

Original Research Article

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Performance Evaluation of Maize with Square Spacing for Maximizing the Yield Potential through Subsurface Drip Fertigation

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ABSTRACT

There has been a growing gap between the demand for maize and its supply. One of the reasons often attributed to decline in maize productivity is poor production practices, awareness and characterized by low use of modern inputs. In order to avoid the lack of all the above to assess the current levels of technical efficiency of maize cultivation like spacing of Maize cultivation with effective management of irrigation practices could be taken as a study. The study was taken up for the cultivation of maize crop (variety of Co H(M) 6) with main treatments of sub surface drip irrigation through calculated water requirement of crops (WRc) at 75%, 100% & 125% and sub treatments of fertilizer application through fertigation at 50%, 75% & 100% of RDF. The irrigation was given in alternative days and the fertigation was given once in a week as per the schedule given in crop production guide. The inline emitter spacing is 40 cm and lateral spacing is 80 cm were considered for drip layout and paired row system was followed. The irrigation with 75 % WRc consumed 338 mm of irrigation water and recorded lower yield of 5070 kg/ha with the yield penalty of 31% (2300 kg/ha) when compared to 100 % irrigation water. Similarly the irrigation with 125% consumed 529 mm of irrigation water and recorded the grain yield of 7343 kg/ha with a reduction in yield of 250 kg/ha. The treatment I₃F₁ (125 % WRc with 100% fertigation) was consumed higher quantity of irrigation water (529 mm) with lowest WUE (9.28 kg/ha mm) and water productivity (0.93 kg/m³ & Rs. 129.83 ha/mm) when compared to other treatments. The treatment I₂F₃ consumed 434 mm of irrigation water and recorded highest yield which saved 30 per cent of irrigation water when compared to control. In control the yield was 22 per cent significantly lowered when compared to I₂F₃. The combination of Irrigation with 100% WRc and 100% fertigation has given higher yield of 7670 kg/ha when compared to reduced quantity of fertigation.

Keywords

Crop water requirement, fertigation, Square spacing, Subsurface drip irrigation

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Introduction

Maize is grown throughout the year in India. It is also known as all season crop. Maize is predominantly cultivated during kharif season with 85 per cent of the area under cultivation during this season. Maize is the third most important cereal crop in India after rice and wheat. It accounts for 9 per cent of total food grain production of the country. Maize production in India has grown at a CAGR (compound annual growth rate) of 5.5 per cent over the last ten years from 14 million tonnes in 2004-05 to 23 million tonnes in 2013-14 (FICCI, 2013). Factors such as adaptability to varied agro-climatic conditions, less labour, intensive and low water consuming crop which influence the yield and water consumption. Therefore in many areas, maize becomes alternate crop to rice which resulted in increase in area under maize cultivation.

Irrigation plays a paramount role in increasing the productivity of crops and enhancing the cropping intensity. Apart from benefiting the farmers, irrigation development also helps to increase the employment opportunities and wage rate of agricultural labourers. However, water is becoming increasingly scarce in Tamil Nadu due to increased industrialization and intensive agriculture. With the fast decline of irrigation water potential and continued expansion of population and economic activity in many parts of the State the problems of water scarcity is expected to be aggravated further. Sivanappan (2004) stated that using micro irrigation for various crops saves water upto 40-70 percent besides yield increase.

Fertigation is one such technology where water-soluble fertilizer or chemical can be applied in precise amounts in synchrony with the plant needs, directly into the root zone of the crop. This not only economizes the water

use, but also improves nutrient use efficiency, as the fertilizer applied remains confined to the root zone of the crop. Information on the moisture and nutrient distribution under fertigation is rather scanty. While considering from the nutrient point of view, this system would be considered essential, though the vegetable - based system would be profitable (Ramesh, 2002). Drip irrigation holds promise in this respect (Narda and Lubana, 1999). Drip fertigation permits application of nutrients directly at the site of high concentration of active roots (Sivanappan *et al.*, 1987).

