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Impact of Pusa hydrogel on growth, flower yield and quality parameters of Marigold cv. Culcutta Orange under various irrigation regimes

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ABSTRACT

A study entitled "Effect of Pusa Hydrogel on Growth Performance, Flower Yield, and Quality Attributes of Marigold (cv. Calcutta Orange) under Different Irrigation Regimes" was carried out at the Department of Floriculture and Landscape Architecture, College of Horticulture, Bagalkot. The interaction between the irrigation and Pusa Hydrogel levels revealed maximum plant height of (80.11 cm) at 90 DAT in 80 per cent CPE irrigation interval with 5.25 kg per ha of hydrogel (I_2H_4). Higher number of primary branches per plant of 16.98 and 17.95 was reported in treatment combination of drip irrigation at 80 per cent CPE+5.25 kg per ha of hydrogel (I_2H_4) at 90 DAT and higher number of secondary branches per plant of 39.21 was reported in treatment combination drip irrigation at 80 per cent CPE+5.25 kg per ha of hydrogel (I_2H_4) at 90 DAT, respectively. Maximum individual flower weight (6.38 g), yield per plant (550.92 g) and yield per plot (18.66 kg) was recorded in plants irrigated with 80 per cent CPE with 5.25 kg/ha hydrogel (I_2H_4) and lowest yield was obtained in plants irrigated with 60 per cent CPE without any application of hydrogel (I_3H_5). Flower diameter and shelf life were found to be non-significant in the treatment combination of different levels of irrigation and hydrogel. Maximum B:C ratio (1.64) was obtained when irrigation was scheduled at 80 per cent CPE along with the application of 5.25 kg/ha hydrogel.

Keywords: *Pusa hydrogel, marigold, CPE, Culcutta Orange, irrigation*

Introduction

Marigold (*Tagetes spp.*), a member of the family Asteraceae, is one of the most widely cultivated and versatile ornamental crops in the floriculture industry. Its adaptability to varied agroclimatic conditions, profuse and continuous flowering habit, and relatively short duration to harvest make it a preferred choice for growers. Marigold produces loose, marketable flowers in a wide range of colors, shapes, and sizes, coupled with good keeping quality, making it highly valued in garland making, decoration, landscape use, and extraction of pigments for the food and pharmaceutical industries. It is recognized as one of the most important commercial flower crops globally and holds a dominant position in India, where it contributes to more than half of the total loose flower production [8]. Water management, however, has emerged as a critical challenge for sustainable crop production. India is already experiencing the dual burden of physical and economic water scarcity [9] of the 142 million hectares of cultivated land, nearly 85 million hectares (around 60%) fall under dryland conditions, receiving less than 1150 mm of average annual rainfall, with more than 30% of the geographical area facing low rainfall (below 750 mm). Such constraints underline the importance of efficient water use technologies in horticultural crops. In recent years, soil conditioners and water-retentive amendments such as hydrogels, organic conditioners, and synthetic polymers have gained prominence. These materials improve soil moisture retention, reduce irrigation frequency, and enhance plant growth and yield, thereby offering promising solutions for floriculture crops like marigold grown under water-limited conditions.

These soil conditioners help to minimize the loss of water and increase the success of planting [12]. The new Pusa Hydrogel is one such a semi-synthetic superabsorbent polymer which has been developed by the ICAR-Indian Agriculture Research Institute (IARI). Pusa hydrogel has been in use since 2012, and its benefits are now being reaped across the country. Pusa hydrogel is bio-degradable and they contain labile bonds either in the polymer backbone or in the cross-links used to prepare the hydrogels. This product displays a swelling potential exceeding 500 times its weight in pure water. Notably, its swelling ratio increases with a rise in temperature up to 500 ^{0}C without any adverse effect on the polymer matrix structure. It enhances the crop productivity per unit available water and nutrients, particularly in moisture stress conditions. In this view, the present investigation entitled the "Impact of Pusa hydrogel on growth, flower yield, and quality parameters of Marigold cv. Culcutta Orange was carried out at College of Horticulture, UHS Bagalkot, to study the vegetative, flowering, yield, and quality parameters of marigold as influencedby the presence of hydrogel.

