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Effect of sewage water on growth and yield of marigold (*Tagetes erecta* L.)

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Abstract
Marigold is one of the commercial loose flower crops which belongs to Asteraceae family. It is popular for its ease of cultivation and wide adaptability to varied agro climatic conditions. Rapid industrialization and urbanization has led to the increase in the volume of the waste water generation. Therefore, utilization of the sewage water for the irrigation could be the alternative way for this. As the sewage water also provides the nutrients and the other trace elements. The present work done at College of Horticulture; Kolar situated in the Eastern dry agro climatic Zone. Due to scattered rainfall pattern and depletion of ground water, irrigation is becoming highly challenging in these areas. In this regard use of sewage water in horticulture crops with proper scientific study will helpful to solve the growing problem. The experimental details include the African marigold (Maxima Yellow, Arka Bangara 2) plants were potted under polyhouse condition during rabi season and laid out in Factorial Randomized Complete Block Design (FRCBD) with 2 factors and 10 treatments with three replications. It was noted that growth parameters *viz.*, plant height, number of branches, leaf area, shoot girth, plant spread were significantly highest in plants treated with 100% untreated sewage water (T_2) and in yield parameters also highest in T_2.

Keywords: Sewage water, growth, yield, marigold, *Tagetes erecta* L.

Introduction
Marigold (*Tagetes erecta* L.) is one of the most commonly grown commercial flower crops in India. It belongs to the family Asteraceae. The two main popularly grown species in marigold are *Tagetes erecta* L. and *Tagetes patula* L. which have their origin in Mexico and South Africa, respectively. *Tagetes erecta* L. is popularly known as "African marigold" while *Tagetes patula* L. as "French marigold". (Swathi and Naik, 2017) [9]. Marigold has got considerable choice among the gardeners and flower growers on account of its ease in cultivation and wide adaptability in varied agro climatic conditions. Sustainable flower production requires optimal nutritional management to attain a high ornamental value of plant and to reduce production costs (Polara *et al.*, 2014) [8]. Marigold has a great demand as loose flowers, and is widely used for making garlands and for decorative purposes. Apart from this, it's extracted colour used as colorant in the food and animal feed industry.

Rapid industrial developmental activities and increasing population growth had declined the resources day by day throughout the world. The population increase has not only increased the fresh water demand but also increased the volume of wastewater generated. Therefore, there is an urgent need to conserve and protect fresh water and to use the water of lower quality for irrigation. Various studies confirm that treated sewage water can be useful as an additional water resource for irrigation (Palese *et al.*, 2009; Mehrdadi *et al.*, 2007) [6, 5]. Disposal of sewage waste water is a problem of increasing importance throughout the world. At present 17.4 million cubic liters of raw sewage is generated per day in urban areas of the country (Mara *et al.*, 2007) [4]. Sewage water is used as a source of irrigation as well as a source of plant nutrients and trace elements allowing farmers to reduce and even eliminate the use of chemical fertilizers and as an organic matter that serves as a soil conditioner and humus replenisher (Bakhsh and Hassan 2005) [1].

The present work done at Kolar district situated in the Eastern dry agro climatic Zone. It experiences a semi-arid climate. Due to scattered rainfall pattern and depletion of ground water, irrigation is becoming highly challenging. In this regard use of sewage water in horticulture crops with proper scientific study will helpful to solve the growing problem. In this regard, a study entitled "Effect of sewage water on growth, yield and quality of marigold (*Tagetes erecta* L.)" was carried out.

Material and Methods

This present research work was carried out at College of Horticulture, Kolar located at 13.13 ˚N, 78.13 ˚E. with an average elevation of 849 meters. The experimental details include the African marigold plants were potted under polyhouse condition at during rabi season. The experiment was laid out in Factorial Randomized Complete Block Design (FRCBD) with 2 factors and 10 treatments with three replications. The treatments details include Factor A: sewage water treatment (T) with T_1 (bore well water), T_2 (Untreated sewage water), T_3 (25% Bore well water + 75% Untreated sewage water), T_4 (50% Bore well water + 50% Untreated sewage water) and T_5 (75% Bore well water + 25% Untreated sewage water) and Factor B: marigold varieties (V) with V_1 Arka Bangara 2 and V_2 Maxima Yellow.