Maize (*Zea mays L.*) is an important cereal crop of India and plays pivotal role in agricultural economy both as staple food for larger section of population, raw materials for industries and feed for animals. With intention of achieving evergreen revolution, intensive research in maize has been started anticipating its importance for food and feed.

In India maize is grown in an area of 6.2 m.ha, with a production of 10.57 m.t and the average productivity is 1700 kg ha⁻¹ (Anon, 2003). The present annual requirement of grain maize for different purposes is 12 m.t of which 4.5 m.t for poultry (Sounderajan, 2002) with a gap of 1.5 m.t. In Tamil Nadu, maize is cultivated in an area of 0.20 m.ha. with a production of 0.24 m.t. with an average productivity of 1189 kg ha⁻¹ (Anon, 2006). By 2020 AD, the requirement of maize for various sectors will be around 100 m.t, of which the poultry sector demand alone will be around 31m.t. (Seshaiah, 2000).

Materials and Methods

The main focus of this project was to initiate maize crop in NCDZ (New Cauvery Delta Zone) as alternative cropping system for rice especially during summer which consume less quantity of irrigation water.

Summer 2016 & 2017

Season: Summer (2016 - 2017)

Crop: Maize

Crop spacing: 40 x 40 cm (Square spacing)

Design: split plot

Replications: 3

Treatments

The treatment consists of three irrigation regimes in main plots and three fertilizer levels in sub plots.

Main Plot: Irrigation regimes

I₁ - Drip irrigation at 75% calculated water requirement of crops (WRc)

I₂ - Drip irrigation at 100% calculated water requirement of crops (WRc)

I₃ - Drip irrigation at 125% calculated water requirement of crops (WRc)

Design data for drip

Lateral pipe size - 16 mm

Spacing between the lateral pipe - 80 cm

Emitter type - Inline emitter

Spacing between the emitter - 40 cm

Sub plots: Fertilizer levels

F₁ - 50% Recommended dose of fertilizer through drip irrigation

F₂ - 75% Recommended dose of fertilizer through drip irrigation

F₃ - 100% Recommended dose of fertilizer through drip irrigation

(The RDF of Maize = 150:75:75 kg NPK ha⁻¹)

Comparison treatment

One control treatment with conventional ridges and furrow irrigation on IW/CPE ratio 1.0 and the soil application of 100 per cent recommended dose of fertilizer was included for comparison.

Summer 2016 & 2017

The details of study for both the year of summer 2016 & 2017 are given below. The second crop of summer 2017 experiment was conducted (variety of Co H(M) 6) with main treatments of sub surface drip irrigation through calculated water requirement of crops (WRc) at 75%, 100% & 125% and sub treatments of fertilizer application through fertigation at 50%, 75% & 100% of RDF. The irrigation was given in alternative days and the fertigation was given once in a week as per the schedule given in crop production guide.

Square Spacing effect

The inline emitter spacing is 40 cm and lateral spacing is 80 cm were considered for drip layout and paired row system was followed. The emitter is located in the centre of crop which could distribute the water for 4 crops as shown in Figure 1.

As per the location of emitter every crop could receive the water from two numbers of emitter accordingly.

Study of moisture distribution pattern under drip irrigation

The moisture distribution pattern of subsurface drip irrigation was studied under different irrigation schedules viz., 75%, 100% and 125% of calculated crop water requirement (WRc) of maize. The WRc is calculated using the below formula;

$WR / \text{plant} = PE \times Pc \times Kc \times \text{wetting percentage (80\%)}$

Where,

WR = Water Requirement in mm

PE = Pan Evaporation in mm

Pc. = Pan Co-efficient

Kc = Crop Co-efficient

According to the irrigation schedule the movement of water in soil from the drip irrigation was studied. For this study the soil sample was collected from both sides of the emitter from the surface in vertical and horizontal direction after application of the measured quantity of water calculated through the above equation. Totally 15 samples (each side 6 samples and centre on the emitter 3 samples) were collected and the soil moisture (in percentage) was estimated through volumetric analysis. The soil moisture study was conducted in three different locations of each irrigation schedule, the average moisture in each irrigation schedule was plotted in the surfer 8.0 software

