Evaluation of surface and drip irrigation methods for marigold flower (*Tagetes erecta* L.) under Raichur condition

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ABSTRACT

The experiment was carried out to study the effect of surface irrigation and drip irrigation methods on Marigold flower from October 2012 to March 2013 at New Orchard of Main Agricultural Research Station, University of Agricultural Science, Raichur. The objective was to work out the different levels irrigation of marigold and to compare the performance of growth parameter, yield, quality parameters, irrigation efficiencies and economics of drip and furrow irrigation (60, 80, 100 and 120 % ET). The water saved in drip irrigation over furrow irrigation was found to be 74.92 %, 68.07%, 61.45% and 54.65% for 60%, 80%, 100% and 120% ET respectively. The response of Marigold to different drip irrigation levels in terms plant height, number of flower per plant, number of branches and were significantly superior in respect of 80 per cent followed by 100 per cent ET level. Marigold under different irrigation treatments except 60 per cent ET level performed very well in terms of average ten flower weight and diameter of flower. The highest yield of marigold flower 19.63 t ha^{-1}was obtained in 80 per cent ET level which was closely followed by 100 per cent ET level (17.03 t ha^{-1}).The application and distribution efficiencies were found to be higher with drip irrigation treatments as compared to furrow irrigation. All the drip irrigation treatments recorded higher benefit: cost ratio (4.88 to 2.30). The furrow irrigation produced a benefit cost ratio of 1.73. The general trend considering the different parameters tested suggests that 80 per cent ET level can be used to achieve higher yield of Marigold in sandy loam soils, under Raichur (semi arid conditions).

Keywords: drip irrigation, surface irrigation, marigold flower, semi-arid

INTRODUCTION

Micro irrigation technology is rapidly expanding all over the world, especially in the water scarce areas of developed countries. It is very popular in the United States, Israel and some parts of Europe. North America and Europe have the highest record of Micro Irrigation System (MIS) utilization while Asia is in the development stage. Irrigation plays a vital role in Australian agriculture; here irrigated agriculture uses 75% of total water. This technology has also established a stronghold in the Asian regions, where it is best utilized in India and China but still there is ample market potential with a continuously rising population. Drip irrigation is becoming the most

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demanded technology. Water scarcity is the most important driving factor of the MIS industry and apart from the area available for crop production, growing population in the country and lower GDP in the agriculture sector also contributes to the growing demand for MIS. The other major contributor to this market is growing pollution levels due to which the water availability has declined and in the near future this trend is expected to continue.

Micro irrigation is a relatively new method, which was developed all over the world towards the later part of the last century. This system has gained wide popularity in areas of acute water scarcity and in areas where horticultural and commercial crops are grown. During the year 1991, micro irrigation was being practiced in as many as 35 countries in the world, out of which India ranked seventh in terms of coverage of area. The other countries, which have brought substantial area under drip irrigation, include USA, Spain, Australia, South Africa, Israel and Italy. The area covered under drip irrigation is highest in Maharashtra followed by Andhra Pradesh and Karnataka [1].

Drip irrigation reduces water contact with crop leaves stems and fruit. Thus, conditions might be less favorable for disease development. Agricultural chemicals can be applied more efficiently with drip irrigation. Since only the crop root zone is irrigated, nitrogen already in the soil is less subject to leaching losses and applied nitrogen fertilizer can be used more efficiently. In case of insecticides, fewer products are needed. In India, marigold ranks first among the loose flowers followed by chrysanthemum, jasmine, tuberose and crossandra [2]. Today, there is huge demand for natural colours of marigold, calendula and hibiscus, in the international market and marigold is one such potential flower crop.

Marigold also has got therapeutic values. The flowers either fresh or dried are much used in stews, soups, mixed with cheese and drinks. Even today, the marigold is used by herbal doctors for simple ailments. The juice extracted from leaves is used for getting relief from boils, carbuncles and ear, floral extract is a good remedy for eye diseases and ulcers, petal juice heated with an equal quantity of ghee given thrice a day cures the bleeding piles as well as purifies the blood. The dried petals are used against ringworms, stubborn wounds; bedsores, persistent ulcer and a mouth wash for bed gums. Essential oil acts as a repellent against flies, ants and mosquitoes. Apart from this, essential oil is used in high grade perfumes and cosmetic industries. Marigold is also used for other purposes like making garlands, decorations and for religious purposes.