Thirty days old healthy seedlings were transplanted to each pot. The pots (60 cm x 45 cm) were filled with 2:1:1 ratio of red earth, sand and FYM and added with recommended dose of fertilizers (125:60:60 kg NPK/ ha) and treatments were imposed and soil samples were collected for further studies. The growth, yield and quality parameters were also analyzed.

Fig 1: General view of research plot

Results and Discussion

Growth parameters

All the growth parameters viz, plant height, number of branches, leaf area, shoot girth, plant spread was significantly differed at all stages of plant growth in the marigold. It was observed that all the growth parameters were significantly highest in plants treated with 100% untreated sewage water (T_2) followed by T_3 and T_4. (Table 1)

The maximum plant height at 30, 60 and 90 DAT (31.11 cm, 41.04 cm and 49.70 cm respectively) was observed in the plants which were treated with 100% untreated sewage water (T_2) when compared with control (28.60 cm, 34.75 cm and 39.73 cm) (T_1). However, on par results were noticed in T_3 and T_4. Likewise, the leaf area (54.20 cm2, 92.05 cm2 and 102.61 cm2) and stem girth (2.67 cm, 2.77 cm and 3.00 cm) were also maximum in T_2 followed by T_3 and T_4 and all the parameters were observed lower in the plants treated with the borewell water (control).

Among the varieties, plants belong to Maxima Yellow were significantly taller (33.46 cm, 42.80 cm and 49.64 cm) and had maximum leaf area (44.45 cm2, 86.66 cm2 and 93.32 cm2) compared to Arka Bangara 2. Whereas the stem girth was observed maximum in Arka Bangara 2 (2.37 cm, 2.49 cm and 2.73 cm).

Similar trend was noticed even in interaction. The maximum plant height (35.06 cm, 49.04 cm and 59.33 cm) was recorded in T_2V_1 and minimum height was observed in T_4V_2 and T_1V_2 and maximum leaf area was also recorded in T_2V_1 (56.60 cm2, 98.90 cm2 and 105.86 cm2) and minimum in T_1V_2 at 30, 60 and 90 days after transplanting respectively.

This can be attributed to more availability of N, P, K content, and other micronutrient. Untreated or partially treated sewage water has been determined to be one of the most important factors in lake eutrophication, mainly as a result of the large amounts of nutrients present (Manios *et al*., 2006) [3].

Maximum number of branches per plant (10.07, 14.86 and 18.96) and plant spread in N-S (32.36 cm) and in E-W (31.20 cm) were recorded when plants were treated with 100% untreated sewage water (T_2) when compared with control which is on par with T_3 and T_4 at 30, 60 and 90 days after transplanting respectively. In contrast the minimum number of branches (8.06, 10.16 and 13.13) at all stages of growth and lowest plant spread N-S (24.33 cm) and E-W (25.46 cm) was observed in (T_1) control.

In variety Maxima Yellow maximum number of branches (10.60, 14.08 and 17.12) were recorded and minimum in Arka Bangara 2. Whereas the plant spread in N-S (28.00 cm) and E-W (27.36 cm) was noted in Arka Bangara 2 variety and minimum in Maxima Yellow.

The data pertaining to the interaction between variety and treatment was mentioned in table 1. The maximum number of branches (11.46, 16.40 and 21.26 per plant), maximum plant spread in N-S (33.53 cm) and E-W (32.00cm) were found in T_2V_1 at 30, 60 and 90 days after transplanting respectively and minimum number of branches were found in T_1V_2. Whereas, minimum plant spread in N-S was observed in T_3V_1 and in E-W in T_1V_1.

This might be due to higher nutritional value of sewage water. As sewage water is rich in macro and micronutrients, various growth parameters indicated positive response. Petousi *et al.*, 2017 [7] reported that the application of all treated sewage water had positive (for primary treated waste water and secondary treated waste water) or neutral (tertiary treated waste water) effect in comparison with the application of tap water, number of branches and plant spread were increased with the application of untreated and primary treated sewage water.

