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Aravindhan S
Department of Floriculture and Landscaping, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

M Jawaharlal
Directorate of Extension Education, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

SP Thamaraiselvi
Department of Floriculture and Landscaping, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

V Davamani
Department of Environmental Sciences, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Correspondence
M Jawaharlal
Directorate of Extension Education, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Effect of heavy metals on morphological and flowering parameters of African marigold (*Tagetes erecta*)

Aravindhan S, M Jawaharlal, SP Thamaraiselvi and V Davamani

Abstract
An experiment was carried out to study the effect of heavy metals on morphological and flowering parameters of African marigold. The study includes the spiking of heavy metals lead and chromium at various concentrations (50, 100, 150 and 200 ppm of each heavy metals are used), treated sewage water contaminated soil and control as treatments. The experiment was conducted as pot culture experiments. The results revealed that the highest plant height (44.8 cm) was recorded in treated sewage water contaminated soils. The maximum number of primary branches (6.3) was observed in control plants while the flower bud initiation was on par in case of lead (50 mg kg^{-1}), chromium (50 mg kg^{-1}) and treated sewage water contaminated soil. The maximum flower size (5.1 cm) was noticed in treated sewage water contaminated soil.

Keywords: African marigold, heavy metals, lead and chromium

Introduction
Soil pollution has recently been attracting considerable public attention since the magnitude of the problem in our soils calls for the immediate action (Garbisu and Alkorta 2003) [4]. As a result most of the soils are contaminated with heavy metals such as lead, chromium, arsenic and cadmium. Current practice for remediating heavy metal contaminated soils relies heavily on 'dig and dump' or encapsulation, neither of which addresses the issue of decontamination. Immobilization or extraction by physiochemical techniques can be expensive and appropriate for small areas where rapid and complete decontamination is required (Martin and Bardos, 1996; BIO-WISE, 2000) [7]. An alternative technique for the soil reclamation is the concept of phytoremediation.

Phytoremediation is the modern concept wherein it utilises the plants to degrade or detoxify the heavy metals and accumulate in their plant parts. This technique is considered as an emerging trend, cost effective and helps in site restoration. Adaptation of flowering annuals such as African marigold in the phytoremediation process helps to add aesthetic sense to the location and also rectifies the soil contaminations. The use of flowering plants will help in preventing the heavy metals entering food chain and also aids in secondary source of income through loose flowers. In this study, African marigold (*Tagetes erecta* Linn.) was exposed to heavy metal stress (lead and chromium) and their morphological and flowering nature under heavy metal stress conditions are observed.

Materials and methods
The present investigation was carried out at Botanic Gardens, Department of Floriculture and Landscaping, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India during 2018-2019. The experiment was conducted in heavy metal spiked pots wherein 25 days old Marigold cv. Coimbatore local (orange) seedlings are transplanted in it. The treatments include control, treated sewage water contaminated soils, lead at 50, 100, 150 and 200 mg kg^{-1} concentration and chromium at 50, 100, 150 and 200 mg kg^{-1}. Thus the experiment consists of ten treatments under Completely Randomized Design (CRD) with three replications and five plants were kept for each replication. The pinching was done after 15 days of transplanting and observations are carried out. The nutrients and water requirement are provided as per crop requirement. The observed data are analysed statistically by AGRES and the critical difference was measured at five percent probability.

Results and discussion

Effect of heavy metals on plant height

The maximum plant height of 31.33 cm after 30 days of transplanting was recorded in sewage water treated soils followed by lead (50 mg kg^{-1}) and control with 29.70 cm and 28.43 cm respectively. The lowest plant height of 21.43 cm was measured in treatment with chromium (200 mg kg^{-1}) followed by lead (150 and 200 mg kg^{-1}) and chromium (150 mg kg^{-1}) with 22.96 cm,23.5 cm and 23.5 cm respectively. These data are represented in table 1. The similar trend is followed in plants after 60 days of transplanting with the maximum plant height of 44.77 cm was recorded in sewage water treated soils followed by control with 40.65 cm. The lowest plant height was recorded in chromium (200 mg kg^{-1}) with 30.83 cm. From this, it can be concluded that increase in heavy metal concentration of lead and chromium in the soil will reduce the plant growth drastically. This is in accordance with the findings of Mansour *et al.* (2015) [5] in African marigold under Cd stress and the findings of Rajalakshmi *et al.* (2011) [8] in African Marigold under lead stress conditions. There is sudden decline in plant growth of *Lemna minor* under Cd stress was reported by Bianconi *et al.* (2013) [3] and it also represents the results similar to this one. Also, oxidative stress is induced by chromium initiates the photosynthetic degradation of plants which affects its plant growth was the major reason for sudden decline of plants under Cr stress was reported by Ambika Asati *et al.* (2016) [1].

