water requirement along with black plastic mulch. Several other scientists working with drip irrigation and mulch on various fruit crops also stressed on the significant improvement in yield parameters *viz.*, Dixit *et al.* (2003), Sriniwas (2005) and Coelho and Borges (2004) in mango; Shirgure *et al.* (2000) in Nagpur mandarin, Sulochanamma *et al*. (2005) in pomegranate and Ramniwas *et al*. (2012) in guava etc. here, the possible reason for highest yield under 100% ETc and mulching, maintained optimum soil moisture throughout fruit growing period and mulching also has helped in soil moisture and nutrient conservation and favorable hygrothermal balance, which ultimately helps in better yield.

Water use efficiency (g liter^{-1} water)

Current findings evident that, the water use efficiency (WUE) was found to be influenced variably by different irrigation and mulching treatments (Table 3). The data on main effect of irrigation indicate the WUE to the tune of 5.51 g liter^{-1} water under I_1 (75 % ETc) and minimum WEU (4.90 g liter^{-1} water) was recorded in I_2 (100 % ETc). Similarly, maximum WUE (5.91 g liter^{-1} water) registered with M_1 and minimum (4.50 g liter^{-1} water) was noted in M_0 (without mulching). Similarly, the maximum WUE (6.28 g liter^{-1} water) was noted with conjugation of mulching and 75% ETc (I_1M_1). However, minimum WUE (4.26 g liter^{-1} water) was noted in without mulching and 100 % ETc (I_2M_0). The results suggested that, 75 % ETc was registered highest yield per unit water consumption. From present investigation the highest WUE might be due to the effect of improved soil, microclimate, weed free environment, low evaporation and higher moisture availability in the root zone that helped in better nutrient uptake by plant resulting in earlier and better vegetative growth, which then enhanced the photosynthesis rate and translocation of synthesized food from leaves to fruits, resulted in early harvesting and increased number of fruits per plant under black plastic mulch. Among the different treatments the conjugation of irrigation and mulching has proven higher WUE i.e. 25 percent water saving over 100 % ETc + un-muching condition, without adverse effect on yield and similar finding are suggested by Panigrahi *et al.* (2010) in mango with 60% water through drip with black polythene mulch and Srivastava *et al.* (1999) in banana. Here, the lower WUE in 100 % ETc without mulching due to huze water lost through evaporation which lead to least WUE that of 75 % ETc with mulching. Similarly, Tiwari *et al.* (2014) also noted higher WUE with 80% of irrigation met through drip irrigation along with plastic mulching in sapota. From the present study it was indicated that I_1 has recorded 12.45 percent more water use efficiency compared to I_2. The mulching has also registered 23.86 % higher WUE compared to unmulched condition. Similarly the intreraction of irrigation and mulching the treatment I_1M_1 has noted 32.17 % more WUE compared to I_2M_0 and 14.44 % better WUE with I_1M_1 compared to I_2M_1.

Fertilizer use efficiency (q kg-1 fertilizer)

The present study exhurted that, the fertilizer use efficiency (FUE) has significantly influenced by different irrigation and mulching treatments (Table 4). The data of main effect of irrigation was indicated the FUE to the tune of 0.79 q kg^{-1} fertilizer under I_2 (100 % ETc) and minimum FUE (0.66 q kg^{-1} fertilizer) was recorded in I_1 (75 % ETc). Similarly, maximum FUE (0.82 q kg^{-1} fertilizer) registered with M_1 and minimum (0.69 q kg^{-1} fertilizer) was noted in M_0 (without mulching). Similarly, the maximum FUE (0.89 q kg^{-1} fertilizer) was noted with conjugation of 100 % ETc and mulching (I_2M_1). However, minimum FUE (0.57 q kg^{-}

[1]fertilizer) was noted in without mulching and 75 % ETc (I_1M_0). Present study suggests that, application 100 % ETc along with mulching proven to higher FUE compared to other treatments it may be due to the plastic mulch increase soil moisture by reducing loss of water through evaporation, increase nutrient use efficiency by reducing loss of nutrients through leaching, surface run off or volatilization, eliminates weed growth at the vicinity of tree, thereby providing congenial environment for enhanced tree growth, fruit yield and quality, besides ameliorating leaf nutrient contents and water use efficiency Neilsen *et al.* (2003) in apple and Barman *et al*. (2017) in guava Cv. Lalit. From our study I2 (100 % ETc) has registered 16.46 % better FUE as compared to I_1 (75 % ETc). Regarding to mulching, the mulched plants was found 23.17 % efficient in fertilizer usage. Similarly the interaction of mulching along with 100% ETc has exurted 35.96 % higher FUE over 75 % ETc + without mulching.

