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EFFECT OF DIFFERENT PLANTING DENSITY, IRRIGATION AND FERTIGATION LEVELS ON GROWTH AND YIELD OF BRINJAL (*SOLANUM MELONGENA* L.)

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ABSTRACT
A field experiment was carried out during 2009-2010 at Department of Agronomy, Dr. B.S.K.K.V, Dapoli, Dist. Ratnagiri (M.S.) to study the effect of three planting densities (S_1-75x75cm, S_2-75-50x90cm and S_3-175-50x50cm), three drip irrigation levels (I_1-100 per cent, I_2-80 per cent and I_3-60 per cent of crop evapotranspiration) and two fertigation levels (F_1-100 per cent and F_2-80 per cent of RDF through drip) on growth and yield of brinjal. The results showed that the planting density S_3 (175-50x50cm) recorded significantly superior growth parameters, biomass production, yield attributes and highest fruit yield (44.76 t ha^{-1}). While the irrigation scheduled at I_1 -100 per cent ET_{crop} noticed higher values of growth parameters, biomass production, yield attributes and maximum fruit yield (40.17 t ha^{-1}). Similarly Fertigation level F_1 100 per cent RDF through drip registered superior growth parameters, biomass production, yield attributing characters and fruit yield (39.63 t ha^{-1}) as compared to fertigation level F_2-80 per cent RDF through drip.

INTRODUCTION

Brinjal or egg plant (*Solanum melongena* L.) belonging to the family Solanaceae is the native of India. It is one of the most popular and important vegetable grown in almost all parts of India except in higher altitudes. It is a popular vegetable with all the people and hence it is rightly called the vegetable of the masses. Brinjal has got high nutritive value, as it contains 92.70 g moisture, 1.4 g protein, 0.30 g fat, 0.30 g minerals, 0.30 g fiber, 4.0 g carbohydrates, 18.0 mg calcium, 18.0 mg oxalic acid, 47.0 mg, phosphorus, 2.0 mg potassium, 124 I.U. vitamin 'A', 0.11 mg riboflavin and 12.0 mg vitamin C per 100 g of edible portion (Choudhary, 1967).

Drip irrigation system is one of the advanced method of irrigation. The system is popular in arid and semi arid regions with high evaporation losses. In drip irrigation water is conveyed through network of pipes up to root zone of crop and applied through emitters, frequently and with a volume approaching the consumptive use of plants and thereby minimizing conventional losses as deep percolation and evaporation from soil which give better water use efficiency. Drip irrigation can save water upto 40 to 70 per cent as well as increasing the crop production to the extent of 20 to 100 per cent (Reddy and Reddy, 2003).

Fertigation which has become the state art in brinjal vegetable production because the nutrients can be applied in correct doses and at appropriate stage of plant growth. In addition it improves fertilizer use efficiency, hastens the maturity of crop and improves the quality of produce. The fertigation has number of advantages like improvement in nutrient use efficiency, placement of nutrients in the vicinity of crop root zone and saving of nutrients. Fertigation reduces the ammonia volatization, leaching losses, phosphate fixation etc. as much more in band placement. In lateritic soil, the lateral movement of water applied through drip is minimum hence the crop gives better response to the dose of nutrients applied through drip (Salunkhe, 2006)

Crop geometry and plant population plays important role in obtaining high yield. Optimum plant population for brinjal crop varies considerably due to environment under which it is grown. It is not possible to recommend a generalized optimum plant population since a crop gives better response to specific management practices. Therefore, it is very necessary to quantify optimum plant population by adjusting the spacing. In view of above points, an experiment was proposed to study of cost effective layout of drip and effect of irrigaton and fertigation levels on brinjal (*Solanum melongena* L.).

