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RESEARCH ARTICLE

Growth and Flowering Responses of Two Marigold Species Under Water Stress Conditions with Uses Different Mulches

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ABSTRACT

Water stress is an important abiotic stress that limits plant growth and productivity. A pot experiment was conducted by using randomized complete block design (RCBD) with three replications (each replication containing four plants) to evaluate morphological (vegetative growth and flowering parameter) and proline content attributes that can be used for characterization of drought tolerance in two cultivars of Marigold (*Tagetes patula* and *Tagetes erecta*). Three drought levels at 100% (control), 75% and 50% field capacity were maintained throughout the experiment. Flowering characteristics include day number from planting to flowers bud emergence, day number to anthesis, number of flowers per plant and flower diameter were studied also, the growth parameter including plant high, number of branches, plant dry weight, root dry weight, plant biomass and Proline content were studied. Results showed that overall plant quality of cultivars decreased with the progression of drought stress where 70% F.C can be considered appropriate for acceptable plant quality, whereas *Tagetes patula* performed better compared to *Tagetes erecta* for all attributes studied.

INTRODUCTION

The herbaceous annual marigold (*Tagetes erecta* L.) is a member of the Asteraceae family (Kumar *et al.,* 2016). Marigold is used for ornamental and medicinal uses. Because it contents aromatic nature and essential oil, it is frequently used in the cosmetic and perfume industries (Regaswamy and Koilpillai, 2014). Marigolds are a popular seasonal blooming plant and growing in public parks, gardens, and along roadsides throughout the year. Marigold great number species contain beautiful yellow, deep orange, and white blooms with dark green leaves. According to Valdez-Aguilar *et al.*, (2009), the African marigold is somewhat taller than the French marigold. For landscaping purposes, several genotypes of both species are typically utilized as bedding and container plants, additionally, it has been noted that several African marigold species are sold in marketplaces as cut flowers for garlands. Marigolds have become popular among flowers due to their abilities to survive in a range of environmental conditions (Mlcek and Rop, 2011).

Mulching can be considered to create a cover on the soil surface that is used for different purposes and perspectives. Adding mulch plays a role in maintaining soil moisture by protecting the plant from transpiration and direct evaporation from the soil surface and reduces the need for irrigation water. Wang *et al.,* 2022 reported that maze seed yield and biomass was increased by applied mulch. The mulch reduces soil temperature and conserving more moisture and having effective on increasing water use efficiency. Reducing soil temperature, preventing weed growth, improving soil structure, soil fertility by trapping nutrients, and preventing plants from being damaged by using mulch (Yang *et al.,* 2006; Baets *et al.,* 2011). According to the research results of Abbasi *et al.,* (2019), the use of live mulch in marigold cultivation is of great importance. By increasing soil moisture and root growth conditions and increasing the leaf area, mulch improved marigold yield and yield components compared to the treatment (no mulch application). In another experiment on marigold, the application of live and dead mulch increased flower yield by controlling weeds and improving plant growth conditions (Anjil Ela *et al.,* 2014).

Water use efficiency is one of the most important considerations when selecting plants for areas with limited water and high temperatures throughout the developmental phase. Many reactions and mechanisms influence the efficiency of a plant's water consumption, including cuticle thickness, leaf angle, leaf surface, stomatal opening and closing, root-to-stem ratio, etc. (Giordano *et al.,* 2021). Even though stomata closure reduces gas exchange and photosynthesis, water consumption efficiency increases. Water use efficiency regulates the relationship between transpiration and photosynthesis. Improved water use efficiency is one mechanism by which plants adapt to drought stress, whereas lower water use efficiency is characteristic of sensitive plants (Jin *et al.,* 2018). Depending on genotype and stress level, water use efficiency can often decline, increase, or remain constant (Cameron *et al.,* 2006). The results showed a downward trend in changes in the number of flowers as one of the important components of flower yield due to deficit irrigation Jamali *et al*., (2021). According to Raja Babu *et al*., 2018 when study the different mulching treatments and different levels of irrigation. Among irrigation treatments, observed highest values for parameters like plant height (47.98 cm), primary branches (7.73), dry matter production (58.87 g), days to flower bud initiation (34.05 days), duration of flowering (77.74 days), flower diameter (5.57 cm). Alos, the mulching recorded highest values for parameters like plant height (51.10 cm), primary branches (8.05), dry matter production (66.21 g), days to flower bud initiation (35.05 days), duration of flowering (77.73 days), flower diameter (5.75 cm), Number of flowers per plant (88.08). The aim of this study is to investigate the effect of cultivation methods and mulch application on growth and flowering of two cultivar of marigold plant and to evaluate the effect of different levels of irrigation on the morphological and physiological traits of marigold plant.