MATERIALS AND METHODS

A field experiment was conducted from October 2012 to March 2013 at new orchard of Main Agricultural Research Station, UAS, Raichur 16°15´ N latitude and 77°20´ E longitude and is at an elevation of 389 m above mean sea level (MSL). The climate is semi-arid and average annual rainfall is 722 mm. The soil was sandy clay loam in texture and had pH of 7.65. There were five irrigation treatments, i.e., 60, 80, 100 and 120 percent ET in drip irrigation and surface irrigation, taken for the studies which were laid out in randomized block design with four replications. African marigold cv. orange double from University of Agricultural Science, Raichur was selected for the experiment. Flowers are solitary and orange in colour.

The 30 days old healthy and uniformly grown seedlings were used for transplanting at spacing of 50 cm × 45 cm in drip and 60 cm × 45 cm in surface irrigation. The seedlings were transplanted in ridges of 10 m length were made at a spacing of 0.80 m width for control treatment and buffers were given to prevent moisture movement from one treatment plot to another treatment plot. For drip irrigation raised beds with paired rows of 10 m length and 0.8 m width were formed, in furrow treatment 10 m length and 1 m width were formed. Three laterals of 12 mm diameter were used each bed with a inline dripper at 40 cm distance and discharge of 2 l/h irrigation was provided daily after calculating water requirement based on past 24 hours of pan evaporation while in furrow (surface) irrigation it was scheduled ones in seven days.

The peak water requirement can be calculated by Q = A × B × C /E , where Q is the quantity of water required (mm/ day), A is daily evapotranspiration (mm), B is Canopy factor, C is Crop co-efficient and E is efficiency of drip irrigation system (per cent). Duration of irrigation (DI) was calculated by DI (Hours) = Dripper discharge/ (Dripper spacing × Inline spacing). The water application efficiency of drip irrigation was calculated by $E_a = (e \times q_{min} \times T/V) \times 100$, whereas Ea is application efficiency (%), e is total numbers of emitters q_{min} is minimum emitter flow rate (lph), T is total irrigation time (hr) and total volume of water applied (L) [3]. The application efficiency of furrow irrigation was calculated by Ea= W_s/W_f where as W_s is water stored in the root zone, liter and W_f is water deliverd to the field. The water use efficiency of drip and furrow irrigation was calculated by E_u =Y/WR, where is E_u is water use efficiency (kg/m^3), Y is crop yield (kg) and WR is total amount of water used in the field (m^3). For periodical field observations, six plants were selected randomly from each treatment and were tagged. Observations such as plant height, stem girth, number of branches per plant, number of leaves per plant, leaf area, leaf area index, flower diameter, number of flower per plant, weight of ten flowers and shelf life were taken from selected six plants.

Economics of drip irrigation and furrow (surface) irrigation method was worked out to compute the net returns and benefit-cost ratio. For this purpose, the life period of polyvinyl chloride (PVC) items was considered as 10 years [4] and that of the submersible pump set was taken as 15 years [5]. One ha area, under each treatment was considered for comparison. The fixed cost, operation cost and total cost were worked out. Fixed cost consisted of interest on initial cost and depreciation on the system. The interest calculated on the capital was at the rate of 12 percent per annum as per the prevailing bank rates. The depreciation on the system was worked out as follows, D= I –S/ L where as D is Depreciation per annum (Rs), I is Initial cost of system (Rs), S is Salvage value (10% of initial cost), Rs and L is Economic life period, years (Economic life of PVC-10 years and pump-15 years). Operating cost is the amount which is actually paid by the cultivator in cash throughout the crop period for carrying various agricultural operations. Total operational cost of the system is the operating cost plus interest on operational cost at the rate of 12 percent. The total cost is calculated as follows: total cost = fixed cost + operating cost.

RESULTS AND DISCUSSION

Water requirement of marigold flower

The first irrigation was applied up to field capacity to all the plots of different irrigation treatments. Subsequently, the irrigation water was delivered through drip irrigation as per treatments and in furrow irrigation the crop was irrigated at variable frequency and depth of irrigation was calculated. The amount of water applied per month for different levels of drip irrigation and furrow irrigation are presented in table 1. For drip irrigation at 60 per cent ET, the monthly water requirement varied from 1.72 mm (October) to 58.82 mm (February). Similarly, the amount of water required for 80, 100 and 120 per cent ET. For control (furrow irrigation) the water requirement varied from 40 mm in October to 200 mm December.

