Original Research Article

Effect of different levels of irrigation on yield and yield attributes of winter marigold crop (*Tagetes erecta* L.)

Abstract

Agriculture has been indispensable for the subsistence of the people of India in general and farmers in particular. It has naturally been the cornerstone of the Indian economy since time immemorial and agriculture has played a major role in the country's economy since its inception. The research work was done to study the effect of irrigation levels on the yield and growth of winter marigolds. Marigold (*Tagetes erecta L.*) had been taken twice the winter season of 2019-20 and 2020-21. The average flower yield (t/ha) was recorded under the treatment I_1 (12.03 t/ha) was found maximum and it was followed by I_2 (10.51 t/ha), I_3 (9.73 t/ha). The consumptive water use (CWU) was found maximum (26.62 cm) in 100% of ET_c and the lowest CWU was found (21.03 cm) in 80% of ET_c through a drip system of irrigation in the cropping year 2020-21. Similarly, in 2019-20 CWU was found maximum (18.02 cm) in 100% of ET_c, while the lowest CWU was found (14.42 cm) in 80% of ET_c. The water use efficiency was found highest in I_3 (0.77 t/ha/cm) and minimum WUE was found in I_2 (0.525 t/ha/cm) in the cropping year 2019-20. For 2020-21, a maximum WUE was recorded in I_2 (0.497 t/ha/cm) and the minimum WUE in I_3 (0.335 t/ha/cm).

1. Introduction

Water has always been an essential component of human existence, and it is available in limited form from natural resources. Our population increase continuously, and they affect the limited natural resource directly. The agriculture sector has used a huge amount of freshwater, so it is very important to utilize natural resources carefully. Different irrigation methods are used in agriculture. Of these, micro-irrigation is one of the best suitable methods for getting high water use efficiency (WUE) [3].

India is mostly a farming country, and agriculture employs around 70% of our population and accounts for one-third of our national income. Recently, the share of the agriculture sector in the national Gross domestic product (GDP) has risen to 20% [7].

Micro-irrigation systems (such as the drip irrigation system) help save 27 to 42 per cent of water. It helps to increase WUE by reducing soil evaporation and drainage losses. Evaluation of hydraulics of drip irrigation systems helps improve irrigation system design and better control of irrigation water. Its field application efficiency can be up to 90%, compared to 60-80% for sprinklers and 50-60% for surface irrigation [5]

A large amount of plastic waste is generated from the food items used every day, due to which there is land pollution, water pollution and air pollution in large quantities. Recycling plastic waste has become very expensive and difficult, but reusing is a good way to reduce plastic waste [8]. Almost every farmer in Chhattisgarh has a piece of land called Biyara, used as a threshing floor after harvesting the crop. That piece of land remains unusable for a whole year after some time. They were using this land for production without ploughing the field and farming using less water.

This research has been prepared to look at all the points like the judicious utilization of precious water resources, judicious utilization of reusable plastic bags, saving water, and keeping in mind the Chhattisgarh government's Narva, Garwa, Ghurva and Bari schemes. By this, stored rainwater is used for irrigation and solar energy is used to pump that stored water. For a kitchen garden, barren and unfertile land, a portable plant growing system had been developed using waste plastic material to be easily collected in our society. The research work was done to study the effect of irrigation levels on the yield and yield attributes of winter marigold. Marigold (*Tagetes erecta L.*) had been taken twice the winter season of 2019-20 and 2020-21.

2. Materials and Methods

2.1 Study area

The experiment was laid out at Dept. of Soil and Water, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, India, to cultivate winter marigold with solar power operated improvised drip system of irrigation. Raipur is situated in the central part of Chhattisgarh. The experimental site is located at Latitude 21^{o}14’6” N and Longitude 81^{o}43’10” E and an altitude of 302 meters above the mean sea level. An area of 261 m^2 (18 x 14.5 m) of the experiment has been considered for the study. *Pusa-Narangi* variety of marigold was taken into consideration for cultivation. Seeds were sown in the nursery and 25 days old seedlings were transplanted to the main field, i.e. Reusable flour bags, Conventional grow bags and Plastic bottles.