Table 1: Growth parameters in marigold varieties as influenced by the sewage water treatment level

Treatments (T)	Plant height (cm)			Number of branches			Stem girth (cm)			Leaf area (cm^2)			Plant spread (cm)	
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	N-S	E-W
T_1 Bore well water (Control)	28.60	34.75	39.74	31.20	72.28	75.01	2.15	2.27	2.56	31.20	72.28	75.01	25.46	24.33
T_2 (100% Sewage Water)	31.11	41.05	49.70	54.20	92.05	102.61	2.67	2.77	3.00	54.20	92.05	102.61	32.36	31.20
T_3 (25% B.W+ 75% S.W)	29.94	37.67	43.57	44.21	84.71	96.88	2.31	2.41	2.70	44.21	84.71	96.88	27.73	25.96
T_4 (50% B.W+50% S.W)	29.68	37.24	43.31	44.51	81.43	90.18	2.16	2.33	2.64	44.51	81.43	90.18	26.56	26.40
T_5 (75% B.W+ 25% S.W)	29.34	36.31	42.54	38.96	80.71	85.60	2.30	2.44	2.64	38.96	80.71	85.60	25.63	24.53
S. Em±	5.25	5.63	4.79	4.43	1.13	9.30	0.31	0.28	0.27	4.43	1.13	9.30	3.84	3.84
CD (P=0.05)	1.75	1.88	1.59	1.47	0.37	3.10	0.10	0.09	0.09	1.47	0.37	3.10	1.28	1.28
Varieties (V)														
V_1 (Maxima Yellow)	33.46	42.80	49.63	10.60	14.08	17.12	2.26	2.40	2.68	44.45	86.66	93.32	27.10	25.50
V_2 (Arka Bangara)	26.00	32.00	37.89	7.07	10.05	14.20	2.37	2.49	2.73	40.78	77.81	86.79	28.00	27.36
S. Em±	5.12	3.56	3.03	1.32	3.02	2.25	0.19	0.18	0.17	2.80	0.71	5.88	3.00	2.43
CD (P=0.05)	1.10	1.18	1.00	0.44	1.00	0.75	0.06	0.06	0.05	0.93	0.23	1.96	0.81	0.81
Interaction (Treatment x Varieties)														
T_1V_1	32.87	38.63	43.09	10.80	12.80	15.00	2.18	2.32	2.60	32.46	75.36	77.39	25.20	22.80
T_1V_2	25.80	30.87	36.30	5.40	7.53	11.26	2.12	2.23	2.51	29.93	69.20	72.63	25.73	25.86
T_2V_1	35.07	49.04	59.33	11.46	16.40	21.26	2.62	2.73	2.93	56.60	98.90	105.86	33.53	32.00
T_2V_2	27.16	33.05	40.07	7.80	13.33	16.66	2.72	2.82	3.07	51.80	85.20	99.36	31.20	30.40
T_3V_1	34.15	41.17	50.29	10.40	13.46	16.73	2.14	2.28	2.68	47.16	89.23	101.73	25.06	23.46
T_3V_2	25.74	31.45	36.85	6.20	9.26	14.06	2.45	2.54	2.72	41.26	80.20	92.03	30.40	28.46
T_4V_1	31.79	41.35	47.25	9.46	13.20	15.80	2.10	2.29	2.63	46.22	83.61	94.24	26.40	25.20
T_4V_2	25.41	33.13	39.36	6.66	11.20	15.26	2.22	2.36	2.66	42.80	79.26	86.13	26.73	27.60
T_5V_1	33.47	43.83	48.27	10.86	14.53	16.80	2.26	2.38	2.58	39.83	87.40	86.23	25.33	24.06
T_5V_2	25.89	31.51	36.82	9.26	8.93	13.73	2.36	2.49	2.70	38.10	83.80	75.20	25.93	24.46
S. Em±	7.42	7.97	6.77	2.94	6.76	5.03	0.44	0.40	0.38	6.27	13.16	1.60	5.43	5.43
CD (P=0.05)	2.47	2.66	2.26	0.98	2.25	1.67	0.14	0.13	0.12	2.09	4.38	0.53	1.81	1.81