Economics

The economics of mango influenced by different levels of irrigation and fertilization had shown significant among the treatments and the data is presented in Table 4.1.32 and the detail of cost of cultivation is given in table-5 and 6**.**

The data on cost of cultivation per hectare revealed that, the irrigation treatment I_2 has recorded maximum gross returns and net returns (3.55 and 3.06 lakh ha^{-1}, respectively) and least values were registered with I_1 (3.00 and 2.50 lakh ha^{-1}), similarly maximum gross returns and net returns (3.71 and 3.16 lakh ha^{-1}, respectively) was registered with M_1 (with mulching) and minimum was noted with M_0 (2.82 and 2.38 lakh ha^{-1}, respectively). The maximum benefit cost ratio (BCR) was registered with I2 (7.20) and minimum BCR was noted with I_1 (6.07). Here, 100 % ETc gave 15.67 % higher BCR compared to 75 % ETc. Similarly, maximum benefit cost ratio (BCR-6.86) was registered with M_1 (with mulching) and minimum BCR (6.41) was noted with M_0 (without mulching) and the mulched plants has registered 6.56 % more BCR compared to unmulched plants. Similarly, maximum gross returns and net returns (4.00 and 3.46 lakh ha^{-1}, respectively) was registered with I_2M_1 (with mulching) and minimum was noted with I_1M_0 (2.57 and 2.13 lakh ha^{-1}, respectively) and the maximum BCR (7.41) was noted with conjugation of 100% ETc and mulching (I_2M_1). However, minimum BCR (5.83) was noted in without mulching and 75% ETc (I_1M_0). Present study suggests that, application 100 % ETc along with mulching proven to higher BCR compared to other treatments it may be due to the plastic mulch increase soil moisture by reducing loss of water through evaporation, increase nutrient use efficiency by reducing loss of nutrients through leaching, surface run off or volatilization, eliminates weed growth at the vicinity of tree, thereby providing congenial environment for enhanced tree growth, fruit yield resulted higher BCR in mango (Pradhan *et al.*, 2010). From this the interaction of 100 % ETc along with mulching has gave 21.32 % higher BCR compared to 75 % ETc + unmulched condition, 14.98 % more compared to 75 % ETc + mulched plants and 5.3 % higher BCR compared to 100 % ETc + unmulched condition.

4. Conclusion

From the investigations on the effect of irrigation and mulching was proved that the maximum fruit yield, water and nutrient use efficiency, and the higher BCR were also obtained with the application of 100 % ETc along with mulching. But the WUE was highest with 75 % ETc + with mulching, and it is also suggested the during water scare

condition the combination of 75 % ETc + with mulching is an effective way to manage irrigation without any adverse on fruit yield, quality and economy of mango Cv. Banganpalli. In this instance efficient water use is possible with crop improvements by enabling crops to grow successfully under drought environments and use of advanced water-saving irrigation techniques and measures can significantly reduce water consumption, improve agronomic water use efficiency, save labor and costs, reduce the adverse effects of agricultural water resource availability from climate change and relieve the crisis of water resource and so on.

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Table: 1 Physical and chemical properties of experimental soil.

Particulars	Value for 0-60 cm depth
A. Physical properties	
Sand (%)	70
Silt (%)	19
Clay (%)	11
Textural class	Red sandy lome
B. Chemical properties	
pH	7.5
Electrical conductivity (dS m^{-1} at 25°C)	0.33
Organic carbon (%)	0.56
Available N (kg ha^{-1})	185
Available P_2O_5 (kg ha^{-1})	23
Available K_2O (kg ha^{-1})	240

Table 2: Effect of irrigation and mulching on fruit yield (kg $tree^{-1}$) of mango Cv. Banganpalli *.

Particulars	Fruit yield (kg $tree^{-1}$)

	M_0	M_1	Mean
I_1 (75% ETc)	57.18^{d}	75.78b^{c}	**66.48^{b}**
I_2 (100% ETc)	68.56c	89.11^{a}	**78.83^{a}**
Mean	**62.87^{B}**	**82.45^{A}**	
Factors	**F- Test**	**SEm±**	**CD at 5%**
Irrigation (I)	*	2.346	7.308
Mulching (M)	*	2.346	7.308
Interaction (IXM)	*	3.317	10.61

(Average values of two years data)

Note: **M_0**- Without mulch; **M_1**-With mulch; **F-Test (*)**-significant; **CD** at 5 per cent level of significance; **NS**-Non-significant.

