
Subplot					
S_0	69.8	131.5	1260.8	1900.0	496.8
S_1	70.0	117.0	1215.8	1920.8	408.5
S_2	65.8	148.2	1490.8	2158.3	513.6
S_3	60.7	174.5	1480.0	2742.5	641.2
Interaction					
M_0S_0	74.5	105.5	1032.5	1187.5	323.0
M_0S_1	85.0	86.0	765.0	962.5	162.4
M_0S_2	97.5	109.5	1460.0	1900.0	477.2
M_0S_3	79.5	138.5	1632.5	2377.5	621.1
M_1S_0	85.0	114.0	1340.0	1887.5	677.6
M_1S_1	77.5	140.0	1612.5	2800.0	609.9
M_1S_2	52.5	180.0	1750.0	2275.0	501.2
M_1S_3	47.5	185.0	1420.0	2550.0	589.0
M_2S_0	50.0	175.0	1410.0	2625.0	489.9
M_2 S_1	47.5	125.0	1270.0	2000.0	453.2
M_2S_2	47.5	155.0	1262.5	2300.0	562.6
M_2S_3	55.0	200.0	1387.5	3300.0	713.7
S Em ± Main	0.2	2.7	145.9	37.0	20.4
Sub	2.0	7.5	281.5	155.7	52.7
Main x Sub^{-1}	3.0	11.6	446.7	236.4	81.6
C.D (P=0.05) Main	0.7	9.5	NS	130.5	72.1
Sub	5.8	21.9	NS	454.1	153.7
Main x Sub^{-1}	8.7	NS	NS	693.2	NS

the interactions, fertigation through organic sources with 75 % of RDF recorded a soil pH of 6.19. The lower pH of soil with recommended fertilizers may be attributed to the addition of acidic fertilizers and the same was relatively better when applied along with FYM.

The organic carbon content in soil was significantly influenced by doses and sources of fertigation. Application of 100 % RDF recorded significantly higher organic carbon (0.93 %) as compared to either 75 % (0.59 %) or 125 % (0.82 %). Among the sources, application through water soluble fertilizers recorded significantly higher organic carbon (0.92 %) as compared to other sources and the control. Among the interactions, 100% RDF through water soluble fertilizers recorded significantly higher organic carbon (1.16%) differing significantly from rest of the treatment combinations except the treatment application of 125% RDF through soil application of organics (1.05%). The higher organic carbon content with water soluble fertilizers may be attributed to the better availability of plant nutrients in turn favouring the accumulation of organic carbon in the soil.

The nitrogen content in soil was significantly influenced by doses and sources of fertigation. Application of 100 % RDF recorded significantly higher available nitrogen (150.7 kg ha^{-1}) as compared to either 75 % (96 kg ha^{-1}) or 125 % RDF

(133 kg ha^{-1}). Among the sources, application through water soluble fertilizers recorded significantly higher available nitrogen (148.2 kg ha^{-1}) as compared to other sources and the control. Among the interactions, 100 % RDF through water soluble fertilizers recorded significantly higher N (187.1 kg ha^{-1}) differing significantly from rest of the treatment combinations.

The available phosphorous content in soil was significantly influenced both by the doses and sources of fertigation. Application of 125 % RDF recorded significantly higher available phosphorous (40.92 kg ha^{-1}). Among the sources, soil application nutrients through organic sources recorded significantly higher available phosphorous (47.31 kg ha^{-1}) as compared to other sources and the control. Among the interactions, 75 % RDF through organic sources recorded higher available phosphorous content (58.46 kg ha^{-1}) differing significantly from rest of the treatment combinations except application of 125 % RDF through soil application of organic sources (55.91 kg ha^{-1}) and application of 100 % RDF through water soluble fertilizers (54.19 kg ha^{-1}).