2.2. Weather data of the study area during 2019-20

The weather data recorded during the investigation period from 13th December 2019 to 30th March 2020. The maximum temperature during the experiment varied between 21.3 ^{o}C to 35.8 ^{o}C, and the minimum temperature varied between 10.8 ^{o}C to 22.1 ^{o}C. The maximum rainfall during the period of the experiment was 35.8 mm. The average maximum relative humidity for different months varied from 75.9 to 93.6 %, while monthly average minimum relative humidity varied between 27.3 to 56.3 %. The average sunshine values varied from 2.4 to 9.8 hours, maximum wind velocity during the crop period was 4.1 km hr^{-1} and the minimum was recorded 1.6 km hr^{-1}. (Dept. of Agrometreology, IGKV. 2020)

2.3. Weather data of study area during 2020-21

The weather data recorded during the investigation period from 2nd December 2020 to 26th March 2021. The maximum temperature during the experiment varied between 27.7 ^{o}C to 37.9 ^{o}C whereas, the minimum temperature varied between 9.2 ^{o}C to 20.1 ^{o}C. The maximum rainfall during the period of the experiment was 6.2 mm. The average maximum relative humidity for different months varied from 58.3 to 88.7 %, while monthly average minimum relative humidity varied between 14.3 to 40.6 %. The average sunshine values varied from 3.2 to 9.5 hours, maximum wind velocity during the crop period was 4.2 km hr^{-1}

and the minimum was recorded 1.4 km hr^{-1}. (Dept. of Agrometreology, IGKV. 2021)

2.4 Treatment Details

To study the effect of irrigation levels, three different irrigation levels like I_1-100% (crop evapotranpiration) ET_c, I_2- 90% of ET_c and I_3- 80% of ET_c were selected as the main plot, and three types of plastic grow containers like M_1-Reusable flour bag (RFB), M_2- Conventional grow bag (CGB), M_3- Plastic bottle (PB) were selected as a subplot and having a split-plot design with three replications had been adopted. In each replication, 540 plants of winter marigold crop at 30 cm plant to plant spacing, whereas 50 cm row to row spacing have been planted for experimentation. Irrigation was provided based on (ET_c) using soil and agrometeorological parameters. The prepared field and other details are shown in Table 1.

The solar power water distribution system incorporates a special solar pump with a portable 150-watt solar panel. A cost-effective and minimal carbon emission portable plant growing system was developed; no-tillage operations were required to cultivate the marigold crop. The result revealed that farming is possible in barren and infertile land using waste plastic bags for cultivating flower crops helps to reduce water and carbon footprints. With the help of Reusable plastic bags like 5 to 10 kg *Atta* bags, conventional grow bags and 2-litre plastic bottles, a sustainable plant growing system was developed for barren and infertile land.

2.4.1 Plant growing media

All grow containers were placed according to the layout design and filled with soil, Farm Yard Manure (FYM) and coco-peat in the ratio of 40:40:20 (V:V:V), respectively. Physico-chemical properties of the prepared media were tested in the Dept. of Soil Science Laboratory, IGKV, Raipur. The ratio of prepared media was found better for horticulture crops by Nair and Bharathi (2015) [6] and [1].

2.4.2 Nursery preparation of marigold

A nursery for winter marigold (*Tagetes erecta* L.) for this experiment was prepared by Horticulture Department, IGKV, Raipur, in which nursery beds of dimensions 1.0 m x 4.0 m (width x length) was prepared. Healthy seeds were sprinkled in rows on nursery beds prepared by pulverizing soil, mixed with farmyard manure (FYM) at the rate of 250 kg ha^{-1}. When needed, water was given at intervals of a few days. The entire nursery bed was covered with paddy straw for proper germination and to avoid weevils. After germination, all paddy straws were removed and left uncovered. Good quality seedlings were ready after about 28 days and were ready for transplanting

2.4.3 Improvised Drip Irrigation System

The improvised drip irrigation (IDI) system helps to keep the soil surface dry and reduces water evaporation, thus saving water and improving fertilizer uptake. The dry soil significantly reduces weed development and plant diseases, increases the dripline’s lifetime, and protects it from mechanical and environmental damage. Arrangement of lateral lines over the grow containers is very difficult and emitter positions change continuously when lateral lines are displaced. So durable improvisation is necessary for lateral lines' emitter position and stability. A small (18 mm) hole is made in all grow containers and laterals are placed 5 cm into the grow containers to solve this problem.

