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Effect of irrigation levels and methods on yield and water use efficiency of marigold (*Tagetes erecta* L.)

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Abstract

The field experiment was conducted for consecutive two seasons during rabi 2017-18 and 2018-19 at Instructional Farm, College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner (Rajasthan) to study the effect levels and methods of irrigation on yield and water use efficiency of marigold (*Tagetes erecta* L.). The experimental layout was carried out in randomized block design with four replications and treatments included three irrigation levels and three irrigation methods. Irrigation was given based on pan evaporation values following alternate day irrigation schedule for drip irrigation while, surface irrigation was given according to the locally adopted frequency. Results showed that IW/CPE ratio 1.0 recorded significantly higher flower yield (145.4 and 140.2 q ha^{-1}) in 2017-18 and 2018-19, respectively. Maximum water use (721.73 and 606.43 mm) was observed with same irrigation treatment in 2017-18 and 2018-19, respectively. Although, high water use efficiency (WUE) of 25.91 and 27.37 kg ha^{-1} mm^{-1} was observed at IW/CPE ratio 0.6 in 2017-18 and 2018-19, respectively. Under different irrigation methods, maximum flower yield (150.6 and 144.6 q ha^{-1}) and high WUE (26.43 and 29.31 kg $ha^{-1}mm^{-1}$) was recorded under drip irrigation treatment in 2017-18 and 2018-19 respectively.

Key words: Irrigation level, marigold, WUE, yield

Introduction

Marigold (*Tagetes erecta L.*) is an annual plant, erect and fast-growing with dark green, glossy and aromatic leaves which have deep recesses, grows up-to one meter and above, bears single or fully double large sized globular heads of yellow, orange and white shades. It belongs to the family of *Asteraceae*. Marigold is grown as loose flower in bulk which is sold in the market for decoration of homes, temples, offices, marriage gardens *etc.* and making garlands and worshiping God. It is in great demand as loose flower throughout year and commonly used for decoration, making garlands for religious and social functions (Kumar *et al.*, 2010). Demand of marigold as cut flower or as extracted products is also high in many countries (Spain, Mexico, UK, United States, Italy, South Korea, Taiwan, Japan *etc.*). Hence, export of marigold will increase the economic level of farmers (Luis *et al.,* 2009). Marigold is one of the most commonly grown commercial flowers in India. It occupies an important place among loose flowers. It has nearly two third of total loose flower growing area in India.

In India, flowers cover an area of 339 thousand ha with a total production of 1991 thousand tonnes (loose flowers). Tamil Nadu is leading loose flower producing state followed by Karnataka, Andhra Pradesh *etc.* In Rajasthan, it covers an area of 4.0 thousand ha and the total production is 7.5 thousand tonnes (loose flowers) only (Anonymous, 2018). Marigold is contributing its highest portion as loose flower in Rajasthan.

Irrigation improves the water regime of soil creating favorable conditions for growing plants. Frequent oscillations of weather conditions in the region, first of all the amount and distribution of precipitation, are the reason why irrigation is needed in crop production. Water is becoming an increasingly scarce resource in many areas of the world, especially in arid and semi-arid regions (Bosma *et al.,* 2003). Proper irrigation scheduling results in increasing water use efficiency (WUE) and yield of crop. WUE relates to how much yield is obtained per unit of applied water. Scheduling of water application is very critical, as excessive irrigations reduce yield, while inadequate irrigation also causes water stress (Sujatha and Shanmuga, 2017). Drip irrigation is very important and efficient method of irrigation when compared to other conventional method of irrigation. Drip irrigation method plays very important role as it uses less water and gives more yield due to precise and direct application of water in root zone as per crop water requirement. A considerably saving in irrigation water, increased growth and development and yield under drip irrigation has been reported by Imtiyaz *et al.,* (2000) and Rajbir Singh *et al.,* (2009).

Material and Methods

The field experiments to study the effect of irrigation levels and methods on marigold were conducted for two consecutive years of *rabi* 2017-18 and 2018-19 at Instructional farm, College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner (Rajasthan) on light textured soil. The experimental layout was carried out in randomized block design and replicated four times. Treatments included

three irrigation levels (main treatments) *viz.*, IW/CPE ratio 0.6 (M_1), IW/CPE ratio 0.8 (M_2), IW/CPE 1.0 ratio (M_3) and three irrigation methods (sub treatments) *viz.*, Check basin method (I_1), Furrow method (I_2), Drip irrigation method (I_3). The weather condition was dry and rainfall during period of experimentation during crop growing period was 6.6 mm and 37.1 mm in 2017-18 and 2018-19, respectively. Total pan evaporation during crop growing period was 731.09 mm and 656.1 mm of 2017-18 and 2018-19, respectively.

Thirty five days old seedlings of marigold var. *Pusa Narangi Gainda* were transplanted on 10th December, 2017 and 23rd November, 2018 at row spacing of 50 cm using seed rate 1-1.5 kg ha^{-1} (nursery). FYM @ 25 q/ha was applied to the experimental area during field preparation. The recommended fertilizers *i.e.* N (200 kg ha^{-1}), P_2O_5 (100 kg ha^{-1}) and K_2O (100 kg ha^{-1}) was applied to raise the crop. Half dose of nitrogen along with the full dose of phosphorus and potassium were given at the time of field preparation and half dose of nitrogen was applied in two splits after 30 days and 50 days of transplanting. Dry transplanting was done. Immediately after transplanting, irrigation was applied to ensure proper crop establishment. There after surface irrigations were applied as per treatment. Drip irrigations were given in alternate days. The irrigation events and irrigation water applied (mm) in experiments is given in Table 1. All other packages of practices were adopted as recommended for this region.