MATERIALS AND METHODS

The study was carried out in the lath house of the Department of Horticulture, College of Agriculture Engineering Sciences, University of Duhok, Kurdistan region, Iraq. The two species (*Tagetes patula* and *Tagetes erecta*) of marigold plant. So, the experiment includes (2×3×3×3×4= 216) plant. The seeds of marigold cultivars were imported from the Pagano Costantino company in Italy. through Kurdistan offices, which is one of the agricultural offices in Duhok, and the seeds were planted in peatmoss the first time after germination the seedling, transplanting was done four weeks after sowing at one seedling per pot. The pots were arranged in factorial fitted in a completely randomized design with three replicates transferred to a growing medium containing (river soil and peatmoss at 2:1 v/v) in 24 cm pots. The pots were placed in a lath house with an average day/night temperature of 25 C°/18 °C. Factors considered two marigold species (*T.patula* and *T. erecta*), three different mulch (un-mulch, hay and green grasses) and water rate (50, 75 and 100) % per week. **Parameter**: Number of days from planting to flower bud emergence, Number of days from planting to anthesis, Number of flower plant^{-1}, Flower diameter (cm), plant height, number of branches, plant and root dry weight of plant, plant biomass and proline contain.

Extraction Process:

Proline was extracted according to the method proposed by Dahl-Lassen *et al.,* (2018). A weight of 3 grams of the sample was placed in a 25 mL volumetric flask, to which 25 mL of 1M hydrochloric acid was added and heated at 55°C for 3 hours. After that, the sample was evaporated using a rotary evaporator, and 5 mL of sodium citrate (pH 2.2) was added. The sample was then filtered using a 0.45 μm plastic filter and prepared for injection into the device.

Derivation Process:

1 mL of the extracted sample was taken, and 200 μL of 5% orthophthalaldehyde (OPA) was added. The mixture was shaken for 2 minutes, and then 100 μL of the final mixture was injected into the HPLC device. Data collection began two months after transplanting, at a two-week interval for twelve weeks.

HPLC Conditions:

HPLC mode SYKAM – German using to detection of proline, the mobile phase was acetonitrile: MeOH: 5 % OPA water = (60 : 25 : 15) at Flow rate = 1.0 ml / min , the Column separation was C18 – NH_2 (25cm * 4.6 mm) the Detector was Florescent and the Ex = 365 nm , Em = 445 nm .

STATISTICAL ANALYSIS

The experiment was carried out using a completely randomized design. Each treatment comprised three replicates and four plants for each replication. Collected data were subjected to analysis of variance (ANOVA) and the mean values were assessed by Duncan Test at P ≤ 0.05 using program (**SAS**).

RESULTS

1. Effect of cultivars, Different mulch and Water rate % on flowering parameters.

Results obtained in Table 1 show that the effect of cultivars was significantly different on all flowering parameters except the number of flowers per plant, which was not significant between the two cultivars and reached (3.784 and 3.684) flowers for *Tagetes patula* and *Tagetes erecta* respectively. The lower day number from planting to flower bud emergence and the lowest day number from flower bud emergence to anthesis are shown in *Tagetes erecta* cultivar and were reached at 76.611 and 41.549 days, respectively. While *Tagetes patula* gave the maximum flower, the significant diameter reached 5.310 cm.

Table (1): Effect of different cultivar on flowering parameters.