Effect of drip fertigation on growth and yield of maize

The second crop of summer 2016 experiment was conducted (same variety) by the revised main treatments of sub surface drip irrigation through calculated water requirement of crops (WRc) at 75%, 100% & 125% and sub treatments of fertilizer application through fertigation at 50%, 75% & 100% of RDF. The irrigation was given in alternative days and the fertigation was given once in a week as per the schedule given in TNAU crop production guide.

Effect of sub surface drip irrigation on water saving

The irrigation was scheduled according the calculated irrigation water requirement viz.,

75%, 100% and 125% and the irrigation was given once in alternative days. The two days cumulative pan evaporation data was collected from meteorological station, SWMRI, Thanjavur and calculated the WRc and irrigation was given accordingly.

The Water Use Efficiency (WUE) and water productivity are calculated by the below formula.

$$WUE = (\text{Total yield (kg/ha)}) / (\text{Total irrigation water used (mm)}) \times 100$$

$$\text{Water productivity} = \text{Yield (kg)} / \text{Volume of irrigation water used (m}^3\text{)}$$

(Or)

$$\text{Water productivity} = \text{Total income (in Rs./ha)} / (\text{Total irrigation water used (mm)})$$

Effect of fertigation on fertilizer saving

The fertilizer was given on weekly basis through venture system. The quantity of fertilizer N, P & K was calculated and followed the fertigation schedule from TNAU crop production guide. The Fertilizer Use Efficiency (FUE) for N, P & K were calculated by the below formula;

$$FUE = (\text{Total fertilizer used (Kg/ha)}) / (\text{Yield (Kg/ha)}) \times 100$$

Economics

The total cost of cultivation was calculated on every individual treatments and gross income is accounted both yield and the residual of stubbles. B: C ratio of every treatment was calculated separately using the below formula.

$$B: C \text{ ratio} = \text{Total gross income (Rs.)} / \text{Cost of cultivation (Rs.)}$$

Pooled data analysis

Comparative studies of two years pooling (Summer 2016 & 2017) data viz., yield, WUE & water productivity of subsurface drip irrigation were analyzed and found the variation of every individual treatments.

Results and Discussions

Study of moisture distribution pattern

The soil moisture study was conducted in three different locations of each irrigation schedule, the average moisture in each irrigation schedule was plotted in the surfer 8.0 software as shown in Fig. 2, 3 & 4.

In 75% of WRc the percentage of moisture varied from 17.2 to 24 % and it was found that the centre of emitter the highest percentage of moisture (24%) was obtained. The moisture pattern was linearly varied from centre to both sides of emitter up to 20 min both horizontal and vertical directions as depicted in Fig. 2.

Similarly in 100% WRc, the percentage of moisture was varied from the maximum of 26% to the minimum of 18.3%. The linear movement of moisture around the emitter is evenly ranged with approximately 1% deviation in all the directions from the centre of the emitter as shown in Fig.3. Hence, the lateral and vertical movement of moisture is almost equal in range with respect to the horizontal and vertical directions.

Whereas the 125% WRc, the percentage of moisture was distributed from 22.8 to 28% where the highest percentage of moisture was obtained in the exact location of emitter. The distribution of moisture in one side (right side) is higher (1.5% more) than other side due to the rapid flow of water in one side as shown in Fig. 4. Similar trends of results were

found by Ali *et al.*, (2010) and Isoda *et al.*, (2007). Hence, the study revealed that moisture distribution in all the directions from the emitter is spatially varied in all the irrigation schedules. 100% WRc is found to have optimal distribution of moisture when compared with others.