The water saving over furrow irrigation was maximum for 60 per cent ET treatment (74.92%), followed by 80 per cent ET (68.07%), 100 per cent ET (61.45%) and 120 per cent ET (54.65%) treatments. From these results it may be concluded that there is a substantial amount of water saving by drip irrigation system as compared to furrow irrigation. This may be attributed to the fact that maximum amount of water applied will be stored in the root zone in case of drip irrigation treatments and the deep percolation losses are minimum. These results are in agreement with the earlier findings [6].

Table 1. Monthly amount of water applied to marigold flower under different levels of drip and furrow irrigation.

Months	Amount water applied through drip irrigation at different irrigation levels, mm				Water applied in furrow irrigation
	T1 (60% ET)	T2 (80% ET)	T3 (100% ET)	T4 (120% ET)	
20th October	40	40	40	40	40
21st October 31st Oct	1.72	2.29	2.86	3.44	40
November	6.17	8.21	10.27	12.32	160
December	20.98	27.97	34.97	41.94	200
January	50.03	66.71	83.38	100.06	160
February	58.82	78.44	96.11	115.33	160
1st March to18th March	42.98	57.30	71.63	85.96	120
Total	220.70	280.90	339.22	399.09	880
% saving water over furrow	74.92	68.07	61.45	54.65	

Irrigation capacity (duty) and delta

The capacity of unit quantity of water to irrigate a crop is an important factor for any irrigation system presented in table 2. With increase in the level of irrigation the amount of water applied also showed an increasing trend; whereas the irrigation capacity was found on a decreasing pattern. It was also observed that, the irrigation capacity was lowest 1.13×10^{-4} ha m^{-3} for furrow irrigation. The highest irrigation capacity of 4.53×10^{-4} ha m^{-3} was obtained for the treatment water application at 60 per cent ET. Delta is the depth of irrigation (expressed in cm) required during the crop period. Delta is the depth of irrigation (expressed in cm) required during the crop period. Delta of water for different treatments is presented in table 2. It was observed from the table that delta was highest (88 cm) for furrow irrigation and among the drip irrigation treatments, it was lowest (22.07 cm) for water application at 60 per cent ET and it was highest (39.90 cm) for water application at 120 per cent ET.

Table 2. Irrigation capacity (duty) of $1m^3$ of water and delta of water for different treatments for the crop period.

Treatments	Water applied in (lit $plot^{-1}$)	Water applied in (m^3 ha^{-1})	Irrigation capacity (ha m^{-3})	Delta (cm)
T1	1765.6	2207.0	4.53×10^{-4}	22.07
T2	2247.2	2809.0	3.55×10^{-4}	28.09
T3	2713.7	3392.2	2.94×10^{-4}	33.92
T4	3192.4	3990.5	2.50×10^{-4}	39.90
T5	7040.00	8800.00	1.13×10^{-4}	88.00

Biometric parameters

The results revealed that there was significant difference in growth and yield of marigold under different irrigation methods. plants receiving water at 80 per cent ET recorded maximum height