A drip irrigation system with a lateral size of 16 mm of 18 m length, 1.3 *l* h^{-1} emitters (inline) at 1 kg/cm^2 at 30 cm spacing (60 number of emitter per lateral) was used to study hydraulic performance. Irrigation water was supplied from the 2,000-litre storage tank, 0.1 hp solar operated pump was used to lift the water stored in the storage tank. The flow rate or discharge of the emitter was collected directly in the measuring cylinder. Discharge of emitters concerning test time was converted into discharge per hour.

2.4.4 Irrigation water requirements

Crop evapotranspiration is the amount of water that is lost through evapotranspiration. Reference evapotranspiration (ET0) was calculated using a

Penman-Monteith method (Doorenbos and Pruitt, 1977) with the help of meteorological data recorded by the meteorological observatory of IGKV, Raipur (C.G.). The plants were irrigated daily by drip irrigation systems. The crop coefficient (Kc) for different growth stages of marigold was considered based on the unpublished report and local studies carried out in India. The actual evapotranspiration was estimated by multiplying reference evapotranspiration and crop coefficients for the different periods based on crop growth stages.

$$IR = (ET_0 \times Kc) - R \quad (1)$$

$$V = IR \times A \quad (2)$$

$$\text{Irrigation time (hours day}^{-1}\text{)} = \frac{\text{water requirement in litre per day}}{\text{rate of application litre per hr}}$$

IR = net depth of irrigation (mm day^{-1})

ET_0 = reference Evapotranspiration (mm day^{-1})

K_c = crop coefficient

R = rainfall (mm per day)

V = net volume of water required by a plant (m^3 day^{-1})

A = area under each plant (m^2)

2.5 Yield Calculation

The following observations were recorded during the crop growth period on five randomly tagged competitive plants from each plot of every replication for studying various characters, i.e. growth character, flowering, and yield, as shown in Tables 1 & 2. The average values of marigold like plant height (cm), number of branches and etc., for both years, i.e. 2019-20 and 2020-21, at different crop growth stages after transplanting, as influenced by the different irrigation levels and grow containers, are described herein. For two years, experimented data had been analyzed at 30 days after transplanting (DAT), 60 DAT, and 90 DAT.

Marketable and total flower yield tone per hectare was worked out with the help of flower yield per plot by using the following formula:

$$\text{Yield (t/ha)} = \frac{\text{weight of flower in kg/plot} \times 10000}{\text{plot area} \times 1000} \quad ...(3)$$

2.6 Statistical Analysis

The experiment was laid out in a split-plot design (SPD). The data obtained from the various characters under study were analyzed by analyzing variance described by Gomez and Gomez (1984). To compute the mean value of treatments, standard error and critical values were calculated as follow:

1. Standard error of the mean

SEm = ± Ve … (4)

2. Critical difference (CD)

CD = SE (d) × t value at 5% error (df) … (5)

3. Result and Discussions

3.1 Irrigation efficiency

Emission uniformity of the system decides the uniform distribution of discharge by each emitter or uniform distribution of water to each plant. The calculated emission uniformity data in a solar power operated improvised drip irrigation at 0.25 kg/cm^2 operating pressure has been presented in Table 2. The maximum average emission uniformity of 98.35 % was observed. The maximum application efficiency and distribution efficiency were found at 95.62 % and 98.80 %, respectively, at 0.25 kg per cm^2 operating pressure.

3.2 Effect of different levels of irrigations on yield and yield parameters

The following observations were recorded during the crop growth period on five randomly tagged competitive plants from each plot of every replication for studying various characters, i.e. growth character, flowering, and yield, as shown in Table 3 & 4.

3.2.1 Plant height (cm)

At 30 DAT, the plant height in treatment I_1 (15.92 cm) is higher than in treatment I_2 (15.80 cm) and I_3 (15.71 cm), respectively. At 60 DAT, the plant height in treatment I_1 (44.50 cm) is higher than in treatment I_2 (44.17 cm) and I_3 (43.02 cm), respectively. At 90 DAT, the plant height in treatment I_1 (79.56 cm) is higher than in treatment I_2 (77.92 cm) and I_3 (76.41 cm), respectively. Plant height (cm) at 30 DAT showed no significant difference ($p>0.05$) and plant height (cm) with CD value 0.40 at 60 DAT showed a significant difference ($p<0.05$). Similarly, no significant difference ($p>0.05$) was found in plant height (cm) at 90 DAT of the marigold crop at three different irrigation levels. All data are shown in Table 3

3.2.2 Number of branches

Data on a number of branches at different growth stages of the marigold plant after transplanting as influenced by the different irrigation levels are shown in Table 3.