Effect of drip fertigation on growth and yield of maize

The results revealed that, in summer 2016 the study of sub surface drip fertigation on the production of maize were observed and given in Table 1. The highest plant height (158.4 cm) was obtained in treatment I₂F₃ (Irrigation at 100 % WRc with 100% RDF) followed by I₃F₃ (156.4 cm) and the lowest height was recorded (107.2 cm) in I₁F₁ (applying irrigation at 75% WRc with 50% RDF).

It was found that increasing and decreasing water and fertigation stress was significantly resulted in a decrease of plant height.

There is also a significant effects were observed from No. of grains/cobs and 1000 grains weight as shown in Table 1. Reduced amount of irrigation also caused reduced number of grains with lesser weight, counting to be the highest numbers of grains and weight of 1000 grain in treatment I₂F₃ (310 & 21.80 gm), followed by I₃F₃ (292 & 21.60 gm) and the least was recorded in treatment I₁F₁ (155 & 16.80 gm).

The same way the cob length and girth found to be highest in I₂F₃ (23.67 & 18.33 cm), followed by treatment I₃F₃ (22.94 & 17.17 cm) and the least was recorded in I₁F₁ (19.33 & 14.07 cm), whereas the control has recorded 22.47 & 16.66 cm.

The results revealed that, in summer 2017 the study of sub surface drip fertigation on the production of maize were observed and given

in Table 1. The highest plant height (198.7 cm) was obtained in treatment I₂F₃ (Irrigation at 100 % WRc with 100% RDF) followed by I₃F₃ & I₂F₂ (196 cm) and the lowest height was recorded (182.7 cm) in I₁F₁ (applying irrigation at 75% WRc with 50% RDF). It was found that increasing and decreasing water and fertigation stress was significantly resulted in a decrease of plant height.

There is also a significant effects were observed from No. of grains/cobs and 1000 grains weight as shown in Table 1. Reduced amount of irrigation and fertigation also

caused reduced number of grains with lesser weight, counting to be the highest numbers of grains and 1000 grain weight is in treatment I₂F₃ (306 & 143.6 gm), followed by I₃F₃ (295.6 & 141.2 gm) and the least was recorded in treatment I₁F₁ (222.4 & 118.1 gm), whereas the control was recorded 250.1 & 130.3 gm.

The same way the cob length and girth found to be highest in I₂F₃ (26.2 & 17.4 cm), followed by treatment I₃F₃ (25.8 & 16.1 cm) and the least was recorded in I₁F₁ (22.9 & 13.3 cm).

Table.1 Influence of treatments on crop growth parameters (2016 & 2017)

Treatments	Summer 2016					Summer 2017				
	Pl. height (cm)	Cob length (cm)	Cob girth (cm)	No. of grains/cob	100 grains wt (gm)	Pl. height (cm)	Cob length (cm)	Cob girth (cm)	No. of grains / cob	100 grains wt (gm)
I ₁ F ₁	107.2	19.3	14.1	155	16.8	182.7	22.9	13.3	222	118.1
I ₁ F ₂	121.2	19.3	15.1	195	17.4	188.9	24.6	14.7	235	126.0
I ₁ F ₃	132.1	19.5	15.3	207	18.9	194.3	25.4	15.8	238	129.4
I ₂ F ₁	115.0	20.0	15.0	175	17.2	187.4	23.2	14.1	230	119.9
I ₂ F ₂	134.3	21.1	17.5	224	17.9	196.1	25.1	16.1	258	131.6
I ₂ F ₃	158.4	23.7	18.3	310	21.8	198.7	26.2	17.4	306	143.6
I ₃ F ₁	120.9	20.7	15.2	177	17.5	188.6	23.1	14.4	229	121.1
I ₃ F ₂	133.0	21.2	16.7	252	19.2	195.5	25.0	15.3	263	134.5
I ₃ F ₃	156.4	22.9	17.2	292	21.6	196.4	25.8	16.1	295	141.2
Control	145.2	22.5	16.7	270	20.8	194.5	24.3	16.1	250	130.3