Cultivar	Day number from planting to flowers Bud emergence	Day number from flowers Bud emergence to anthesis	Number of flowers per plant	Flower diameter cm
Tagetes patula	82.938[a]	45.772[a]	3.784[a]	5.310[a]
Tagetes erecta	76.611[b]	41.549[b]	3.684[a]	3.893[b]

In the present investigation, significant differences were observed among all mulches, providing the scope of improvement on flower quality of marigold cv. T*agetes patula* and *Tagetes erecta* (Table 2). The perusal of data clearly reveals that the covering of mulches has significantly influenced day number from planting to flower bud emergence and day number from flower bud emergence to anthesis significantly. The number of days for bud initiation and day number from flower bud emergence to anthesis was found to be minimum day (74.630 and 37.611 days, respectively, observed in the un-mulch treatment for *Tagetes erecta cultivar,* followed by the same treatment for *Tagetes patula* (81.722 and 41.167), respectively. The number of days for bud initiation was found to be maximum (83.815 and 80.130 days) in treatment when using green grasses much. While the number of flowers per plant and flower diameter are the maximum results, show when green grasses mulch put in the soil pot (4.222 flowers and 6.091 cm) is for the *Tagetes erecta* cultivar.

Table (2): Effect of different cultivar and different mulch on flowering parameters

Cultivar	Different mulch	Day number from planting to flowers Bud emergence	Day number from flowers Bud emergence to anthesis	Number of flowers per plant	Flower diameter cm
Tagetes patula	Un-mulch	81.722[a]	41.167[bc]	3.352[b]	4.092[c]
	Hay	83.278[a]	48.278[a]	3.778[ab]	5.746[ab]
	Green grasses	83.815[a]	47.870[a]	4.222[a]	6.091[a]
Tagetes erecta	Un-mulch	74.630[a]	37.611[c]	3.833[ab]	2.664[d]
	Hay	75.074[b]	41.278[bc]	3.589[b]	4.036
	Green grasses	80.130[ab]	45.759[ab]	3.630[b]	4.980[bc]

In order to investigate the effect of water rate % on flowering parameters such as day number from planting to flowers bud emergence, day number from flowers bud emergence to anthesis, number of flowers per plant, and flower diameter, we found significant effects in (Table 3). The lesser day number from planting to flower bud emergence and the day number from flower bud emergence to anthesis were obtained when the pot irrigated by 50% tap water reached (68.481 and 37.426 days), respectively, for the Tagetes erecta cultivar compared to the 100% and 75% water for the Tagetes patula, which observed the maximum day number from planting to flower bud emergence and the day number from flower bud emergence to anthesis reached (85.500 and 47.630), respectively. However, the best result for the number of flowers per plant and flower diameter was obtained for the Tagetes patula cultivar, which reached 4.352 flowers and 5.898 cm under the water-irrigated 100%

Table (3): Effect of different cultivar and water rate% on flowering parameters

Cultivar	Water rate %	Day number from planting to flowers Bud emergence	Day number from flowers Bud emergence to anthesis	Number of flowers per plant	Flower diameter
Tagetes patula	50	80.685[a]	43.574[a]	2.778[c]	4.798[b]
	75	82.630[a]	47.630[a]	4.222[a]	5.234[ab]
	100	85.500[a]	46.111[a]	4.352[a]	5.898[a]
Tagetes erecta	50	68.481[a]	37.426[a]	3.033[c]	3.107[c]
	75	80.278[a]	43.981[a]	3.667[b]	4.165[a]
	100	81.074[a]	43.241[a]	4.352[a]	4.407[b]