Yield parameters

Yield parameters were recorded and presented in Table 2. First bud was appearance (20.33 DAT) was recorded in plants were treated with 100 percent untreated sewage water treatment (T_2) followed by T_3, due to more plant height, number of branches per plant and number of leaves. Thus, resulting in vigorous growth in these treatments, plants approached to early reproduction as they did not suffer to limitation of nutrients as compared with control. Minimum days taken for 50 percent flowering (27.50 DAT) was also recorded in T_2 this might be due to early first bud appearance in these two treatments as compared with rest of the treatments. As sewage water usually contains high macro and micronutrients, its application in soil improved soil properties and consequently increased plant productivity (Lindsay, 1978). It was also noted that highest number of flowers (65.30 flowers per plant) were recorded in T_2 followed by T_3 this was due to more plant height, more number of branches per plant and number of leaves in T_2 treated plants, this can be attributed to production of maximum number of flowers per plant in marigold. Finally, the total weight of flowers (463.40 g per plant) and total yield (18.02 t ha^{-1}) were highest in T_2 significantly higher when compared with T_3 and T_4, the lowest was observed in the control this might be due to due to more flower diameter and maximum number of flowers per plant.

Among varieties first bud appearance (23.33 DAT), minimum days taken for 50 percent flowering (31.53 DAT), highest number of flowers per plant (52.56), highest flower weight (336.31 g per plant) and highest flower weight (13.10 t ha^{-1}) was recorded in Maxima Yellow and followed by Arka Bangara 2.

Same trend was continued in interaction between varieties and treatments (Table 2). The minimum days taken for first bud appearance (20.33 DAT) was recorded in T_2V_1 which was on par with T_1V_2 (20.33 DAT) and maximum days taken was found in T_1V_1. The maximum number of flowers (71.36 flowers per plant) were also recorded in T_2V_1 and minimum number of flowers were recorded in T_1V_2 (31.70 flowers per plant). Maximum flower weight was recorded in T_2V_1 (522.96 g per plant) and minimum flower weight (181.34 g per plant) was recorded in T_1V_2. Interaction showed significantly different values on total weight of flowers (Table 2). The maximum total flower weight (21.49 t ha^{-1}) was recorded in T_2V_1 and minimum number of flower weight recorded in T_1V_2.

Table 2: Yield parameters in marigold varieties as influenced by the sewage water treatment level

Treatments (T)	Number of days to first bud appearance	Number of days to 50% flowering	Number of flowers per plant	Flower weight (g plant^{-1})	Yield (t ha^{-1})
T_1 Bore well water (Control)	26.33	37.00	33.60	200.50	6.90
T_2 (100% Sewage Water)	20.33	27.50	65.30	463.40	18.02
T_3 (25% B.W+ 75% S.W)	21.33	28.50	56.56	355.45	13.37
T_4 (50% B.W+50% S.W)	24.00	32.00	52.64	314.08	11.87
T_5 (75% B.W+ 25% S.W)	24.50	34.50	38.00	223.79	8.40
S. Em±	3.42	4.47	0.11	7.97	0.28
CD (P=0.05)	1.14	1.49	0.34	23.86	0.86
Varieties (V)					
V_1 (Maxima Yellow)	23.33	31.53	52.56	336.31	13.10
V_2 (Arka Bangara)	23.26	32.26	45.87	286.58	10.32
S. Em±	2.16	2.83	0.07	5.04	0.18
CD (P=0.05)	0.72	0.94	0.21	15.09	0.54
Interaction (Treatments x Varieties)					
T_1V_1	26.66	36.66	35.50	219.65	7.69
T_1V_2	26.00	37.33	31.70	181.34	6.11
T_2V_1	20.33	27.33	71.36	522.96	21.49
T_2V_2	20.33	27.66	59.23	403.85	14.55
T_3V_1	21.66	28.66	60.50	377.08	14.64
T_3V_2	21.00	28.33	52.62	333.82	12.10
T_4V_1	23.33	30.66	54.64	329.32	12.56
T_4V_2	24.66	33.33	50.64	298.85	11.18
T_5V_1	24.66	34.33	40.80	232.54	9.11
T_5V_2	24.33	34.66	35.20	215.04	7.69
S. Em±	4.84	6.33	0.16	11.27	0.40
CD (P=0.05)	1.61	2.11	0.48	33.75	1.22