Materials and Methods

An indigenously developed product Pusa hydrogel that boosts crop productivity per unit of available water and nutrients was used in the present investigation particularly in moisture-stressed conditions. This experiment was conducted in Marigold cultivar "Culcutta Orange". Healthy seedlings of marigold were used for the experiment collected from a local Nursery. The land was ploughed and harrowed two to three times upto a depth of 30 cm to bring it to a fine tilth by removing all the weeds, stubbles and stones. 3-4 leaf healthy seedlings were selected and planted at a spacing of 60 x 45 cm. Light irrigation was given once in two days by the use of drip irrigation. Recommended dose of nutrients was given at half dose during the early stages of crop development, such as 50 percent N and full dose P, K, and the remaining dose was given at the later stage of crop growth 50 days after transplanting. For better crop growth foliar spray of 19:19:19 at 10g/l was given at 45 days after transplanting. Irrigation was then scheduled at weekly intervals based on cumulative pan evaporation. Control of pests like cutworm was done by spraying with chlorpyriphos @ 2 ml per litre of water. For control of leaf spot and Fusarium wilt, the crop was sprayed with tebuconazole @ 1g/litre of water. The observations of five plants randomly selected and tagged in each treatment and replication was recorded on various parameters viz; plant growth, flowering, yield, and quality. The mean value of the data was recorded to represent a particular treatment with respect to character. Gross income was calculated based on the total flower yield of Marigold (t/ha) and prevailing market price of Marigold flower (/kg) and expressed as total income per hectare.Gross income and total costs per hectare were used to calculate net income per hectare.

Results and Discussion

Plant height of (73.44 cm) was maximum and recorded at 90 DAT in the treatment of I_2 (Irrigation 80 per cent CPE). Similar findings were also reported by [7] in marigold, and [4] in ginger. Increasing hydrogel content also increased the plant height. In table 1. It is highlighted that the maximum plant height (77.75 cm) was exhibited in H_4 (5.25 kg/ha hydrogel), and in the interaction effect highest plant height (80.11 cm) was recorded in I_2H_4 (80 per cent CPE with 5.25 kg/ha of hydrogel) at 90 DAT. Similar results were also reported by [4]. He found that superabsorbent had a favorable effect on stem elongation which could be due to the strong ability super absorbents to absorb water and conserve it in the soil. These records are in agreement with [5] in ginger, and [6] in chrysanthemum. Table 2 we can see that maximum number of primary and secondary branches (15.51 and 32.43, respectively) was recorded in I_2(Irrigation 80 per cent CPE) at 90 DAT. Number of branches increased due to the acceleration of the vegetative growth during the crop period. These records are in agreement with [4] in stevia, [2] in purple basil, [7] in marigold, [5] in ginger and [6] in chrysanthemum. The number of branches increased significantly as the concentration of Pusa Hydrogel increased. While maximum number of primary and secondary branches (16.22 and 33.25, respectively) was recorded in H_4 (5.25 kg/ha hydrogel) at 90 DAT (Table 2). The results of this study revealed that the Pusa Hydrogel had a significant impact on Marigold growth in terms of branch number, especially when water was scarce. Pusa Hydrogel had a considerable effect on these parameters, as evidenced by the number of shoots. These results correspond with [4] in chrysanthemum and [1] in coleus. Maximum number of primary and secondary branches (17.95 and 39.21) was recorded in I_2H_4 (80 percent CPE with 5.25 kg/ha of hydrogel) at 90 DAT. Similar results were reported by [5] in chrysanthemum and [4] in ginger.