Effect of heavy metals on number of primary branches

From the Fig. 1, it can be concluded that the maximum number of branches was found in control (6.33) followed by chromium (50 mg kg^{-1}) and sewage treated soils with 5.66 and 5.53 respectively. The minimum number of branches was noted in treatment with chromium (200 mg kg^{-1}) followed by lead (200 mg kg^{-1}) 4.46 and 4.56 respectively. The result clearly indicates that significant decrease in number of branches in different treatments is due to the effect of high concentration of metal and its stress that restricts plant growth. The results are in agreement with the findings of Ramana *et al.* (2013) [9] in different plant species under Cr contaminated soils. The results are similar with the findings of Chitraprabha *et al.* (2018) [6] in African marigold under Cr contaminated soils. The major reason for reduction in growth of plants is due to high level of Pb induces oxidative stress by increasing the production of ROS in plants was observed by Reddy *et al.* (2005) [10].

Effect of heavy metals on days to flower bud initiation

The data represented in Table. 1 shows that the early flower bud initiation was observed in sewage treated soils at 41.96 days after transplanting followed by lead (50 mg kg^{-1}) and chromium (50 mg kg^{-1}) with 43.10 and 43.33 days after transplanting respectively. High concentration of heavy metals delays the flowering in most of the flower crops. This result can be agreed with the findings of Atanassova *et al.* (2014) in several flower crops. The findings also conclude that the higher concentration leads to reduction in blooming period significantly under Cu and Pb contaminated conditions in *Salvia splendens*.

Effect of heavy metals on flower diameter

It is evident from the Fig. 2 that the maximum flower diameter was found to be 5.07 cm in the sewage treated soil treatment and is followed by lead (50 mg kg^{-1}) with 5.03 cm. The minimum flower size was noticed in treatment with chromium (200 mg kg^{-1}) at 3.60 cm. The increase in concentration of any heavy metals decreases the photosynthetic activity by inducing oxidative stress, this results in decline of plant growth and also flower size. Also, high concentration of lead in soils may reduce the uptake of mineral nutrition by plants. This results are in accordance with the observations carried out by Sharma and Dubey (2005) [11].

Conclusion

Based on the results of this study, it is concluded that African marigold can be grown well under treated sewage irrigation water and in lead contaminated soil upto 50 mg kg^{-1} concentration without affecting its morphological and flowering parameters.

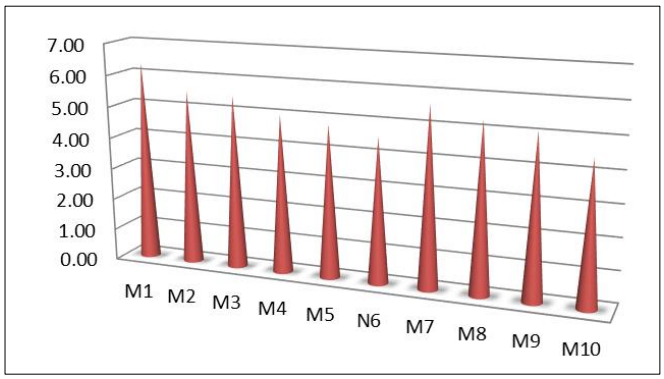

Fig 1: Effect of heavy metals on number of primary branches

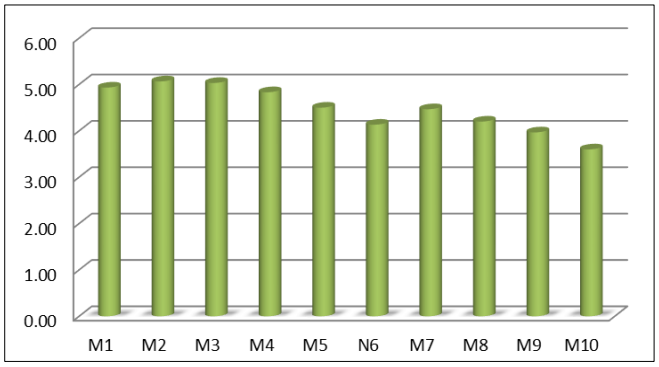

Fig 2: Effect of heavy metals on flower diameter

Table 1: Effect of heavy metals on plant height and days to flower bud initiation

Treat-------ments	Plant Height (cm)		Days to flower bud initiation
	30 DAT	60 DAT	
M1	28.43	40.65	44.96
M2	31.33	44.77	41.96
M3	29.70	39.63	43.10
M4	26,53	37.57	45.60
M5	22.96	35.77	47.33
M6	23.50	33.06	52.43
M7	27.97	37.93	43.33
M8	25.17	35.83	46.76
M9	23.00	33.40	50.73
M10	21.43	30.83	56.06
S.Ed	0.5929	0.7317	0.7486
CD (p = 0.05)	1.2368	1.5262	1.5616
Treatment concentrations	M1- Control; M2-Sewage water contaminated soil; M3-Pb 50 mg kg^{-1}; M4- Pb 100 mg kg^{-1};M5- Pb 150 mg kg^{-1};M6- Pb 200 mg kg^{-1};M7- Cr 50 mg kg^{-1};M8- Cr 100mg kg^{-1};M9- Cr 150mg kg^{-1};M10- Cr 200 mg kg^{-1}		

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