MATERIALS AND METHODS

A field experiment was conducted during *Rabi-hot* weather of 2009-2010 at Department of Agronomy, Dr. B.S.K.K.V, Dapoli, Dist. Ratnagiri (M.S.). The soil of experimental field was sandy clay loam in texture (Sand-52.82%, Silt- 53.13%, Clay- 24.55%), high in organic carbon (1.25%) and moderately acidic in reaction (pH 5.74), medium in available N (310.5 kg ha^{-1}), low in available P_2O_5 (12.48 kg ha^{-1}) and high in K_2O (247.3 kg ha^{-1}) content. Bouyoucos hydrometer method (Jackson, 1973) and Triangular diagram of prewifft Taylor (Piper, 1956) for physical properties, Potentiometric method (Jackson, 1973) for Soil pH, Walkely and Black titration method (Black, 1965) for Organic carbon in soil, Alkaline $KMNO_4$ method (Subbiah and Asija, 1956) for Available N in soil, Brays method (Brays and Kurtz, 1945) for Available P in soil, Flame photometer method (Jackson, 1973), The experiment was laid out in split plot design (Panse and Sukhatme, 1967) consisted of three planting density viz., (S_1-75x75cm, S_2-75-50X90cm, S_3-175-50x50cm) and three irrigation levels (I_1-100 per cent ET_{crop}, I_2-80 per cent ET_{crop}, I_3-60 per cent ET_{crop}). The sub plot treatments comprising of two fertigation levels *viz.,* (F_1-100 per cent RDF through drip, F_2-80 per cent RDF through drip). Thus these eighteen treatments combinations were replicated thrice. There were two controls (check basin) with manual application of recommended dose of fertilizer (C_1) and without fertilizer (C_2) in combination of surface irrigation at 1.0 IW/CPE ratio respectively which kept separated beside main and submain treatments.

FYM was applied uniformly after preparing the spots of required size before transplanting. One seedling was transplanted at each spot with 3-4 cm depth. The transplanting was done for three different spacing i.e. S_1 75x75cm, S_2 75-50x90cm, S_3 175-50x50cm in case of drip irrigation system and 75x75cm in case of check basin to maintain uniform plant population per hectare. The gap filling was done after seven days from transplanting. Three hand weeding were done to make the weed free plot. Plant protection measures were carried out throughout the crop season. For recording biometric observations, ten representative plants from each net plot were selected randomly. The selected plants were labeled with proper notations and all the biometric observations were recorded from these plants. First periodical observation was recorded at 30 days after transplanting and subsequent observations were recorded at every 30 days interval from first observation till the 120 DAT. Picking of fruits was undertaken at 2 to 3 days interval; full length (15-16 cm) tender fruits were hand-picked from net plot. The tender fruits from 10 observational plants were harvested separately during each harvesting for recording observations. Total yield of each net plot was calculated by summation of weight of fruits per net plot from all pickings. The grand total of each plot was converted on hectare basis (t ha^{-1}). Ten selected plants from each net plot, were used for recording the stalk dry matter production at harvest and the values were converted on hectare basis (kg ha^{-1}).

The irrigation was scheduled based on pan evaporation of data with interval of alternate day. The volume of water applied was calculated by using following formula. (Vermeiren and Jobling, 1980) V = Ep x Kp x Kc x A x Aw where, V- Volume of water to be applied, lit/alternate day/plot, Ep- Pan evaporation of previous two days, mm, Kp- Pan factor (0.7), Kc- Stage wise crop coefficient, A- Area of plot m^2, Aw- Wetted area for brinjal (0.75). The operation time of drip unit (t) was calculated by using the formula (Pawar, 2001)

$$t = \frac{V}{q \times N_o} \times 60$$

Where, t = Operation time of system (min), V = Volume of water to be applied, lit/alternate day/plot, q = Average emitter discharge (lph), Ne = Number of emitter per plots

For check basin, irrigation was applied to the crop with depth of 5 cm, IW/CPE = 1.0. For the experimental treatments fertigation was given in three split doses. The N, P and K were given at interval of 30, 60 and 90 DAT through 19:19:19 grade and remaining quantity of N was given through urea by calculating the quantity of fertilizer. For control C_1 (100 per cent RDF through soil application) 1/3rd quantity of N and 100 per cent P, K was applied as a basal dose and remaining 2/3rd quantity of N was applied at 30 ,60 and 90 DAT through manual application of solid fertilizers viz., Urea, SSP and MOP. For control C_2 no fertilizer was given which kept as absolute control.