(121.25 cm) which was on par with 100 per cent ET (116.25 cm) the significant difference with the 60 per cent and 120 per cent ET (89.25 cm, 106.25 cm), whereas lowest value was found in control treatment (76.50 cm). The data pertaining to leaf area per plant receiving 80 percent ET recoded significantly maximum (829.25 cm^2) followed by 100, 120 and 60 percent ET. The minimum value was noticed in control treatment (670.00 cm^2). Plants receiving water at 80 per cent ET recorded maximum stem girth (2.49 cm) which was on par with 100 per cent ET (116.25 cm) and significant difference with the 60 per cent and 120 per cent ET (1.98 cm, 2.27 cm). The lowest value was found in control treatment (1.64 cm). Plants receiving water at 80 per cent ET recorded the maximum number of branches (31.5) which was on par with the 100 per cent (29.5) and significant difference with 60 per cent and 120per cent ET treatments (23.15, 26.25) whereas lowest values were found in control treatment (17.00). Plants receiving water at 80 per cent ET recorded maximum number of leaves (180.50) which was on par with 100 per cent ET (177.25) and significant differences with the 60 per cent and 120 per cent ET (157.00 and 165.75) whereas lowest value was found in control treatment (105.00). Plants receiving water at 80 per cent ET recorded the maximum leaf area index (0.56) which was on par with 100 per cent ET (0.55), significantly differences with the 60 per cent and 120 per cent ET (0.47, 0.51), the minimum values were noticed in control treatment (0.37). The total marketable yield per hectare as influenced by different level of irrigation methods and levels of drip irrigation are presented in table 3. The total yield was significantly higher in 80 per cent ET recorded the maximum yield (19.62 t ha^{-1}) which was on par with 100 per cent ET (17.03 t ha^{-1}) and significant difference with 60 per cent and 120 per cent ET (11.01 and 14.46 t ha^{-1}) the lowest yield was recorded in case of control treatment (7.48 t ha^{-1}). Higher yield in drip irrigation may be attributed to higher plant stands and better plant growth, which enable higher accumulation of photosynthesis. Better growth of plants led to higher yield in drip irrigation at 80 per cent ET level followed by 100 per cent ET level, these results are in agreement with the earlier findings [7].

Table 3. Effect of irrigation systems on growth and yield of marigold.

Treatments	Plant height (cm)	Leaf area (cm^2)	Stem girth (cm)	Number of leaves	Number of branches	Leaf area index
T_1 (60 % ET)	89.25	809.25	1.98	157.00	23.15	0.47
T_2 (80 % ET)	121.25	829.25	2.49	180.50	31.50	0.56
T_3 (100 % ET)	116.25	819.25	2.46	177.25	29.50	0.55
T_4 (120 % ET)	106.25	816.75	2.27	165.75	26.25	0.51
T_5 (Surface irrigation)	76.50	670.00	1.64	105.00	17.00	0.37
CD (0.05)	8.57	9.51	0.12	10.87	2.57	0.03

Data in respect of flower diameter are presented in table 4. The flower diameter ranges from 4.40 to 7.23 cm in different treatments under study. The maximum flower diameter of (7.25 cm) was found in case of 80 per cent ET, which was on par with 100 per cent ET (6.95 cm) and significant difference with 60 per cent ET and 120 per cent ET (5.73, 6.28 cm), the minimum values were noticed in control treatment (4.4 cm). Similar results were observed in the earlier works [8]. The results of number of flower per plant for different irrigation treatments are presented in table 4. The maximum number of flower per plant (76.75 per plant) was found in case of 80 per cent ET, which was significantly higher than the other treatments, similarly other treatment of 100 per cent ET (66.5 per plant) which was on par with 120 per cent ET treatment (63.25 per plant). The minimum value was found in control treatment (48 per plant).

The results of shelf life marigold flower for different irrigation treatments are presented in table 4. The maximum shelf life of flowers was recorded in 80 per cent ET (4.5 days) which was on par with 100 per cent ET (3.95 days) and significant difference with 60 per cent and 120 per cent ET (3 and 3.15days) whereas control treatment recorded the lesser shelf life of flower (2days). The results of yield per plot for different irrigation treatments are presented in table 4. The plants receiving water at 80 per cent ET recorded the maximum yield (15.69 kg plot^{-1}) which was on par with 100 per cent ET (13.83 kg plot^{-1}) significant difference with 60 per cent and 120 per cent ET (9.81, 11.00 kg plot^{-1}). The lowest yield was noticed in control treatment (5.99 kg plot^{-1}). The results of ten flower weight for different irrigation treatments are presented in table 4. The maximum ten flower weight of 71.55 gm was found in case of 80 per cent ET, which was on par with the treatment of 100 per cent ET (69.85 gm) and significant difference with 60 per cent ET and 120 per cent ET (41.25 and 52.5 gm). The minimum value was found in control treatment (37.00 gm).

Table 4. Effect of irrigation methods and irrigation level on yield traits, quality and yield marigold flower.