Irrigation was applied on the basis of pan evaporation values following alternate day irrigation schedule for drip irrigation, while for surface irrigation water was given according to treatment. The daily evaporation reading was recorded by USWB class A Pan Evaporimeter.

All the parameters *i.e.* water use (mm), yield (q ha^{-1}) and WUE (kg ha^{-1} mm^{-1}) determined using standard procedure. Ten plants from each plot were selected randomly and tagged for recording yield parameters. The water use efficiency was calculated by dividing yield (kg ha^{-1}) with total depth of the water applied (mm) including effective rainfall. In the check basin and furrow method, irrigation water given was quantified after knowing the discharge rate and irrigation time. Then at the end of the season total irrigation water applied was worked out. The analysis and interpretation of

Table 1. Irrigation events and irrigation water applied (mm)

Treatments	Check basin method				Furrow method				Drip irrigation (mm)	
	No. of irrigation		Delta (mm)		No. of irrigation		Delta (mm)			
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
IW/CPE ratio 0.6	8	7	406.6	387.1	10	8	406.6	357.1	441	395.9
IW/CPE ratio 0.8	11	9	556.6	487.1	14	11	566.6	477.1	586	515.5
IW/CPE ratio 1.0	14	11	706.6	587.1	18	14	726.6	597.1	732	635.1

Data includes rainfall of 6.6 mm (2017-18) and 37.1 mm (2018-19)

Table 2. Effect of irrigation methods and levels on yield water use efficiency of marigold

Treatments	Flower Yield (qha^{-1})		Water use (mm)		WUE (kg ha^{-1} mm^{-1})	
Irrigation levels	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
IW/CPE ratio 0.6	108.3	104	418.07	380.03	25.91	27.37
IW/CPE ratio 0.8	139.2	133.2	569.73	493.23	24.43	27
IW/CPE ratio 1.0	145.4	140.2	721.73	606.43	20.15	23.12
Sem±	1.8	1.84				
CD at 5%	5.24	5.35				
Irrigation methods						
Check basin method	116.7	112	569.84	493.23	20.48	22.7
Furrow method	125.6	120.9	569.84	493.23	22.05	24.5
Drip irrigation	150.6	144.6	569.84	493.23	26.43	29.31
Sem±	1.8	1.84				
CD at 5%	5.24	5.35				

data were done using the Fisher's method of analysis of variance technique as described by Gomez and Gomez (1984).

Result and Discussion

The data presented in Table 2 revealed that increase in IW/CPE ratio from 0.6 to 1.0 increased flower yield. Drip irrigation level of IW/CPE ratio 1.0 gave maximum flower yield (145.4 and 140.2 q ha^{-1}, respectively) over IW/CPE ratio 0.6 and 0.8. Further, highest (721.73 and 606.43 mm) and lowest (418.07 mm and 380.03) water use was recorded at drip irrigation level of IW/CPE ratio 1.0 and IW/CPE ratio 0.6 in 2017-18 and 2018-19 respectively. Higher irrigation level maintains soil physical conditions in congenial condition for growth and yield by maintaining optimum soil-moisture-balance around plant base. Probably, this may be reason for increasing flower yield with increased IW/CPE ratio. Similar results were also obtained by Ayyanna *et al.* (2014). Highest WUE (25.91 and 27.37 kg ha^{-1} mm^{-1}, respectively) was recorded with drip irrigated crop at IW/CPE ratio 0.6 and lowest with IW/CPE ratio 1.0 (20.15 kg ha^{-1} mm^{-1} and 27.37, respectively). These results were similar to the findings of Sujatha and Shanmuga, (2017).

Irrigation methods had significant influence on flower yield and was maximum (150.6 and 144.6 q ha^{-1}) under drip irrigation followed by furrow method (125.6 and 120.9 q ha^{-1}) and check basin method (116.7 and 112.0 q ha^{-1}) in 2017-18 and 2018-19, respectively. In furrow and check basin method where the soil moisture fluctuates from excess or saturation on the day of irrigation to field capacity to different degree of dryness and virtually plant suffers due to moisture stress just before the next irrigation. Because of this reason, crop performance was comparatively poor in furrow and check basin method of irrigation as compared to drip irrigation. Irrigation method also had a significant influence on WUE. However, maximum WUE (26.43 and 29.31 kg ha^{-1} mm^{-1}) was recorded with drip irrigation followed by furrow method. Minimum WUE (20.48 and 22.70 kg ha^{-1} mm^{-1}) was recorded under check basin method.

Among the irrigation levels IW/CPE ratio of 0.8 was found optimum for marigold. Drip irrigation gave higher flower yield followed by furrow and check basin method of irrigation. Drip irrigation level recorded higher water use efficiency in comparison to surface methods of irrigation.

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