The results of the analysis indicated that the different mulch, water deficit stress, and cultivars had significant effects on the flowering parameter shown in Table 4. The lesser day number from planting to flowers bud emergence and day number from flowers bud emergence to anthesis was obtained when the pot Un-mulch and irrigated by 50% tab water reached (65.667 and 37.000 days) respectively for *Tagetes erecta* cultivar follow by *Tagetes patula* cultivar observed the lowest day number from planting to flowers bud emergence and day number from flowers bud emergence to anthesis when planted in pot without mulch and irrigated by 50% tab water which give (77.667 and 36.333 days) compared to the same cultivar which observed the maximum day number from planting to flowers bud emergence, day number from flowers bud emergence to anthesis reached (86.000 and 51.000 days) respectively when planted in pot with hay mulch and irrigated by 100%. However, the highest number of flowers per plant and flower diameter was obtained for *the Tagetes patula* cultivar, which reached 4.833 flowers and 6.831 cm in treatment containing green grasses mulch and 100%

irrigated by tap water. While the minimum number of flowers per plant was obtained for *the Tagetes erecta* cultivar, which reached 2,500 flowers in treatment containing hay mulch and 50% irrigated by tap water, the lowest flower diameter for *the Tagetes patula* cultivar reached 2.399 cm in treatment having hay mulch and 50% irrigated by tap water.

Table (4): Effect of different cultivar, different mulch and water rate% on flowering parameters

Cultivar	Different mulch	Water rate %	Day number from planting to flowers Bud emergence	Day number from flowers Bud emergence to anthesis	Number of flowers per plant	Flower diameter
Tagetes patula	Un-mulch	50	77.667^{abc}	36.333^{e}	2.667^{fg}	3.741^{d-g}
		75	83.167^{a}	48.167^{abc}	3.667^{abc}	4.205^{d-g}
		100	84.333^{a}	39.000^{b-e}	3.722^{abc}	4.330^{d-g}
	Hay	50	81.944^{a}	46.944^{a-e}	2.500^{g}	5.064^{a-d}
		75	81.889^{a}	46.889^{a-e}	4.333^{abc}	5.643^{a-d}
		100	86.000^{a}	51.000^{a}	4.500^{abc}	6.532^{ab}
	Green grasses	50	82.444^{a}	47.444^{a-d}	3.167^{efg}	5.588^{a-d}
		75	82.833^{a}	47.833^{abc}	4.667^{ab}	5.853^{abc}
		100	86.167^{a}	48.333^{abc}	4.833^{a}	6.831^{a}
Tagetes erecta	Un-mulch	50	65.667^{d}	37.000^{de}	3.333^{d-f}	2.399^{g}
		75	76.889^{a-d}	38.000^{cde}	3.667^{b-e}	2.713^{fg}
		100	81.333^{ab}	37.833^{cde}	4.500^{abc}	2.880^{efg}
	Hay	50	69.667^{cd}	38.278^{cde}	3.100^{efg}	2.801^{efg}
		75	79.333^{abc}	44.333^{a-e}	3.500^{d-f}	4.484^{b-f}
		100	76.222^{a-d}	41.222^{a-e}	4.167^{a-d}	4.822^{a-e}
	Green grasses	50	70.111^{bcd}	37.000^{de}	2.667^{fg}	4.122^{d-g}
		75	84.611^{a}	49.611^{ab}	3.833^{b-e}	5.299^{a-d}
		100	85.667^{a}	50.667^{a}	4.389^{abc}	5.519^{a-d}

2. Effect of cultivars, Different mulch and Water rate % on growth parameters.

The data presented in Table 5 show that the effect of cultivars was significantly different on all vegetative parameters except the number of branches per plant and plant biomass cm3 , which was not significant between the two cultivars and the high value reached (6.778 and 33.540) flowers for *Tagetes patula* respectively. About Plant high, Plant dry weight, Root dry weight, and Proline contain shown in *Tagetes patula* cultivar and give the maximum rate reached (64.926 cm, 5.242 g, 3.319 g and 5.122 μmol.g^{-1} FW) respectively. While *Tagetes erecta* gave the minimum results for growth parameter.