Maximum flowering duration (56.25 days) (Table 3) was recorded in plants irrigated with 80 per cent CPE. Early flower bud initiation (43.11 days) was recorded in plants without hydrogel (H_5). With respect to flowering duration, maximum flowering duration (57.27 days) was recorded in plants treated with 5.25 kg/ha hydrogel. [3] and [11] in gerbera and [5] in chrysanthemum had also reported similar results. Maximum yield per plant (503.31 g), yield per plot (17.46 kg), flower diameter (5.32 cm) and shelf life (6.43 days) were recorded in plants irrigated with 80 per cent CPE. [7] in marigold, [5] in chrysanthemum, [5] in ginger and [10] in mustard also revealed similar results. (Table 3) Higher concentration of hydrogel, i.e., 5.25 kg/ha resulted in maximum yield per plant (523.70 g) and yield per plot (18.13 kg) at the grand growth stage. Similar trend was followed in flower diameter (5.86 cm) and shelf life (6.57 days). Comparable observations to these findings were documented by [3] and [11] in Gerbera. Among the treatment interactions, the highest values for yield and related traits were observed in plants irrigated at 80% CPE along with the application of 5.25 kg/ha hydrogel. Under this treatment, maximum individual flower weight (6.38 g), yield per plant (550.92 g), and yield per plot (18.66 kg) were recorded at the grand growth stage. In contrast, the lowest yield (Table 3) was obtained in plants irrigated at 60% CPE without hydrogel application. The higher flower yield under favourable treatments could be attributed to improved yield components, including a greater number of primary and secondary branches and enhanced plant spread. These improvements were likely the result of better growth parameters such as increased total dry matter production, more efficient dry matter partitioning into different plant parts, and higher leaf area. The present study indicated that yield-determining components, particularly the number of primary and secondary branches, were significantly enhanced with increasing concentrations of the superabsorbent polymer. Similar findings were reported by [6] in chrysanthemum and [6] in ginger. From an economic standpoint, the maximum gross return (₹5,59,800), net return (₹3,47,681), and benefit-cost ratio (1.64) were recorded in treatment I_2H_4 (irrigation scheduled at 80% CPE with 5.25 kg/ha hydrogel) (Table 4). Conversely, the lowest gross return, net return, and B:C ratio were recorded in treatment I3H5 (irrigation scheduled at 60% CPE with no hydrogel application). Hence, the results clearly suggest that the adoption of treatment I2H4 can be recommended for enhancing unit productivity as well as maximizing net profit in marigold cultivation.

Conclusion

The experiment can be concluded Pusa hydrogel can play a significant role in uniform distribution of water and can hold moisture for better growth and development of crop. Soil amended with Pusa hydrogel enhanced the growth, yield, soil and physiological parameters of marigold. Pusa hydrogel also reduced the number of irrigations and increased the plant growth. This effect is due to the considerable absorption of water in the hydrogel structure and which gradually releases water to the surrounding soil and roots of plants. Based on these results of the durability of hydrogel in soil, it can be concluded that application of 5.25 kg hydrogel per hectare under irrigation scheduled at 80 per cent CPE can increase the growth and yield of marigold.

Table 1: Influence of different levels of irrigation and hydrogel on vegetative parameters in marigold @ 90 DAT

Treatments	Vegetative parameters														
	Plant height @ 90 DAT					Primary branches @ 90 DAT					Secondary branches @ 90 DAT				
	Irrigation Level														
		I_1	I_2	I_3	Mean		I_1	I_2	I_3	Mean		I_1	I_2	I_3	Mean
Pusa hydrogel	H_1	70.74	72.30	61.06	**68.04**	H_1	12.81	13.62	12.43	**12.95**	H_1	29.31	30.02	21.78	**27.04**
	H_2	73.02	73.11	61.75	**69.29**	H_2	14.23	15.09	12.77	**14.03**	H_2	30.68	33.23	22.08	**28.66**
	H_3	77.04	77.13	71.55	**75.24**	H_3	16.49	17.47	13.00	**15.65**	H_3	32.75	35.13	23.16	**30.35**
	H_4	80.02	80.11	73.11	**77.75**	H_4	17.35	17.95	13.37	**16.22**	H_4	35.61	39.21	24.93	**33.25**
	H_5	63.23	64.57	60.54	**62.78**	H_5	13.14	13.41	11.47	**12.67**	H_5	23.62	24.55	18.46	**22.21**
	Mean	**72.81**	**73.44**	**65.60**		**Mean**	**14.80**	**15.51**	**12.61**		**Mean**	**30.39**	**32.43**	**22.08**	
		S.Em (±)		**S.Em (±)**		**S.Em (±)**		**C.D @ 5%**			**S.Em (±)**		**C.D @ 5%**		
Irrigation (I)		**0.73**		**0.33**		**0.55**		**2.22**			**0.61**		**2.44**		
Pusa hydrogel (H)		**0.73**		**0.33**		**0.67**		**1.96**			**0.61**		**1.80**		
Interaction (I×H)		**1.39**		**0.60**		**1.18**		**3.74**			**1.13**		**3.69**		