Table.2 Yield, WUE and Water Productivity during summer 2016

Treatments	Yield kg/ha	Water used (mm)	Rainfall & Eff. Rainfall (mm)	Total water used (mm)	WUE Kg/ha & mm)	Water productivity in kg/m ³	Water productivity (Rs./ha & mm)
I ₁ F ₁	4484	266	85.8 & 42.9	308.9	14.52	1.45	203.2
I ₁ F ₂	5604			308.9	18.14	1.81	253.9
I ₁ F ₃	5780			308.9	18.71	1.87	261.9
I ₂ F ₁	4584	354		369.9	12.39	1.24	161.6
I ₂ F ₂	6514			369.9	16.41	1.64	229.7
I ₂ F ₃	7436			369.9	18.74	1.87	262.2
I ₃ F ₁	4525	443		485.9	09.31	0.93	130.3
I ₃ F ₂	6588			485.9	13.56	1.36	189.8
I ₃ F ₃	7287			485.9	15.00	1.50	209.9
Control	6637	450			492.9	13.47	1.34

		SED	CD (0.05)
i	→	4.55	12.66
f	→	5.84	12.73
i at f	→	9.43	21.87
f at i	→	10.12	22.05

Table.3 Yield, WUE and Water Productivity during summer 2017

Treatments	Yield kg/ha	Water used (mm)	Rainfall & Eff. Rainfall (mm)	Total water used (mm)	WUE Kg/ha/mm)	Water productivity in kg/m ³	Water productivity (Rs./ha mm)
I ₁ F ₁	4695	312	52 & 26 (5 rainy days)	338	13.89	1.39	171.17
I ₁ F ₂	5195			338	15.37	1.54	189.40
I ₁ F ₃	5330			338	15.77	1.58	194.32
I ₂ F ₁	4818	408		434	11.10	1.11	155.42
I ₂ F ₂	5335			434	12.29	1.23	172.10
I ₂ F ₃	7670			434	17.67	1.77	247.42
I ₃ F ₁	4908	503		529	9.28	0.93	129.89
I ₃ F ₂	5635			529	10.65	1.07	149.13
I ₃ F ₃	7343			529	13.88	1.39	194.33
Control	6283	540			566	11.10	1.11

		SED	CD (0.05)
I	→	21.22	58.99
F	→	27.22	59.27
i at f	→	43.93	101.86
f at i	→	47.12	102.67

Table.4 FUE and cost economics during summer 2016

Treatments	Total fertilizer used (kg/ha)			FUE			Cost of cultivation (Rs.)	Gross Income (Rs.)	B.C. ratio
	N	P	K	N	P	K			
I₁F₁	75	38	38	59.79	118.00	118.00	62700	62776	1.00
I₁F₂	113	56	56	49.59	100.07	100.07	64500	78456	1.22
I₁F₃	150	75	75	38.53	077.07	077.07	66000	80920	1.23
I₂F₁	75	38	38	61.12	120.63	120.63	62700	68376	1.02
I₂F₂	113	56	56	57.65	116.32	116.32	64500	91196	1.41
I₂F₃	150	75	75	49.57	099.15	099.15	66000	104104	1.58
I₃F₁	75	38	38	60.33	119.08	119.08	62700	68950	1.01
I₃F₂	113	56	56	58.30	117.64	117.64	64500	92232	1.43
I₃F₃	150	75	75	48.58	097.16	097.16	66000	102018	1.55
Control	250	75	75	26.55	088.49	088.49	45000	92918	2.11