The available potassium content in soil was significantly influenced by doses and sources of fertigation. Application of 125 % RDF recorded significantly higher soil available potassium (281.3 kg ha^{-1}). Among the sources, application through water soluble fertilizers recorded significantly higher available potassium (284.2 kg ha^{-1}) as compared to other sources and the control. Among the interactions, 100 % RDF through water soluble fertilizers recorded significantly higher potassium (353.8 kg ha^{-1}) differing

Table 4 : Soil fertility and major nutrients of soil in papaya as influenced by fertigation treatments

Treatment	pH	EC (dSm^{-1})	O.C. (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
Main plot						
M_0	5.93	0.20	0.93	150.7	34.12	256.3
M_1	5.96	0.16	0.82	133.0	40.92	281.3
M_2	6.06	0.17	0.59	96.0	39.20	243.1
Subplot						
S_0	5.96	0.22	0.92	148.2	40.59	284.2
S_1	5.99	0.15	0.76	122.3	32.16	251.3
S_2	5.88	0.21	0.76	123.1	47.31	252.1
S_3	6.11	0.13	0.70	112.6	32.26	253.4
Interaction						
M_0S_0	5.71	0.35	1.16	187.1	54.19	353.8
M_0S_1	6.03	0.16	0.95	153.1	26.20	261.3
M_0S_2	5.92	0.15	0.80	128.8	27.56	152.5
M_0S_3	6.09	0.15	0.83	133.7	28.53	257.5
M_1S_0	6.08	0.16	0.75	121.5	35.82	243.8
M_1S_1	5.76	0.13	0.68	109.4	38.46	258.8
M_1S_2	5.80	0.22	1.05	170.1	55.91	351.3
M_1S_3	6.19	0.13	0.81	131.2	33.50	271.3
M_2S_0	6.10	0.14	0.84	136.1	31.77	255.0
M_2 S_1	6.19	0.17	0.65	104.5	31.83	233.8
M_2S_2	5.92	0.26	0.44	70.5	58.46	252.5
M_2S_3	6.04	0.12	0.45	72.9	34.76	231.3
S Em ± Main	0.06	0.02	0.03	4.5	5.15	NS
Sub	NS	0.05	0.07	11.5	NS	NS
Main x Sub^{-1}	NS	0.08	0.11	17.7	NS	71.3
C.D (P=0.05) Main	0.02	0.01	0.01	1.3	1.46	12.1
Sub	0.08	0.02	0.02	3.9	4.51	13.1
Main x Sub^{-1}	0.12	0.03	0.04	6.0	6.92	23.1

significantly from rest of the treatment combinations except application of 125 % RDF through soil application of organic sources (351.3 kg ha^{-1}). These differences in NPK may be attributed to the movement of applied nutrients in the soil both horizontally and vertically as well as concentration of immobile elements (Sathya *et al*., 2008). The easy availability of water-soluble nutrients right at the root zone of the crop through fertigation in a balanced form through RDF might have favoured better availability of plant nutrients favouring their accumulation in the soil.

Fruit yield

The fruit yield in papaya was significantly influenced by fertilizer doses and fertigation sources (Table 5). Application of 75 % RDF through fertigation recorded significantly higher fruit yield (47.34 t ha^{-1}), which was followed by application of organic sources 125 % RDF (44.37 t ha^{-1}). The increase in yield of papaya was over 31 % with fertigation clearly indicating the relative advantage, which may be attributed to higher nutrient use efficiency resulting in more number of fruits, fruit weight, TSS and lower fruit cavity index.

Jeyakumar *et al*. (2010) reported that, application of 100 % recommended dose of N and K_2O through drip resulted in more number of fruits, fruit weight, TSS and low fruit cavity index with soil application of P_2O_5. Although significantly lower cavity index was observed when RDF was supplied with organics to the soil (3.12%), among the fertilizer dosages, relatively lower cavity index (10.51%) was observed with 125% RDF, while, among the sources of nutrients, soil application of only organic sources resulted in marginally lower cavity index (10.44%).