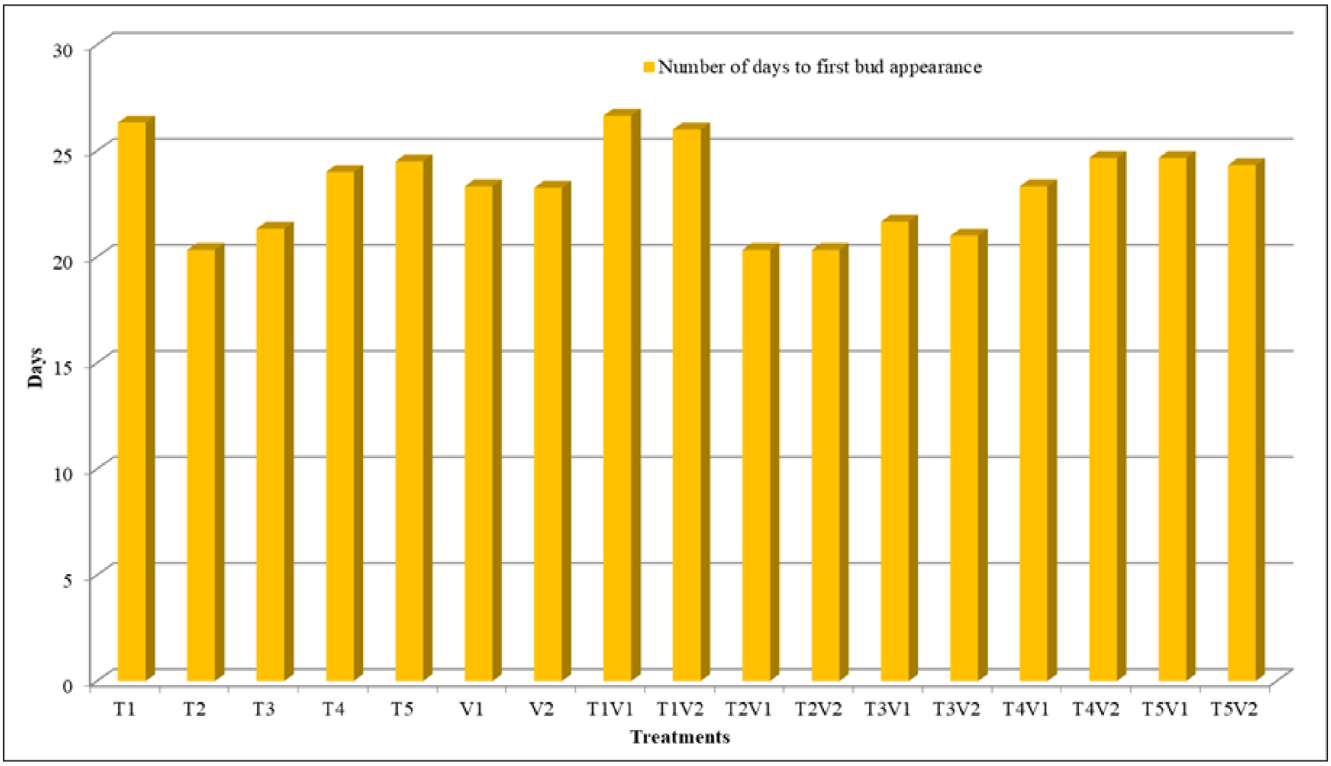

Fig 1: Number of days to first bud appearance in marigold varieties (days) as influenced by different sewage water treatment levels