Treatments	Days to 50 per cent flowering	Number of flowers per plant	Diameter of flower (cm)	Weight of 10 flowers (g)	Shelf life (days)	Yield (kg plot^{-1})
T1	56.75	57.5	5.73	41.25	3	9.81
T2	52.25	76.75	7.25	71.55	4.5	15.69
T3	53.25	66.5	6.95	69.85	3.95	13.83
T4	55.5	63.25	6.28	52.5	3.15	11.00
T5	58.25	48	4.4	37	2.00	5.99
SEM ±	0.37	1.13	0.16	0.73	0.19	0.85
CD (0.05)	1.13	3.49	0.49	2.25	0.6	2.62
Mean	55	62.4	6.16	52.76	3.35	11.29

Table 5. Economics of furrow and drip irrigation levels in marigold flower.

Treatments	Crop yield t ha^{-1}	Total returns Rs ha^{-1}	Total cost of cultivation Rs ha^{-1}	Net returns Rs ha^{-1}	Benefit cost ratio
T1	11.01	1,65,150	50,000	1,15,150	2.30
T2	19.62	2,94,300	50,000	2,44,300	4.88
T3	17.03	2,55,450	500,00	2,05,450	4.10
T4	14.46	2,16,900	50,000	1,66,900	3.33
T5	7.48	1,12,200	41049.6	71,150	1.73

Table 6. Projected additional return from saved water in drip irrigation levels.

Treatments	Water saved over furrow (%)	Yield (t ha^{-1})	Net returns (Rs ha^{-1})	Additional yield with saved water (t)	Total yield (t) (3+5)	Yield increase over furrow (t)	Increase in net returns with saved water (Rs)	Projected net returns with drip irrigation from water used in furrow (Rs) (4+8)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
T1	74.92	11.01	1,65,150	32.88	43.89	36.41	9,93,200	6,58,350
T2	68.07	19.62	2,94,300	41.82	41.44	53.96	6,27,300	9,21,600
T3	61.45	17.03	2,65,450	27.14	44.17	36.99	4,23,036	6,88,486
T4	54.65	14.46	2,16,900	17.40	31.86	24.38	2,61,000	4,77,900
T5	-	7.48	1,12,200					1,12,200

The net returns and benefit-cost ratio for furrow and different drip irrigation levels are presented in table 5. It is seen from the results that among all the drip irrigation treatments the highest net return of (Rs. 2, 44,300 per ha) was obtained at 80 per cent ET, closely followed by the treatment of 100 per cent ET (Rs. 2, 05,450 per ha) and the lowest net return was obtained in control treatment (Rs. 71,150.4 per ha.). For 60 per cent ET net return was found to be (Rs. 1, 15,150 per ha). Among all the drip irrigation treatments the lowest benefit-cost ratio of (1.73) was obtained in control treatment and the highest benefit-cost ratio was found in 80 per cent ET (4.88), followed by 100 per cent ET (4.10), 120 per cent ET (3.33) and 60 per cent ET treatment (2.3). The results fall in line with the earlier findings

Projected additional returns from saved water

From the table 6, it is seen that by using the saved water highest additional yield of (41.82 tones) could be obtained in treatment receiving water at 80 per cent ET, When the water required to irrigate one ha marigold flower was completely used by drip irrigation, the net returns were (Rs. 9, 21,600 per ha) for 80 per cent ET treatment and closely followed by the treatment receiving water 60 per cent ET (Rs. 6, 88,486). The lowest net returns were observed in drip irrigation treatments receiving water at 120 per cent ET (Rs. 4, 77,900) and (Rs. 1, 12,200) per ha for furrow irrigation.

REFERENCES

[1] Shankar V, Lawande KE. Indian J. Hort. 2010, 67(1):56-59.
[2] Ghosh P, Pal P. Natural Product Radiance 2008, 7(5):437-443.
[3] Nakayama FS, Bucks DA. Trickle irrigation for crop production, design, operation and management. Elsevier Science Publisher, Netherlands, 1986, 1-376.
[4] Mallikarjun R, Ayyanagowdar MS, Nemichandrappa M, et al. Karnataka J. Agric. Sci. 2012, 25(4):475-478.
[5] Sahay J. Elements of pumps and tube wells. Agro-Book Agency, Jakkanpur, India, 1986, 39.
[6] Bafna AM, Deftardar SY, Khade KK, et al. J. Water Mgt. 1993, 1(1):1-5.
[7] Antony E, Singandhupe RB. Agric. Water Mgt. 2004, 65:121-132.
[8] Borivoji P, Jelica G, Stanko M, et al. Afr. J. Biotech. 2011, 10(4):2644-2652.