RESULTS AND DISCUSSION

Effect of planting density

The results in (Table 1) revealed that yield contributing characters like number of fruits per plant, average fruit length, average diameter of fruit, average weight of fruit, weight of fruits per plant were significantly influenced by different planting density and revealed that spacing S_3 (175-50x50cm) recorded statistically higher values of number of fruits per plant (25), average fruit length (16.13 cm), average diameter of fruit (14.84 cm), average weight of fruit (86.85 g) and weight of fruits per plant (2543.7 g) over the rest of spacings under study. Similarly, the spacing S_2 (75-50x90cm) was found statistically superior to spacing S_1 (75x75cm). Similar kind of results have been reported by Singh and Singh (1992) and Tumbare *et al.* (2004). The suppression of weed growth in close spacing is significantly high than wide spacing which results into utilization of more solar radiation, soil moisture by plant that leads to superior reproductive growth of plant which ultimately helped to increase the yield attributing characters viz., number of fruits, length, diameter, average weight of fruit and weight of fruits per plant.

Different planting density significantly influenced the fruit yield (Table 2) and revealed that closest spacing S_3 (175-50x50cm) showed significantly higher fruit yield (44.76 t ha^{-1}) over the rest of planting densities under study. Similarly, the planting density S_2 (75-50x90cm) registered statistically superior (37.66 t ha^{-1}) to planting density S_1 (75x75cm) 30.89 t ha^{-1}. The increase in fruit yield in treatment S_3 was to the tune of 30.99 and 15.8 per cent over the treatments S_1 and S_2 respectively. Similar kind of findings were reported by Joshi *et al.* (1980), Rastogi *et al.* (1981), Rao and Lal (1982), Arora and *et al.* (1983), Rastogi *et al.* (1987) Singh and Singh (1992), Sontakke *et al.* (1995), Harminder singh *et al.* (1997), Chadha *et al.*(1998) and Pundir and Porwal (1999), Shukla *et al.* (2013).

With respect to dry matter viz., fruit, leaf, stem and total biomass (Table 3) it was observed that plant spacing S_3 (175-50x50cm) produced significantly greater values of dry matter including fruit (5827.2 kg ha^{-1}), leaf (853.7 kg ha^{-1}), stem (1785 kg ha^{-1}) and total biomass (8467.3 kg ha^{-1}) over the rest of plant spacings under study. Similarly, the plant spacing S_2 (75-50x90cm) noticed statistically superior to spacing S_1 (75x75cm). Increase in growth and yield contributing characters of plant leads to

Table 1: Mean values of number of fruits per plant, average length of fruit (cm), average diameter of fruit (cm) and average weight of fruit (g), weight of fruits per plant (g) as influenced by different

Tr Treatments	No of fruits per plant	Average length of fruit (cm)	Average diameter of fruit (cm)	Average weight of fruit (g)	Weight of fruits per plant (g)
Planting density					
S_1-75x75cm	23.26	14.89	13.63	74.57	1737.7
S_2-75-50x90cm	26.23	15.55	14.25	80.75	2120.7
S_3-175-50x50cm	29.25	16.13	14.84	86.85	2543.7
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
S.Em +	0.046	0.008	0.008	0.081	6.364
C.D. at 5 per cent	0.140	0.025	0.026	0.245	19.07
Irrigation levels					
I_1-100per cent ET_{crop}	27.27	15.71	14.44	82.70	2269.7
I_2-80per cent ET_{crop}	26.17	15.53	14.25	80.72	2126.3
I_3-60per cent ET_{crop}	25.30	15.32	14.03	78.75	2006.1
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
S.Em +	0.046	0.008	0.008	0.081	6.364
C.D. at 5 per cent	0.140	0.025	0.026	0.245	19.07
Fertigation levels					
F_1-100per cent RDF through drip irrigation(WSF)	27.02	15.68	14.39	82.34	2238.8
F_2-80per cent RDF through drip irrigation (WSF)	25.48	15.36	14.09	79.11	2029.3
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
S.Em +	0.040	0.032	0.028	0.077	5.336
C.D. at 5 per cent	0.121	0.096	0.084	0.231	16.00
Control treatments (Average values)					
C_1-100 per cent RDF as soil application	21.5	13.70	12.70	69.8	1500.7
C_2-Absolute control	13.8	11.93	10.13	52.2	720.7
Interaction effect					
Sp x Irr	0.065	0.012	0.012	0.115	9.003
Sp x Fer	0.070	0.055	0.049	0.133	9.243
Irr x Fer	0.070	0.055	0.049	0.133	9.243
Sp x Irr x Fer	0.121	0.096	0.084	0.231	16.01
C.D. at 5 per cent	N.S	N.S	N.S	N.S	N.S