Table.5 FUE and cost economics during summer 2017

Treatments	Total fertilizer used (kg/ha)			FUE			Cost of cultivation (Rs.)	Gross Income (Rs.)	B.C. ratio
	N	P	K	N	P	K			
I₁F₁	75	38	38	62.60	123.55	123.55	62700	65730	1.05
I₁F₂	113	56	56	45.97	92.77	92.77	64500	72730	1.13
I₁F₃	150	75	75	35.53	71.07	71.07	66000	74620	1.13
I₂F₁	75	38	38	64.24	126.79	126.79	62700	67452	1.08
I₂F₂	113	56	56	47.21	95.27	95.27	64500	74690	1.16
I₂F₃	150	75	75	51.13	102.27	102.27	66000	107380	1.63
I₃F₁	75	38	38	65.44	129.16	129.16	62700	68712	1.10
I₃F₂	113	56	56	49.87	100.63	100.63	64500	78890	1.22
I₃F₃	150	75	75	48.95	97.91	97.91	66000	102802	1.56
Control	250	75	75	25.13	83.77	83.77	45000	87962	1.95

Fig.4 Moisture distribution pattern at 125% WRc

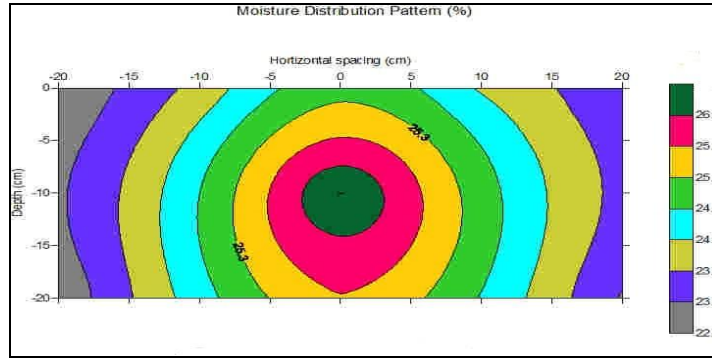
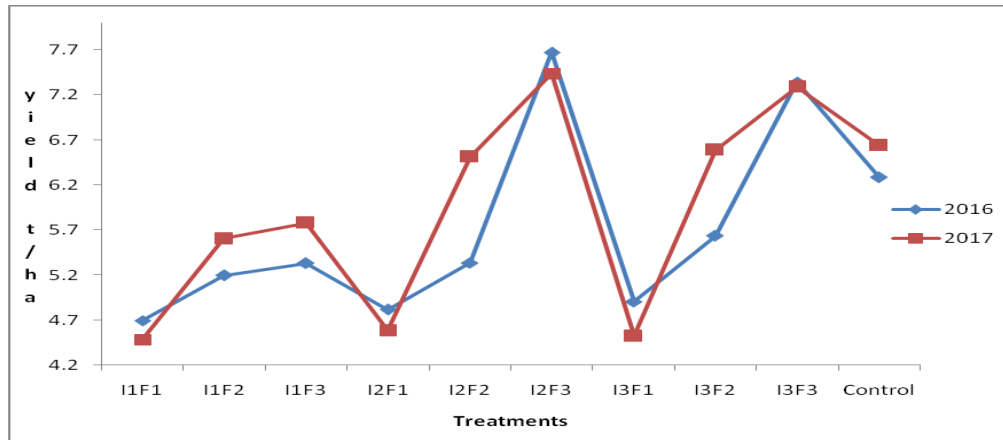


Fig.5 Comparative performance of yield difference during summer 2016– 2017



Effect of sub surface drip irrigation on water saving

During summer 2016 the highest WUE (18.74 kg/ha mm) was recorded in treatment I₂F₃ consumed 370 mm in 30 Nos of irrigations. Of irrigations produced significantly higher grain yield of 7436 kg/ha as depicted in Table 2. The second highest WUE (18.71 kg/ha mm) recorded in treatment I₁F₃ which also received 30 Nos. of irrigations consumed only 266 mm of irrigation water and recorded lower grain yield of 5780 kg/ha. Further the treatments I₃F₁, I₂F₁ & I₁F₁ recorded lesser WUE (09.31, 12.39 & 14.52 kg/ha mm) and observed significantly lower grain yield of 4525, 4584 & 4484 kg/ha respectively and consumed more quantity of water. The sub surface drip irrigation with all the treatments