Table 5 : Fruit yield and quality in papaya with different fertilizer doses and fertigation sources

Treatment	No. of fruits $plant^{-1}$	Individual fruit weight (kg)	Fruit yield (kg $plant^{-1}$)	Fruit yield (t ha^{-1})	TSS (°B)	Cavity Index (%)
Main plot						
M_0	9.50	0.87	6.12	21.18	10.28	13.97
M_1	21.09	0.69	10.49	32.39	9.61	10.51
M_2	20.91	1.14	10.58	32.66	9.86	12.77
Subplot						
S_0	21.17	0.66	11.95	36.87	9.66	13.74
S_1	13.38	0.92	6.82	21.07	10.44	12.75
S_2	15.94	0.75	9.11	28.91	10.57	10.44
S_3	18.18	1.27	8.38	28.13	9.00	12.75
Interaction						
M_0S_0	19.25	0.70	12.73	39.27	10.10	19.06
M_0S_1	7.88	1.53	5.03	15.53	11.28	21.63
M_0S_2	3.25	0.71	1.73	7.70	11.30	3.12
M_0S_3	7.63	0.56	5.00	22.22	8.45	12.08
M_1S_0	23.50	0.54	7.78	24.00	9.30	11.60
M_1S_1	17.88	0.52	7.61	23.50	9.80	5.21
M_1S_2	21.75	0.89	14.38	44.37	9.38	11.23
M_1S_3	21.25	0.79	12.21	37.69	9.98	14.00
M_2S_0	20.75	0.73	15.34	47.34	9.58	10.55
M_2 S_1	14.38	0.72	7.83	24.17	10.25	11.42
M_2S_2	22.83	0.66	11.23	34.67	11.03	16.96
M_2S_3	25.67	2.47	7.93	24.48	8.58	12.18
S Em ± Main	1.33	NS	0.89	2.75	0.37	2.45
Sub	1.33	NS	1.17	3.62	0.47	2.19
Main x Sub^{-1}	2.39	NS	1.97	6.09	0.79	4.10
C.D (P=0.05) Main	4.69	0.248	3.14	9.72	NS	NS
Sub	3.87	0.276	3.41	10.57	NS	NS
Main x Sub^{-1}	7.44	0.483	5.98	18.53	NS	12.85

Table 6 : The economics of papaya cultivation under different fertilizer doses and sources of fertigation

Treatment	Fruit yield (t ha^{-1})	Gross returns (Rs. ha^{-1})	Total cost (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
Main plot					
M_0	21.18	3,17,734	2,46,228	71,506	1.28
M_1	32.39	4,85,820	2,58,475	2,27,345	1.87
M_2	32.67	4,89,975	2,34,119	2,55,856	2.08
Subplot					
S_0	36.87	5,53,050	2,54,147	2,98,903	2.21
S_1	21.07	3,15,990	2,26,582	89,408	1.40
S_2	28.91	4,33,675	2,52,532	1,81,143	1.70
S_3	28.13	4,21,990	2,51,833	1,70,157	1.67
Interaction					
M_0S_0	39.27	5,89,125	2,54,148	3,34,977	2.32
M_0S_1	15.53	2,32,980	2,26,582	6,398	1.03
M_0S_2	7.70	1,15,500	2,50,032	-1,34,532	0.46
M_0S_3	22.22	3,33,330	2,54,148	79,182	1.31
M_1S_0	24.00	3,59,955	2,68,238	91,717	1.34
M_1S_1	23.50	3,52,425	2,33,782	1,18,643	1.51
M_1S_2	44.37	6,65,505	2,70,595	3,94,910	2.46
M_1S_3	37.69	5,65,395	2,61,284	3,04,111	2.16
M_2S_0	47.34	7,10,070	2,40,055	4,70,015	2.96
M_2 S_1	24.17	3,62,565	2,19,382	1,43,183	1.65
M_2S_2	34.67	5,20,020	2,36,970	2,83,050	2.19
M_2S_3	24.48	3,67,245	2,40,068	1,27,177	1.53