A slightly higher number of branches at 30 DAT was recorded under the treatments I_1 (1.33) followed by I_2 (1.32) and I_3 (1.29). At 60 DAT, the maximum number of branches was recorded under the treatment I_1 (7.68) and it was followed by I_2 (7.61) and I_3 (7.39), respectively. Similarly, at 90 DAT higher number of branches was recorded under the treatment I_1 (9.41) and it was followed by I_2 (9.26) and I_3 (9.18), respectively. All data are shown in Table 3

Statistical analysis shows a significant difference ($p<0.05$) in the number of branches with a CD value of 0.015 at 30 DAT. With a CD value of 0.059 at 60 DAT, statistical analysis shows a considerable difference ($p<0.05$). Similarly, in 90 DAT significant difference ($p<0.05$) was found with a CD value of 0.19.

3.2.3 Number of days of first budding

The treatment I_1 (46.33) had the number of days of first budding, followed by I_2 (46.57) and I_3 (48.61). Statistical analysis shows a significant difference ($p<0.05$) in the number of days of first budding of the marigold crop with CD value 1.09 at three different irrigation levels. All data are shown in Table 3

3.2.4 Number of days of first flowering

Under the different levels of irrigation, I_1 (55.54) had the highest number of days of first flowering, followed by I_2 (56.50) and I_3 (59.17), respectively. Statistical analysis shows a significant difference ($p<0.05$) in the number of days of first flowering with CD value 1.674 of the marigold crop at three different irrigation levels. All data are shown in Table 3

3.2.5 No of picking days

A slightly higher number of picking days were recorded under treatment I_1 (8.98), which was followed by treatments I_2 (8.44) and I_3 (7.89). Statistical analysis reveals a significant difference ($p<0.05$) in the number of picking days for the marigold crop at three different irrigation levels, with a CD value of 0.406. All data are shown in Table 4

3.2.6 The average diameter of the flower (cm)

The treatment I_2 (3.47 cm) produced a considerably larger flower diameter than the treatment I_1 (3.34 cm) and I_3 (3.26 cm), respectively. Statistical analysis reveals a significant difference ($p<0.05$) in the average diameter of the flower in the marigold crop at three different irrigation levels, with a CD value of 0.121. All data are shown in Table 4

3.2.7 Number of flowers per plant

The treatment I_1 (43.16) had the highest number of flowers per plant, followed by I_2 (40.87) and I_3 (38.11), respectively. Statistical analysis shows a significant difference ($p<0.05$) was found in the number of flowers per plant with a CD value of 0.901 in the marigold crop at three different irrigation levels. All data are shown in Table 4

3.2.8 Average yield per plant (gm)

A slightly higher average yield per plant was recorded under the treatment I_1 (175.10 gm) and it was followed by I_2 (158.15 gm) and I_3 (139.46 gm), respectively. Statistical analysis shows a significant difference ($p<0.05$) on avg.

yield per plant (gm) with CD value 2.643 in the marigold crop at three different irrigation levels. All data are shown in Table 4

3.2.9 Average yield per plot (kg)

A slightly higher average yield per plot was recorded under the treatment I_1 (3.50 kg) and it was followed by I_2 (3.16 kg) and I_3 (2.79 kg), respectively. Statistical analysis shows that there is a significant difference ($p<0.05$) was found on Avg. yield per plot (kg) with CD value 0.053 in the marigold crop at three different irrigation levels. All data are shown in Table 4

3.2.10 Average flower yield (t/ha)

Significantly avg. flower yield (t/ha) was recorded under the treatment I_1 (11.67 t/ha) was found maximum and it was followed by I_2 (10.61 t/ha) and I_3 (9.28 t/ha). Statistical analysis shows a significant difference ($p<0.05$) was found on avg. flower yield (t/ha) with CD value 0.175 in the marigold crop at three different irrigation levels. All data are shown in Table 4