Table (5): Effect of different cultivars on growth parameters

Cultivar	Plant high cm	Number of branches	Plant dry weight (g)	Root dry weight (g)	Plant biomass cm^{3}	Proline (μmol.g^{-1} FW)
Tagetes patula	64.926^{a}	6.778^{a}	5.242^{a}	3.319^{a}	33.540^{a}	85.122^{a}
Tagetes erecta	48.741^{b}	6.580^{a}	3.831^{b}	2.098^{b}	33.187^{a}	76.063^{b}

The effect of mulching materials on the high plant, number of branches, plant dry weight, root dry weight, plant biomass, and proline content of marigold plants was significant (Table 6). Green grasses mulched statistically had the highest plant height, number of branches, plant dry weight, and root dry weight for the *Tagetes patula* (65.000 cm, 7.407 branches, 6.130 g, and 3.794 g), then those mulched, which had the least result. The number of branches per plant was found to be minimum (6.000) in the un-mulch treatment for *the Tagetes erecta* cultivar. Also, plant and root dry give the lowest value reached (3.167 and1.593) were planted in pot without mulch and for same cultivar. While the plant biomass and proline contain observed in significantly affected by the interaction effect of cultivar and mulch. The maximum value for proline contain was give (100.700 and 86.367 μmol.g^{-1} FW) for two cultivars *Tagetes patula* and *Tagetes erecta* respectively in un-mulch treatment and the best result for plant biomass reach (36.313 and 35.873) for two cultivars *Tagetes patula* in hay mulch and *Tagetes erecta* in green grasses mulch respectively.

Table (6): Effect of different cultivars and different mulch on growth parameters

Cultivar	Different mulch	Plant high cm	Number of branches	Plant dry weight (g)	Root dry weight (g)	Plant biomass cm^3	Proline (μmol.g^{-1} FW)
Tagetes patula	Un-mulch	63.444^{a}	6.296^{bc}	4.419^{bc}	2.671^{b}	28.447^{b}	100.700^{a}
	Hay	66.333^{a}	6.630^{bc}	5.178^{b}	3.491^{a}	36.313^{a}	72.333^{e}
	Green grasses	65.000^{a}	7.407^{a}	6.130^{a}	3.794^{a}	35.860^{a}	82.333^{c}
Tagetes erecta	Un-mulch	47.222^{b}	6.000^{c}	3.167^{d}	1.593^{c}	30.318^{b}	86.367^{b}
	Hay	48.444^{b}	6.704^{abc}	4.128^{c}	2.002^{bc}	33.369^{a}	62.067^{f}
	Green grasses	50.556^{b}	7.037^{ab}	4.200^{a}	2.699^{a}	35.873^{a}	79.756^{d}

Results showed that water rates had a highly significant effect on plant height, number of branches, plant dry weight, root dry weight, plant biomass, and proline content. Among water stress treatments, maximum plant heights of 75.556 cm and 61.444 cm were observed in both cultivars, *Tagetes patula* and *Tagetes erecta,* respectively, when grown under 100% irrigation by tap water, and *Tagetes patula,* on average, was a taller variety compared to *Tagetes erecta*, while these were minimum (55.889 and 38.889 cm), respectively, at 50% irrigation by tap water (Table 7). Between cultivars, the maximum number of branches, plant dry weight, root dry weight, and biomass was significantly recorded in *Tagetes patula,* reaching 8.185 g, 5.939 g, 4.144 g, and 40.852 cm^3, respectively. In addition, the proline content was significantly increased under water deficit stress in the two cultivars. The highest rate of proline content reached (118.400 and 107.867 μmol.g-1 FW) for *Tagetes patula* and *Tagetes erecta,* respectively, under 50% water irrigation. While the minimum rates in the same cultivars (62.500 and 53.567 μmol.g-1 FW)

Table (7): Effect of different cultivars and water rates on growth parameters

Cultivar	Water rate %	Plant high cm	Number of branches	Plant dry weight (g)	Root dry weight (g)	Plant biomass cm^3	Proline (μmol.g^{-1} FW)
Tagetes patula	50	55.889^{b}	4.259^{c}	4.642^{bc}	2.253^{b}	24.318^{c}	118.400^{a}
	75	63.333^{b}	7.889^{a}	5.146^{ab}	3.559^{a}	35.450^{b}	74.467^{c}
	100	75.556^{a}	8.185^{a}	5.939^{a}	4.144^{a}	40.852^{a}	62.500^{e}
Tagetes erecta	50	38.889^{c}	4.667^{c}	3.644^{d}	1.460^{c}	22.332^{c}	107.867^{b}
	75	45.889^{c}	6.741^{b}	3.860^{cd}	2.166^{b}	36.503^{b}	66.756^{d}
	100	61.444^{b}	8.333^{a}	3.990^{cd}	2.669^{b}	40.724^{a}	53.567^{f}