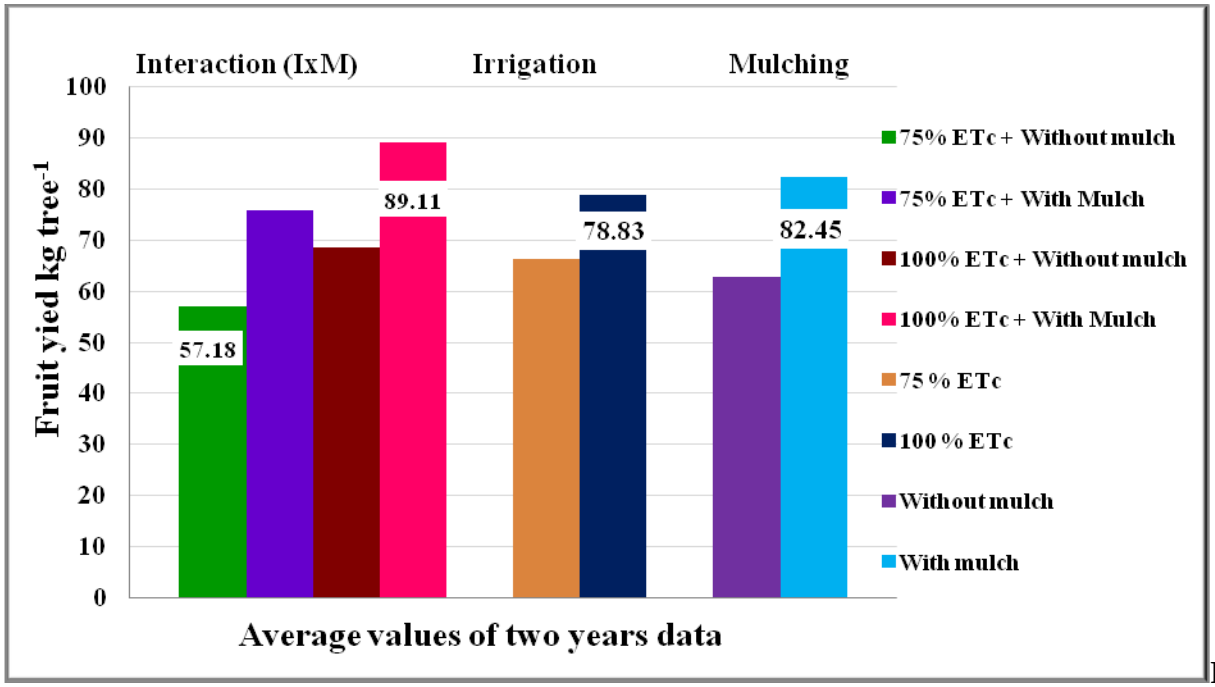

Fig 1: Effect of irrigation and mulching on fruit yield (kg tree^{-1}) of mango Cv. Banganpalli.

Table 3: Water use efficiency of mango (g liter^{-1} water)*.

Particulars	WUE (g liter^{-1} water)		
	M_0	M_1	Mean
I_1 (75% ETc)	4.74	6.28	**5.51^{a}**

I_2 (100% ETc)	4.26	5.54	**4.90^b**
Mean	**4.50^b**	**5.91^a**	
Factors	**F- value**	**SEm±**	**CD at 5%**
Irrigation (I)	*	0.17	0.53
Mulching (M)	*	0.17	0.53
Interaction (IXM)	NS	0.24	-

(*Average values of two years data)

F-value (*)-significant; **CD** at 5 per cent level of significance; **NS**-Non-significant; **M_0**-without mulch; **M_1**-With mulch

Table 4: Fertilizer use efficiency (q kg^{-1} fertilizer)

Particulars	**FUE (q kg^{-1} fertilizer)**		
	M_0	**M_1**	**Mean**
I_1 (75% ETc)	0.57	0.76	**0.66^b**
I_2 (100% ETc)	0.69	0.89	**0.79^a**
Mean	**0.63^b**	**0.82^a**	
Factors	**F- value**	**SEm±**	**CD at 5%**
Irrigation (I)	*	0.023	0.073
Mulching (M)	*	0.023	0.073
Interaction (IXM)	NS	0.033	-

(*Average values of two years data)

F-value (*)-significant; **CD** at 5 per cent level of significance; **NS**-Non-significant; **M_0**-without mulch; **M_1**-With mulch

Table-5: Cost of cultivation for mango Cv. Banganpalli with different levels of irrigation, fertigation and mulching.