Main plot treatments irrigation (I): I_1: 100 % CPE, I_2: 80 % CPE, I_3: 60 % CPE
CPE: Cumulative Pan Evaporation
Sub plot treatments Hydrogel (H): H_1 – 3.0 kg/ ha, H_2 –3.75 kg/ha, H_3 –4.50 kg/ha, H_4 –5.25 kg/ha, H_5 – Control DAT: Days after transplanting

Table 2. Flowering parameters at various growth stages of marigold as influenced by different levels of irrigation and hydrogel

Treatments	Flowering parameters													
	Flower duration (days)					Flower Diameter (cm)					Shelf life(days)			
	Irrigation													
		I_1	I_2	I_3	Mean		I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
Pusa hydrogel	H_1	54.00	54.82	49.02	**52.61**	H_1	5.00	5.23	4.20	**4.81**	5.97	6.26	5.45	**5.89**
	H_2	55.23	55.63	51.82	**54.23**	H_2	5.10	5.33	4.50	**4.98**	6.01	6.45	5.59	**6.02**
	H_3	57.01	57.08	51.93	**55.34**	H_3	5.43	5.47	4.60	**5.17**	6.17	6.72	5.86	**6.25**
	H_4	59.21	59.86	52.74	**57.27**	H_4	6.00	6.30	5.27	**5.86**	6.87	6.91	5.92	**6.57**
	H_5	53.12	53.86	48.19	**51.72**	H_5	4.07	4.27	4.03	**4.12**	5.42	5.81	5.22	**5.48**
	Mean	**55.71**	**56.25**	**50.74**		**Mean**	**5.12**	**5.32**	**4.52**		**6.09**	**6.43**	**5.61**	
		S.Em (±)		**C.D @ 5%**		**S.Em(±)**		**C.D @ 5%**			**S.Em (±)**		**C.D @ 5%**	
Irrigation (I)		**0.54**		**2.20**		**0.08**		**0.34**			**0.21**		**NS**	
Pusa hydrogel (H)		**0.71**		**2.10**		**0.14**		**0.42**			**0.26**		**NS**	
Interaction (I×H)		**1.23**		**NS**		**0.24**		**NS**			**0.45**		**NS**	

Main plot treatments irrigation (I): I_1: 100 % CPE, I_2: 80 % CPE, I_3: 60 % CPE
CPE: Cumulative Pan Evaporation
Sub plot treatments Hydrogel (H):H_1 – 3.0 kg/ ha, H_2 –3.75 kg/ha, H_3 –4.50 kg/ha, H_4 –5.25 kg/ha, H_5 – Control DAT: Days after transplanting

Table 3. Flower yield parameters as influenced by different levels of irrigation and hydrogel