increase in total biomass including fruit, leaf and stem dry matter. The close spacing responses highly to the availability of ample amount of macronutrients (NPK) resulted in a better vegetative growth of the crop and thereby higher dry matter production per unit area.

The spacing S_3 (175-50x50cm) produced maximum growth and growth attributing characters (Table 4) viz., mean plant height (88.85 cm), number of branches per plant (14.5), mean number of leaves per plant (97.25), plant spread (74.62 cm) over wide spacing. Similar kind of reports resulted by Aliyu *et al.* (1991), Tumbare *et al.* (2004). The ultra density crop facilitate in maintaining the soil fertility status which leads to proper growth and development of crop with producing higher number of branches resulted into maximum number of leaves per plant, height and spread. Leaves as the site for photosynthesis accumulates more carbohydrates to further increase their numbers.

Effect of irrigation levels

Yield and yield contributing characters (Table 1) viz., number of fruits per plant, average fruit length, average diameter of fruit, average weight of fruit, weight of fruits per plant were significantly influenced by different irrigation intensities and revealed that irrigation intensity I_1 (100 per cent ET_{crop}) recorded significantly superior values of number of fruits per plant (27.27), average fruit length (15.71 cm), average diameter of fruit (14.44 cm), average weight of fruit (82.70 g), weight of fruits per plant (2269.7 g) over the rest of irrigation intensities under study. Similarly, the irrigation intensity I_2 (80 per cent ET_{crop}) was found significantly superior to irrigation intensity I_3 (60 per cent ET_{crop}). While the control C_2 (surface irrigation with 1 IW/CPE ratio) showed lowest average values of number of fruits per plant (13.8), average fruit length (11.93 cm), average diameter of fruit (10.13 cm), average weight of fruit (52.2 g), weight of fruits per plant (720.7 g) as compared to all irrigation treatments. This might be due to the water stress in decreased level of irrigation resulted in poor plant growth due to restriction imposed on nutrient translocation, photosynthesis and metabolic activities of plant system. All these above referred yield attributes were decreased with subsequent decrease in the level of irrigation. Water is essential for cell division, root development, reproductive growth of plant and translocation of photosynthates. Yield attributing characters increased with increasing the level of irrigation as essential to meet the requirement for metabolic activities. The results corroborate the findings made by Satpute *et al.* (1992), Singandhupe *et al.* (2000) and Pawar and Firake (2003).

Different irrigation levels significantly influenced the fruit yield of brinjal (Table 2) and revealed that irrigation scheduled at I_1 (100 per cent ET_{crop}) produced higher fruit yield (40.17 t ha^{-1}) than irrigation scheduled at I_2 (80 per cent ET_{crop}) i.e. 37.63 t ha^{-1} and I_3 (60 per cent ET_{crop}) i.e. 35.50 t ha^{-1}. Also the similar trend was observed in irrigation level I_2 (80 per cent ET_{crop}) over irrigation level I_3 (60 per cent ET_{crop}). The increase in fruit yield in treatment I_1 was to the tune of 6.32, 11.63, 33.58 and

Table 2: Fruit yield of brinjal (t ha^{-1}) as influenced by different treatments

Treatments	Yield(t ha^{-1})
Planting density	
S_1-75x75cm	30.89
S_2-75-50x90cm	37.66
S_3-175-50x50cm	44.76
'F' test	Sig.
S.Em +	0.112
C.D. at 5 per cent	0.336
Irrigation levels	
I_1-100 per cent ET_{crop}	40.17
I_2-80 per cent ET_{crop}	37.63
I_3-60 per cent ET_{crop}	35.50
'F' test	Sig.
S.Em +	0.112
C.D. at 5 per cent	0.336
Fertigation levels	
F_1-100 per cent RDF through drip irrigation (WSF)	39.63
F_2-80 per cent RDF through drip irrigation (WSF)	35.92
'F' test	Sig.
S.Em +	0.094
C.D. at 5 per cent	0.282
Control treatments (Average values)	
C_1-100 per cent RDF through soil application	26.68
C_2- Absolute control	12.81
Interaction effect	
Sp x Irr	0.158
Sp x Fer	0.163
Irr x Fer	0.163
Sp x Irr x Fer	0.282
C.D. at 5 per cent	N.S