The treatment combination M_2S_0 (75% RDF) recorded maximum fertilizer use efficiency (20.45 kg of yield /kg of nutrient applied) (Fig. 1). This may be due to the application of nutrients directly to the root zone through fertigation coupled with complete solubility of water soluble fertilizers increasing the efficiency of the applied nutrients. Similar results of 75% N and K when applied through drip recorded on par papaya yield with 100% RDF (Sadaraunnisa, 2010). It was attributed to the better yield components like number of fruits/ plant, fruit weight in the treatments where fertilizers were applied through drip compared to soil application of fertilizers. It was also concluded that since there was no significant difference between 100% and 75% N and K treatments through drip regarding yield and yield attributes, the later dosage is economical over the former.

The TSS in papaya fruits was not influenced significantly either by fertilizer doses and the sources of fertigation or their interaction (Table 5). However, relatively higher TSS was observed when RDF was supplied with organics either through soil (11.30 °Brix) or through fertigation (11.28 °Brix).

The cavity index in papaya was significantly influenced by the interaction of fertilizer doses and fertigation sources. Significantly, lower cavity index was observed when RDF was supplied with organics to the soil (3.12) and it was followed by application

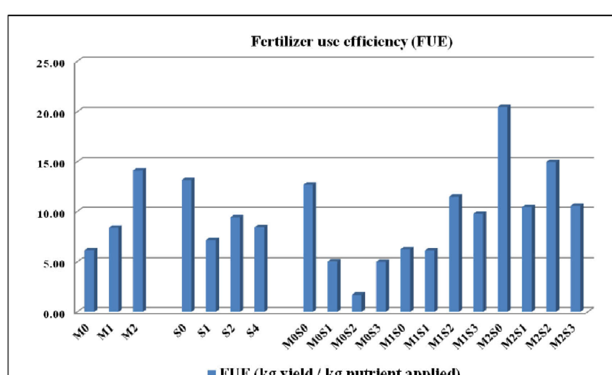

Fig. 1 : Fertilizer use efficiency in papaya as influenced by fertilizer doses and methods

of 125 % RDF through fertigation using organic sources (5.21). The lower cavity index recorded may be attributed to the production of more photosynthates due to more number of leaves and leaf area which might have resulted in better transfer to the sink, the developing fruit with thicker pulp and low cavity index. Jeyakumar *et al.* (2010) also observed that application of 100% recommended dose of N and K_2O through drip resulted in lower cavity index in papaya.

The economics

Fertigation of 75% RDF with inorganic fertilizers was found more economical with higher gross returns (Rs. 7.10 lakh ha^{-1}), net returns (Rs. 4.7 lakh ha^{-1}) and benefit cost ratio (2.96) (Table 6).

The higher net returns with the treatment (M_2S_0) may be attributed to the moderately higher papaya yield (47.34 t ha^{-1}). It was followed by soil application of 125 % RDF through organic sources with better gross returns (Rs. 6.65 lakh ha^{-1}), net returns (Rs.3.94 lakh ha^{-1}) and benefit cost ratio (2.46). In a similar study, Jeyakumar *et al.* (2010) also reported that the increase in number of fruits and fruit weight were attributed for higher fruit yield per tree and the resultant total fruit yield per hectare with high B:C ratio in plants treated with 100 % recommended dose of N & K_2O per plant through drip (50 g N and 50 g K_2O), in addition to soil application of 50 g P_2O_5.

CONCLUSION

The results of field experiment on fertigation in papaya indicated that application of 75% RDF through drip using water soluble fertilizers is beneficial to get higher fruit yield (47.34 t ha^{-1}) with higher nutrient use efficiency and was found economical with higher net returns (Rs.4.7 lakh ha^{-1}) and benefit cost ratio (2.96).

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