The experimental findings indicated that the interaction effect of cultivar, mulch, and water deficit on vegetative growth and proline content was statistically significant (Table 8). Moreover, the results illustrated a plant height, number of branches, and plant dry weight, with ranges spanning from (77.667 cm, 9.000, and 7.623 g), respectively, for the *Tagetes patula* cultivar grown in a pot covered with green grasses mulch and irrigated with 100% tap water, and the result was significantly affected compared to the un-mulched and 50% water. About the root dry weight, plant biomass is the best result shown in the same cultivar at (4.647 g and 45.043 cm^3), respectively, when grown plants in pots covered with hay mulch and under 100% water irrigation; these results were significantly compared with the author treatments.

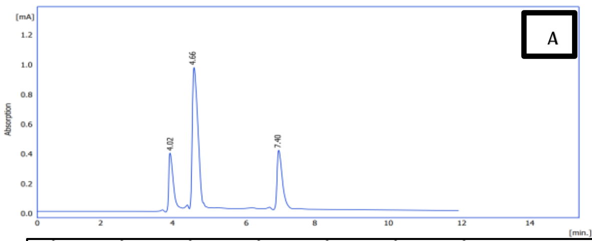
The data regarding the morphological parameter showed that the interaction effect of cultivar, mulch, and water deficit on vegetative growth and proline content was statistically significant. Moreover, the results illustrated a plant height, number of branches, and plant dry weight, root dry weight, and plant biomass range spanning from (71.667 cm, 9.111, 4.380 g, 3.383 g, and 43.860 cm^3), respectively, for the *Tagetes erecta* cultivar grown in a pot covered with green grasses mulch and irrigated with 100% tap water, and the result was significantly affected compared to the un-mulched and 50% water

Notably, water deficit stress resulted in elevated proline content, with the highest mean observed in the *Tagetes patula* and *Tagetes erecta* under such stress conditions. The best results for the two cultivars reached (133.600 and 125.000 $\mu mol.g^{-1}$ FW) when *Tagetes patula* cultivar grown in a pot was not covered with mulch and under 50% water irrigation and *Tagetes erecta* under 50% water irrigation and a pot with hay covered.

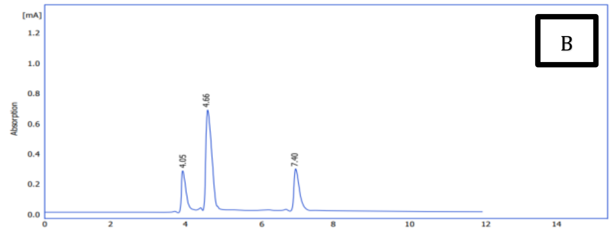
Table (8): Effect of different cultivars, different mulch and water rate % on growth parameters