68.11 per cent over the treatments I_2, I_3, C_1 and C_2 respectively. While the control C_2 (surface irrigation with 1.0 IW/CPE ratio) recorded lowest average value of fruit yield (12.81 t ha^{-1}) as compared to all irrigation treatments. Yield is directly proportional to the total amount of water applied to crop. Increased level of irrigation produced high yield as compared to decreased level. Dry matter production is an important prerequisite for higher yield as it signifies photosynthetic ability of the crop and also indicates other synthetic process during developmental sequences. Similar kind of results have been reported by Limbulkar *et al.* (1998), Christopher Lourduraj *et al.* (1998a), Anonymous (2003c), Imtiyaz *et al.*(2004), Gutal *et al.* (2005) Bhanu Rekha *et al.* (2006) and Sharma *et al.* (2013).

Dry matter yield viz., fruit, leaf, stem and total biomass (Table 3) was significantly influenced by various irrigation levels and observed that irrigation replenishment I_1 (100 per cent ET_{crop}) produced significantly greater values of dry matter including fruit (5770.5 ka ha^{-1}), leaf (847.7 kg ha^{-1}), stem (1745 kg ha^{-1}) and total biomass (8364.7 kg ha^{-1}) over the rest of irrigation replenishments. Similarly, the irrigation replenishment I_2 (80 per cent ET_{crop}) was observed statistically superior to irrigation replenishment I_3 (60 per cent ET_{crop}). While the control C_2 (surface irrigation with 1.0 IW/CPE ratio) showed reduced average values of mean fruit (2433.3 kg ha^{-1}), leaf (420 kg ha^{-1}), stem (923.33 kg ha^{-1}) and total biomass (3776.6 kg ha^{-1}) as compared to all irrigation treatments. For drip, the irrigation was scheduled alternate two or three days which maintained the soil moisture almost near to the field capacity and crop did

Table 3: Fruit, leaf and stem dry matter (kg ha^{-1}) and total biomass of brinjal (kg ha^{-1}) as influenced by different treatments

Treatments	Fruit dry matter (kg ha^{-1})	Leaf dry matter (kg ha^{-1})	Stem dry matter (kg ha^{-1})	Total biomass (kg ha^{-1})
Planting density				
S_1-75x75cm	5654.4	835.0	1661.1	8150.5
S_2-75-50x90cm	5746.6	844.6	1725.0	8316.3
S_3-175-50x50cm	5827.2	853.7	1785.0	8467.3
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em +	1.470	0.283	1.951	2.561
C.D. at 5 per cent	4.406	1.848	5.850	7.680
Irrigation levels				
I_1-100 per cent ET_{crop}	5770.5	847.7	1745.0	8364.7
I_2-80 per cent ET_{crop}	5741.6	844.5	1725.0	8311.1
I_3-60 per cent ET_{crop}	5716.1	841.1	1701.1	8258.3
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em +	1.470	0.283	1.951	2.561
C.D. at 5 per cent	4.406	1.848	5.850	7.680
Fertigation levels				
F_1-100 per cent RDF through drip irrigation (WSF)	5767.0	847.1	1740.0	8355.1
F_2-80 per cent RDF through drip irrigation (WSF)	5718.5	841.7	1707.4	8267.6
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em +	3.105	0.380	2.819	5.566
C.D. at 5 per cent	9.310	1.141	8.451	16.68
Control treatments (Average values)				
C_1-100 per cent RDF as soil application	4803.3	680.0	1410.0	6893.3
C_2-Absolute control	2433.3	420.0	923.33	3776.6
Interaction effect				
Sp x Irr	2.078	0.400	2.759	3.623
Sp x Fer	5.379	0.659	4.882	9.640
Irr x Fer	5.379	0.659	4.882	9.640
Sp x Irr x Fer	9.316	1.142	8.457	16.69
C.D. at 5 per cent	N.S	N.S	N.S	N.S