(Note: Marketable price of mango Cv. Banganpalli 45 ₹ kg^{-1})

No.	Materials/works	I_1M_0	I_1M_1	I_2M_0	I_2M_1
I.	**Inputs**	**30,941.88**	**40,941.88**	**30,941.88**	**40,941.88**
1.	Recommended dose (RDF) is 1000:1000:1000 g of NPK and 50kg FYM $plant^{-1}$ $year^{-1}$ for >10 years old plants (1.33 kg of Urea; 2.2 kg of DAP and 2.0 kg of SOP per plant)	16480.88	16480.88	16480.88	16480.88
	∗ Urea ₹ 5.52 kg^{-1}	732.00	732.00	732.00	732.00
	∗ DAP ₹ 10.4 kg^{-1}	2261.00	2261.00	2261.00	2261.00
	∗ SOP ₹ 17.44 kg^{-1}	348.00	348.00	348.00	348.00
	∗ FYM ₹ 2.00kg^{-1}	10,000.00	10,000.00	10,000.00	10,000.00
	∗ Zinc ₹ 100 kg^{-1}	500.00	500.00	500.00	500.00
	∗ Iron ₹ 80 kg^{-1}	200.00	200.00	200.00	200.00
	∗ Boron ₹ 90 kg^{-1}	180.00	180.00	180.00	180.00
	∗ Magnesium ₹ 80 kg^{-1}	240.00	240.00	240.00	240.00
	∗ Mulch material 2000 ₹ $Roll^{-1}$ (400 x 0.9 m) to cover 20 m canopy area $plant^{-1}$ ha^{-1}	--	10000.00	--	10000.00
II.	**Cultural operations, plant protection and labour charges**	**48,800.0**	**48,800.0**	**48,800.0**	**48,800.0**
2.	Spraying of micronutrients 4 labour (300 ₹. per day)	1200.00	1200.00	1200.00	1200.00
3.	Bunds formation, Weeding, irrigation and fertilizer application 75 labours	21,000.00	21,000.00	21,000.00	21,000.00
4.	Plant protection chemicals and measures (700 litte $water^{-1}$ ha^{-1})	8,800.00	8,800.00	8,800.00	8,800.00
	∗ 16 labours for 4 sprays (300 ₹. per day)	4,800.00	4,800.00	4,800.00	4,800.00
	∗ Neem oil @ 2.5 ml l^{-1} (1.75 l Neem oil and 400 ₹ l^{-1})	700.00	700.00	700.00	700.00
	∗ Thiomethoxam @ 0.5 ml l^{-1} (0.35 l ha^{-1} and 1,600 ₹ l^{-1})	560.00	560.00	560.00	560.00
	∗ Imidachloprid @ 0.5 ml l^{-1} (0.35 l ha^{-1} and 2,000 ₹ l^{-1})	700.00	700.00	700.00	700.00
	∗ Profenophos +cypermetrin 0.5 ml l^{-1}(0.35 l ha^{-1} and 1,200 ₹ l^{-1})	420.00	420.00	420.00	420.00
	∗ SAAF (Carbendazim 12 % + Mancozeb 63 % wp) @ 2.0 g l^{-1} (2.00 kg l ha^{-1} (600 ₹ kg^{-1})	1200.00	1200.00	1200.00	1200.00
	a. Hexaconazole @ 0.5 ml l^{-1} (0.35 l ha^{-1} and 1,200 ₹ l^{-1})	420.00	420.00	420.00	420.00
5.	15- Labours for each harvesting in control (4,500 .00 ₹ $harvest^{-1}$)	9,000.00	9,000.00	9,000.00	9,000.00
III.	**Total cost of cultivation**	**79, 7741.88**	**89, 7741.88**	**79, 7741.88**	**89, 7741.88**

Table 6: Economy of mango influenced by irrigation and mulching treatments*.

Particulars	Gross income (₹ ha^{-1})			Net income (₹ ha^{-1})			BCR		
	M_0	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**
I_1 (75% ETc)	257,298.40	341,028.90	**299,163.70**	213,198.40	286,928.90	**250,063.70**	5.83	6.30	**6.07^B**
I_2 (100% ETc)	308,499.20	400,973.90	**354,736.50**	264,399.20	346,873.90	**305,636.50**	7.00	7.41	**7.20^A**
Mean	**282,898.80**	**371,001.40**		**238,798.80**	**316,901.40**		**6.41**	**6.86**	
Factors	**F- value**	**SEm±**	**CD at 5%**	**F- value**	**SEm±**	**CD at 5%**	**F- value**	**SEm±**	**CD at 5%**
Irrigation (I)	*	10,554.73	32,882.56	*	10,554.74	32,882.60	*	0.21	0.64
Mulching (M)	*	10,554.73	32,882.56	*	10,554.74	32,882.60	NS	0.21	-
Interaction (IXM)	NS	14,926.64	-	NS	14,926.66	-	NS	0.29	-

(*Average values of two years data)

F-value (*)-significant; **CD:** at 5 per cent level of significance; **NS**-Non-significant; **M_0**- without mulch; **M_1**-With mulch