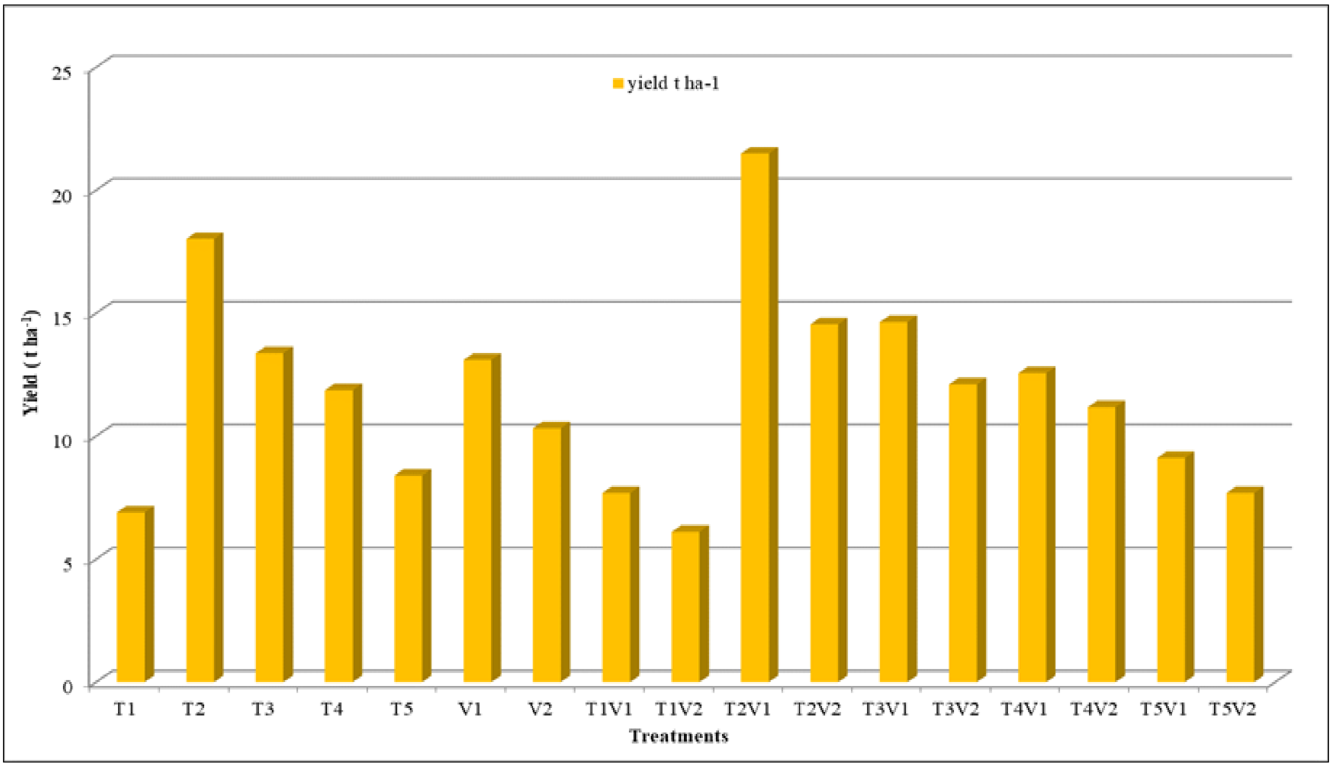

Fig 2: Yield in marigold varieties (t ha^{-1}) as influenced by different sewage water treatment levels

Conclusion

Inferences about the usage of sewage water can be drawn from the findings of the current experiment that 100% sewage water usage in marigold varieties increased the growth parameter and yield of the plant.

Future Scope

Industrialization and urbanization lead to the drastic increase in the volume of sewage water, so utilization of this sewage waster for the irrigation purpose is becoming important in the places where the rainfall is less and places with less ground water availability. Because the sewage water contains the nutrients and the trace elements which serves the plant requirement. So, usage of sewage water in other horticulture crops is beneficial in the arid and semi arid regions.

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