of WR were saved 24% (approx. 100 mm) of irrigation when compared to conventional as practiced by IW/CPE ratio consumed 493 mm of water (9 Nos. of irrigation) which is significantly higher amount of water (Approx. 100 mm) when compared to subsurface drip irrigation and the grain yield of 6637 kg/ha & WUE were recorded 6697 kg/ha & 13.47 kg/ha mm. Similarly the highest water productivity (1.87 kg/m³ & 262.3 Rs/ha mm) was recorded in treatment I₂F₃ and the least was observed in I₃F₁ (0.93 kg/m³ & 130.38 Rs/ha mm).

During summer 2017 the highest WUE (17.67 kg/ha mm) was recorded in treatment I₂F₃ consumed 434 mm of irrigations water in 34 Nos. of irrigations significantly higher grain yield of 7670 kg/ha as depicted in Table 3.

This was followed by treatment I_1F_3 & I_1F_2 which also received 34 Nos. of irrigations consumed only 338 mm of irrigation water and recorded a significantly lower grain yield of 5330 & 5195 kg/ha with the WUE of 15.77 & 15.37 kg/ha mm. Further the treatments I_3F_1 , I_3F_2 , I_2F_1 & I_2F_2 recorded lesser WUE (09.28, 10.65, 11.10 & 12.29 kg/ha mm) and observed significantly lower grain yield of 4908, 5635, 4818 & 5335 kg/ha respectively. The sub surface drip irrigation with all the treatments of WRc were saved 25 % (approx. 120 mm) of irrigation when compared to conventional method was practiced by IW/CPE ratio consumed 566 mm of water (10 Nos. of irrigation) with 11.10 kg/ha mm of WUE which is significantly higher amount of water (Approx. 120 mm) when compared to subsurface drip irrigation and obtained grain yield of 6283 kg/ha. Similar results were found by Yadav *et al.*, (2004), Clark *et al.*, 1999, Cassel *et al.*, 2001 and Dalvi, 1999.

Similarly the highest water productivity (1.77 kg/m^3 & 247.42 Rs./ha/mm) was recorded in treatment I_2F_3 followed by I_1F_2 , I_1F_3 & I_3F_3 (1.54 & 1.58 kg/m^3 and 189.40 & 194.32 Rs./ha mm) and the least was observed in I_3F_1 (0.93 kg/m^3), whereas the control was obtained 1.11 kg/m^3 .

Effect of fertigation on fertilizer saving

Fertigation offers various advantages such as: easy application of amount and concentration of nutrients suited to the crop according to its stage of development; reduces the salinization and groundwater pollution; decreases fluctuation in nutrient concentration in soil during the crop growing season; permits easy use of soluble solid as well as balanced liquid fertilizer and micronutrients (Bar-Yosef, 1999). Efficient fertigation scheduling requires attention to three factors: crop specific nutrient requirements, timely nutrient delivery to meet the crop needs and

controlling irrigation to minimize leaching of soluble nutrients below the effective root zone (Hochmuth and Hanlon, 1995). In summer 2016 the highest FUE of N, P & K (61.1, 120.6 & 120.6) was found to be in treatment I_2F_1 & I_3F_1 , followed by I_1F_1 (59.79, 118.00 & 118.00) and least was recorded in I_1F_3 (38.53, 77.07 & 77.03) respectively, whereas the control has observed significantly lower FUE of 26.5, 88.4 & 88.4 due to manual application of fertilizer as presented in Table 4.

In Summer 2017 the highest FUE of N, P & K (65.44, 129.16 & 129.16) was found to be in treatment I_3F_1 followed by I_2F_1 (64.24, 126.79 & 126.79) and least was recorded in I_1F_3 (35.53, 71.07 & 71.07) respectively. The higher FUE were observed from 50% & 75% RDF which consumed minimum fertilizer and applied through fertigation, whereas the control has observed significantly lower FUE of 25.13, 83.77 & 83.77 due to manual application of fertilizer as presented in Table 5.