3.2.11 Consumptive water use and water use efficiency

The consumptive water use (CWU) was found maximum (26.62 cm) in 100% of ET_c and the lowest CWU was found (21.03 cm) in 80% of ET_c through a drip system of irrigation in the cropping year 2020-21. Similarly, in 2019-20 CWU was found maximum (18.02 cm) in 100% of ET_c, while the lowest CWU was found (14.42 cm) in 80% of ET_c. The water use efficiency was found highest in I_3, which was 0.77 t/ha/cm. The minimum WUE was found in I_2 was 0.525 t/ha/cm in the cropping year 2019-20. For 2020-21, a maximum WUE was recorded in I_2 that was 0.497 t/ha/cm and the minimum WUE in I_3 was 0.335 t ha^{-1} cm^{-1}. All data are shown in Table 4

4. CONCLUSION

In I_1 (100% ET_C) and I_2 (90% ET_c) irrigation levels, the maximum plant growth was observed, while slightly good plant growth was found in the I_3 (80% ET_c) irrigation level. Due to favourable plant growth conditions and better spectral distribution of root growth, marigold plants in Reusable flour bags (RFB) at different irrigation levels had a favourable influence on morphometric features and other yield parameters.

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Table 1. Details of different treatments

S.no	Treatment details	Notation used
Main plot: Irrigation levels		
1.	100 % of ET_c through drip	I_1
2.	90 % of ET_c through drip	I_2
3.	80 % of ET_c through drip	I_3
Sub-plot: Types of grow containers		
1.	Reusable flour bag	M_1
2.	Conventional grow bag	M_2
3.	Plastic bottle	M_3
Replication : 3		
Crop	Marigold	
Scientific name	*T agetes erecta* L.	
Experiment (gross) area	261 m^2 (18 × 14.5)	
Row to row spacing	50 cm	
Plant to plant spacing	30 cm	
Design	Split-plot design	
Main plot size	9 m^2	
Sub-plot size	3 m^2	
Each replication size	81 m^2	
Irrigation	Based on ET_c	

Legent-Title- 2.4

Table 2. Irrigation efficiency at 0.25 kg/cm^2 operating pressure.

Uniformity coefficient		**Application efficiency**		**Distribution efficiency**	
S_q	0.011	Q_{mini}	0.811	q_m	0.837
q_m	0.837	Q_{avg}	0.837	q_a	0.010

Uc (%)	98.59	E_a (%)	96.86	E_d (%)	98.80

Legent- title 3.1

Table 3. Plant height, number of branches, first budding and flowering of marigold plant at pooled data of 2019-20 and 2020-21.

Levels of irrigation	Plant Height (cm)			Number of branches			First Budding	First Flowering
% ET_c	**30 DAT**	**60 DAT**	**90 DAT**	**30 DAT**	**60 DAT**	**90 DAT**	**day**	**day**
I_1	15.92	44.50	79.56	56.06	7.68	9.41	46.33	55.54
I_2	15.80	44.17	78.96	56.27	7.61	9.26	46.57	56.50
I_3	15.71	43.02	77.89	59.11	7.39	9.18	48.61	59.17
SE (d)	0.073	0.141	0.538	0.005	0.021	0.067	0.382	0.587
SE (m)	0.051	0.1	0.38	0.004	0.015	0.047	0.27	0.415
CD (5%)	0.16	0.401	N/A	0.015	0.059	0.19	1.09	1.674

Legent- title 3.2

Table 4. A marigold plant's growth and yield attributes at pooled data of 2019-20 and 2020-21.

Levels of irrigation	Picking days	Average diameter of the flower	Number of flowers	Yield per plant	Yield per plot	Yield per plant	Water use efficiency
% ET_c		**cm**		**g**	**kg/plot**	**t/ha**	**t/ha/cm**
I_1	8.98	3.50	43.16	175.10	3.50	11.67	0.54
I_2	8.44	3.36	40.87	158.15	3.16	10.61	0.55
I_3	7.89	3.23	38.11	139.46	2.79	9.28	0.55
SE (d)	0.142	0.042	0.316	0.927	0.019	0.061	0.004
SE (m)	0.101	0.03	0.223	0.656	0.013	0.043	0.003

CD (5%)	0.406	0.121	0.901	2.643	0.053	0.175	0.012