Table 4: Mean values of plant height (cm), number of branches, number of leaves and plant spread (cm) as influenced by different treatments

Treatments Planting density	Plantheight(cm)	Number of branches	Number of leaves	Plant spread(cm)
S_1-75x75cm	86.46	13.4	96.04	72.31
S_2-75-50x90cm	87.68	13.9	96.65	73.42
S_3-175-50x50cm	88.85	14.5	97.25	74.62
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em +	0.017	0.018	0.008	0.027
C.D. at 5 per cent	0.051	0.056	0.025	0.081
Irrigation levels				
I_1-100 per cent ET_{crop}	88.09	14.1	96.83	73.81
I_2-80 per cent ET_{crop}	87.62	13.9	96.65	73.47
I_3-60 per cent ET_{crop}	87.28	13.7	96.45	73.07
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em +	0.017	0.018	0.008	0.027
C.D. at 5 per cent	0.051	0.056	0.025	0.081
Fertigation levels				
F_1-100 per cent RDF through drip irrigation (WSF)	88.05	14.1	96.8	73.75
F_2-80 per cent RDF through drip irrigation (WSF)	87.28	13.8	96.49	73.15
'F' test	Sig.	Sig.	Sig.	Sig.
S.Em +	0.030	0.025	0.026	0.020
C.D. at 5 per cent	0.090	0.076	0.079	0.061
Control treatments (Average values)				
C_1-100 per cent RDF as soil application	80.73	12.9	91.46	66.13
C_2-Absolute control	72.30	8.10	76.76	53.00
Interaction effect				
Sp x Irr	0.024	0.026	0.012	0.038
Sp x Fer	0.052	0.044	0.046	0.035
Irr x Fer	0.052	0.044	0.046	0.035
Sp x Irr x Fer	0.090	0.076	0.079	0.061
C.D. at 5 per cent	N.S	N.S	N.S	N.S

not experienced stress during the crop growth period in case of treatment I_1 (100 per cent ET_{crop} through drip). Optimum moisture and well aerated soil condition which reflected in better physiological activity in plants and thereby increased dry matter accumulation in brinjal. As the growth characters increased the total dry matter also increased. High frequency of irrigation registered more amount of dry matter including fruit, leaf and stem dry matter. Similar kinds of results have been reported by Sharma and Arora (1987) and Pawar and Firake (2003).

Growth and growth attributing characters (Table 4) such as plant height (88.09 cm), number of branches (14.1), number of leaves per plant (96.83) and plant spread (73.81 cm) were found to be produced maximum in irrigation level I_1 (100 per cent ET_{crop}) than irrigation level I_2 (80 per cent ET_{crop}) and I_3 (60 per cent ET_{crop}). Similar kind of results were reported by Pawar (2001) and Raskar (2003). While the control C_2 (surface irrigation with 1.0 IW/CPE ratio) showed lowest average values of growth parameters viz., plant height (72.30 cm), number of branches (8.10), number of leaves per plant (76.76) and plant spread (53 cm) as compared to all irrigation treatments. The losses due to evapotranspiration was more in hot-*rabi* season due to which the treatment supplied with more amount of irrigation water shown better vegetative growth due to effective absorption and utilization of water, rapid accumulation and translocation of carbohydrates with synthesizing high photosynthesis and abundant moisture availability in soil leads to proper growth and development brinjal which might have resulted into statistical maximum plant height, spread, number of branches, number of leaves during all the stages of crop growth. During entire growth stage, brinjal crop showed the response to moisture availability.