Cultivar	Different mulch	Water rate %	Plant high	Number of branches	Plant dry weight	Root dry weight	Plant biomass	Proline ($\mu mol.g^{-1}$ FW)
Tagetes patula	Un-mulch	50	60.667^{d-g}	4.111^{c}	4.253^{bc}	2.113^{de}	22.467^{g}	133.600^{a}
		75	57.333^{e-h}	7.000^{bc}	4.360^{bc}	2.543^{cde}	30.273^{ef}	89.700^{f}
		100	72.333^{abc}	7.778^{ab}	4.643^{bc}	3.357^{a-d}	32.600^{cde}	78.800^{h}
	Hay	50	53.000^{f-i}	4.222^{c}	4.557^{bc}	2.267^{cde}	26.463^{fg}	102.600^{e}
		75	69.333^{a-e}	7.889^{ab}	5.427^{b}	3.560^{abc}	37.433^{bc}	63.100^{j}
		100	76.667^{ab}	7.778^{ab}	5.550^{b}	4.647^{a}	45.043^{a}	51.300^{m}
	Green grasses	50	54.000^{f-i}	4.444^{c}	5.117^{b}	2.380^{cde}	24.023^{g}	119.000^{c}
		75	63.333^{b-f}	8.778^{a}	5.650^{b}	4.573^{ab}	38.643^{b}	70.600^{i}
		100	77.667^{a}	9.000^{a}	7.623^{a}	4.430^{ab}	44.913^{a}	57.400^{k}
Tagetes erecta	Un-mulch	50	42.667^{ij}	4.444^{c}	2.900^{c}	1.420^{e}	21.353^{g}	107.100^{d}
		75	44.333^{hij}	6.333^{c}	3.350^{c}	1.290^{e}	32.167^{de}	81.400^{g}
		100	54.667^{f-i}	7.222^{bc}	3.250^{c}	2.070^{de}	37.433^{bc}	70.600^{i}
	Hay	50	41.333^{ij}	4.778^{c}	3.957^{bc}	1.527^{e}	22.387^{g}	91.500^{f}
		75	46.000^{hij}	6.667^{bc}	4.087^{bc}	1.927^{e}	36.840^{bcd}	54.400^{l}
		100	58.000^{d-h}	8.667^{ab}	4.340^{bc}	2.553^{cde}	40.880^{ab}	40.300^{n}
	Green grasses	50	32.667^{j}	4.778^{c}	4.077^{bc}	1.433^{e}	23.257^{g}	125.000b
		75	47.333^{ghi}	7.222^{bc}	4.143^{bc}	3.280^{bcd}	40.503^{ab}	64.467^{j}
		100	71.667^{a-d}	9.111^{a}	4.380^{bc}	3.383^{a-d}	43.860^{a}	49.800^{m}

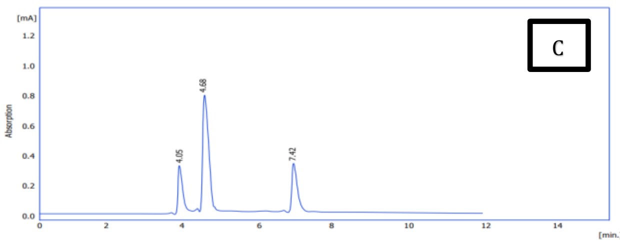
All the charts below show some HPLC results for proline that match the proline results in the tables above. The information is a summary of a study that investigates the proline content in two species of Tagetes: *Tagetes patula* and *Tagetes erecta*. Proline is an amino acid that serves important functions in plant stress responses, particularly in helping plants cope with drought or salinity stress. The chromatography tables recorded in each section (A to F) likely contain data from various experimental conditions related to the plants studied in all Tables (5, 6, 7, 8), which contain data of proline. This study aimed to understand how different environmental factors influence stress responses in these two species of Tagetes through proline accumulation. The findings can contribute to agricultural practices, especially in selecting appropriate mulch types and managing irrigation strategies for optimal plant health.



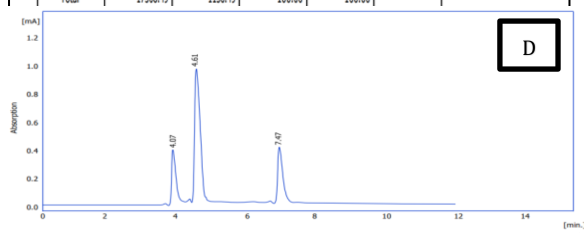
No	Reten. Time [min]	Area [mAU.s]	Height [mAU]	Area [%]	Height [%]	W05 [min]	Compound Name
1	4.02	3652.98	384.08	20.00	20.00	0.05	
2	4.66	19852.44	992.21	60.00	60.00	0.15	
3	7.40	4125.65	400.22	20.00	20.00	0.05	
	Total	27631.49	1776.25	100.00	100.00		