Similar trend of results have been documented by Imamsaheb *et al.*, (2014). Similarly increased yield under drip fertigation were reported by Tumbare *et al.*, (1999) and Tumbare, A.D. and Nikam, D.R. (2004).

Economics

In summer 2016 the control has the highest B.C ratio of 2.11 with yield of 6637 kg/ha, since the control was taken without drip irrigation cost. Treatment (I_3F_2) with 100% irrigation with 100% recommended fertilizer obtained the maximum yield of 7436 kg/ha, besides the highest B.C ratio of 2.11 when compared with other treatments (shown in Table 4). This was followed by treatment I_3F_3 with B.C ratio of 1.55 and the least B.C ratio was found to be in treatment I_1F_1 (75% WRc & 50% recommended fertilizer) of 1.00.

In summer 2017 the control has the highest B.C ratio of 1.95 with yield of 6283 kg/ha, since the control was taken up without drip irrigation cost. Among the drip irrigation treatment (I₃F₂) with 100 % irrigation with 100 % recommended fertilizer obtained maximum yield of 7670 kg/ha, besides the highest B.C ratio of 1.63 when compared with other treatments (shown in Table 5). This was followed by treatment I₃F₃ with B.C ratio of 1.56 and the least B.C ratio was found to be in treatment I₁F₁ (75% WRc & 50% recommended fertilizer) of 1.05.

Pooled data analysis

Comparative studies of two years pooling (Summer 2016 & 2017) data of subsurface drip irrigation were also analyzed and depicted in Fig. 5. The highest average yield (7553 kg/ha) and WUE (18.20 kg/ha mm) was obtained in treatment I₂F₃ (100 % WRc with 100% fertigation) followed by treatment I₃F₃ (125 % WRc with 100% fertigation). The lowest yield was observed on treatment I₁F₁ (75 % WRc with 50% RDF) (Avg. 4590 kg/ha) for both the years. Though the highest yield was recorded in (treatment I₂F₃) 100 % WRc with 100% fertigation, the FUE is comparatively lesser with other treatments due to higher consumption of fertilizer through fertigation which is contrary indicating quite higher consumption of fertilizer when compared to F₁& F₂. The treatment I₃F₁ (125 % WRc with 100% fertigation) was consumed higher quantity of irrigation water (529 mm) with lowest WUE (9.28 kg/ha mm) and water productivity (0.93 kg/m³ & Rs. 129.83 ha mm) when compared to other treatments. The treatment I₂F₃ consumed 434 mm of irrigation water and recorded highest yield which was saved 30 per cent of irrigation water when compared to control. In control the yield was 22 per cent significantly lowered when compared to I₂F₃. The irrigation with 75 % and 125% were

observed reduced plant height, cob length, cob girth, no. of grains / cob, 1000 grain weight, etc., were found to be increasing and decreasing stress.

In conclusions, the irrigation with 75 % WRc consumed 338 mm of irrigation water and recorded lower yield of 5070 kg/ha (avg.) with the yield penalty of 31% (avg. 2300 kg/ha) when compared to 100 % irrigation water. Similarly the irrigation with 125% consumed 529 mm of irrigation water and recorded the grain yield of 7343 kg/ha with a reduction in yield of 250 kg/ha. The treatment I₃F₁ (125 % WRc with 100% fertigation) was consumed higher quantity of irrigation water (529 mm) with lowest WUE (9.28 kg/ha mm) and water productivity (0.93 kg/m³ & Rs. 129.83 ha/mm) when compared to other treatments. The treatment I₂F₃ consumed 434 mm of irrigation water and recorded highest yield which saved 30 per cent of irrigation water when compared to control. In control the yield was 22 per cent significantly lowered when compared to I₂F₃. The combination of Irrigation with 100% WRc and 100% fertigation has given higher yield of 7670 kg/ha when compared to reduced quantity of fertigation.

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