Treatments	Flower yield (g/plant)					Flower yield (kg/plot)				
	Irrigation									
		I_1	I_2	I_3	Mean		I_1	I_2	I_3	Mean
Pusa hydrogel	H_1	500.23	501.20	418.24	**473.22**	H_1	16.63	16.68	15.95	**16.42**
	H_2	511.05	512.34	434.04	**485.81**	H_2	17.58	17.64	16.02	**17.08**
	H_3	520.35	521.50	450.55	**497.47**	H_3	18.10	18.23	16.52	**17.62**
	H_4	549.56	550.92	470.63	**523.70**	H_4	18.62	18.66	17.12	**18.13**
	H_5	429.30	430.60	408.35	**422.75**	H_5	15.88	16.07	15.82	**15.92**
	Mean	**502.10**	**503.31**	**436.36**		**Mean**	**17.36**	**17.46**	**16.29**	
		S.Em (±)		**C.D @ 5%**		**S.Em (±)**		**C.D @ 5%**		
Irrigation (I)		**4.20**		**16.83**		**0.13**		**0.50**		
Pusa hydrogel (H)		**5.50**		**16.15**		**0.17**		**0.49**		
Interaction (I×H)		**9.49**		**29.87**		**0.29**		**0.90**		

Main plot treatments irrigation (I): I_1: 100 % CPE, I_2: 80 % CPE, I_3: 60 % CPE
CPE: Cumulative Pan Evaporation
Sub plot treatments Hydrogel (H):H_1 – 3.0 kg/ ha, H_2 –3.75 kg/ha, H_3 –4.50 kg/ha, H_4 –5.25 kg/ha, H_5 – Control DAT: Days after transplanting

Table 4. Benefit cost ratio in marigold as influenced by different levels of irrigation and hydrogel

Treatment combinations	Yield (t/ha)	Cost of Pusa hydrogel (`/ha)	Other production cost (`/ha)	Total cost of cultivation (`/ha)	Gross returns (`/ha)	Net returns (`/ha)	Benefit cost ratio
I1HI	**16.63**	**3900**	**205294**	**2,09,194**	**4,98,900**	**2,89,706**	**1.38**
I1H2	**17.58**	**4875**	**205294**	**2,10,169**	**5,27,400**	**3,17,231**	**1.51**
I1H3	**18.1**	**5850**	**205294**	**2,11,144**	**5,43,000**	**3,31,856**	**1.57**
I1H4	**18.62**	**6825**	**205294**	**2,12,119**	**5,58,600**	**3,46,481**	**1.63**
I1H5	**15.88**	**-**	**205294**	**2,05,294**	**4,76,400**	**2,71,106**	**1.32**
I2H1	**16.68**	**3900**	**205294**	**2,09,194**	**5,00,400**	**2,91,206**	**1.39**
I2H2	**17.64**	**4875**	**205294**	**2,10,169**	**5,29,200**	**3,19,031**	**1.52**
I2H3	**18.23**	**5850**	**205294**	**2,11,144**	**5,46,900**	**3,35,756**	**1.59**
I2H4	**18.66**	**6825**	**205294**	**2,12,119**	**5,59,800**	**3,47,681**	**1.64**
I2H5	**16.07**	**-**	**205294**	**2,05,294**	**4,82,100**	**2,76,806**	**1.35**
I3H1	**15.95**	**3900**	**205294**	**2,09,194**	**4,78,500**	**2,69,306**	**1.29**
I3H2	**16.02**	**4875**	**205294**	**2,10,169**	**4,80,600**	**2,70,431**	**1.29**
I3H3	**16.52**	**5850**	**205294**	**2,11,144**	**4,95,600**	**2,84,456**	**1.35**
I3H4	**17.12**	**6825**	**205294**	**2,12,119**	**5,13,600**	**3,01,481**	**1.42**
I3H5	**15.82**	**-**	**205294**	**2,05,294**	**4,74,600**	**2,69,306**	**1.31**

Main plot treatments irrigation (I): I_1: 100 % CPE, I_2: 80 % CPE, I_3: 60 % CPE Marigold price: 30/kg CPE: Cumulative Pan Evaporation
Sub plot treatments Hydrogel (H): H_1 – 3.0 kg/ ha, H_2 –3.75 kg/ha, H_3 –4.50 kg/ha, H_4 –5.25 kg/ha, H_5 – Control Pusa hydrogel price: 1300/kg

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