Effect of fertigation levels

(Table 1) shows that yield and yield contributing characters like number of fruits per plant, average fruit length, average diameter of fruit, average weight of fruit, weight of fruits per plant were significantly influenced by fertigation levels and revealed that fertigation level F_1 (100 per cent RDF through drip (WSF)) recorded statistically higher values of number of fruits per plant (27.02), average fruit length (15.68 cm), average diameter of fruit (14.39 cm), average weight of fruit (82.34 g), weight of fruits per plant (2238.8 g) over the fetigation level F_2 (80 per cent RDF through drip (WSF)) under study. While the control C_1 (100% RDF through soil application in combination of surface irrigation with 1.0 IW/CPE ratio) noticed lowest average values of yield parameters viz. number of fruits per plant (21.5), average fruit length (13.7 cm), average diameter of fruit (12.7 cm), average weight of fruit (69.8 g), weight of fruits per plant (1500.7 g) as compared to all fertilizer treatments. The effect was significant in drip obviously due to high efficiency and easy availability of plant nutrients through the liquid fertilizers. Similar kind of findings have been reported by James and Peterson (1992), Kadam and Sahane (2001), Kadam *et al.* (2007).

In case of fruit yield (Table 2), different fertigation levels influenced significantly and registered that fertigation level F_1 (100 per cent RDF through drip (WSF)) found significantly superior fruit yield (39.63 t ha^{-1}) over the treatment F_2 (80 per cent RDF through drip (WSF)) i.e. 35.92 t ha^{-1}. The fruit yield increased to the extent of 9.34, 32.68 and 67.68 per cent in treatment F_1 in comparison with F_2, C_1 and C_2 respectively. While the control C_1 (100% RDF through soil application in combination of surface irrigation with 1.0 IW/CPE ratio) was noticed reduced average value of fruit yield (26.68 t ha^{-1}) as compared to all fertilizer treatments. Similar kind of results were reported by Gnanakumari and Satyanarayana (1971), Vijaykumar *et al.* (1996), Kadam and Sahane (2001), Siviero *et al.* (2001), Shinde *et al.* (2002), Tumbare and Bhoite (2002), Shinde *et al.* (2004), Satpute *et al.* (2008), Sharma *et al.* (2013) and Patel *et al.* (2013).

In case of soluble fertilizers the nutrients become available readily throughout the growth stages of crop which produces optimum yield. However, straight fertilizers when applied into soil they may get leach out, volatilize or get fixed into the soil and hence they become unavailable to crop for their growth and development and hence crop do not produce optimum yield with its full potential. Similar results were also reported by Deolankar and Firake (1999).

Dry matter yield viz., fruit, leaf, stem and total biomass (Table 3) as influenced by various fertigation levels revealed that fertigation level F_1 (100 per cent RDF through drip (WSF)) produced significantly greater values of yield dry matter including fruit (5767 kg ha^{-1}), leaf (847.1 kg ha^{-1}), stem (1740 kg ha^{-1}) and total biomass (8355.1 kg ha^{-1}) over the fertigation level F_2 (80 per cent RDF through drip (WSF)). While the treatment C_1 (100% RDF through soil application in combination of surface irrigation with 1.0 IW/CPE ratio) showed reduced average values of mean fruit (4803.3 kg ha^{-1}), leaf (680 kg ha^{-1}), stem (1410 kg ha^{-1}) and total biomass (6893.3 kg ha^{-1}) as compared to all fertilizer treatments.

Growth and growth attributing characters (Table 4) such as plant height, number of branches, number of leaves per plant and plant spread were significantly influenced by different fertigation levels. The treatment F_1 (100 per cent RDF through drip (WSF)) recorded statistically maximum growth and growth attributing characters viz. plant height (88.05 cm), number of branches (14.1), number of leaves (96.8) and plant spread (73.75 cm) as compared to F_2 (80 per cent RDF through drip (WSF)). While the control C_1 (100% RDF through soil application in combination of surface irrigation with 1.0 IW/CPE ratio) showed less average values of plant height (80.73 cm), number of branches (12.9), number of leaves (91.46) and plant spread (66.13 cm) as compared to all fertilizer treatments. Availability of ample amount of macronutrients (NPK) in soil applied through drip resulted in a better vegetative growth and growth attributing characters of the crop. Similar kind of findings reported by Rao and Lal (1982), Shinde *et al.* (2002) and Patel *et al.* (2013).

Interaction effects between planting density, irrigation levels and fertigatioin levels

None of the growth characters and yield attributes were significantly influenced by interaction effects of irrigation levels, planting density and fertigation levels.

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