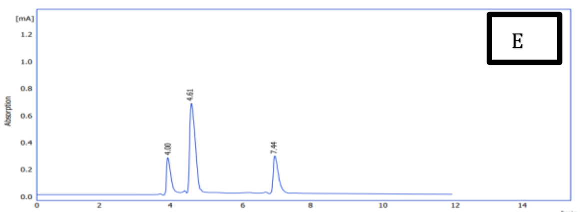
No	Reten. Time [min]	Area [mAU.s]	Height [mAU]	Area [%]	Height [%]	W05 [min]	Compound Name
1	4.05	3152.52	255.64	20.00	20.00	0.05	
2	4.66	10232.74	641.15	60.00	60.00	0.15	
3	7.40	4123.02	262.14	20.00	20.00	0.05	
	Total	17508.49	1158.49	100.00	100.00		



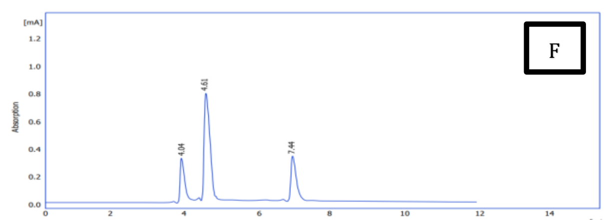
No	Reten. Time [min]	Area [mAU.s]	Height [mAU]	Area [%]	Height [%]	W05 [min]	Compound Name
1	4.05	3475.90	325.45	20.00	20.00	0.05	
2	4.68	11204.65	799.48	60.00	60.00	0.15	
3	7.42	4652.90	330.23	20.00	20.00	0.05	
	Total	19333.05	1455.06	100.00	100.00		



No	Reten. Time [min]	Area [mAU.s]	Height [mAU]	Area [%]	Height [%]	W05 [min]	Compound Name
1	4.07	3320.56	382.65	20.00	20.00	0.05	
2	4.61	17441.65	994.14	60.00	60.00	0.15	
3	7.47	4018.71	401.88	20.00	20.00	0.05	
	Total	24780.14	1779.08	100.00	100.00		



No	Reten. Time [min]	Area [mAU.s]	Height [mAU]	Area [%]	Height [%]	W05 [min]	Compound Name
1	4.00	3065.98	254.15	20.00	20.00	0.05	
2	4.61	9014.57	640.99	60.00	60.00	0.15	
3	7.44	4233.69	261.58	20.00	20.00	0.05	
	Total	16314.08	1161.40	100.00	100.00		



No	Reten. Time [min]	Area [mAU.s]	Height [mAU]	Area [%]	Height [%]	W05 [min]	Compound Name
1	4.04	3522.12	322.65	20.00	20.00	0.05	
2	4.61	10998.07	797.00	60.00	60.00	0.15	
3	7.44	4514.09	329.80	20.00	20.00	0.05	
	Total	19034.15	1451.14	100.00	100.00		

Fig 1: result of proline *Tagetes patula,* A: Result chromatography Table (Uncal - F:\ un- mulch +50% water), B: Result chromatography Table (Uncal - F:\ un-mulch +100% water), C: Result chromatography Table (Uncal - F:\ green grass mulch +50% water). **Result of proline *Tagetes erecta,*** D: Result chromatography Table (Uncal - F:\ un- mulch +50% water), E: Result chromatography Table (Uncal - F:\ un-mulch +100% water), F: Result chromatography Table (Uncal - F:\ green grass mulch +50% water**).**

DISCUSSION

The results of this experiment indicated the importance of mulching in the growth of marigold. It was observed in the course of the study that seedlings of marigold mulched had better growth and flower performance compared with the un-mulched seedlings, this findings was in line with the findings of (Bhardwaj, 2013), which shown that organic mulches are applied to reduce leaching, add to the soil physical properties, control erosion, add organic matter to the soil, regulate soil temperature and water retention, as well as improve the biological processes of the soil leading to improvement of yield and the crops. These attributes are likely to be the reasons for better growth and yield from marigold mulch compared to those without mulch. The use of 20 g mulch material was found useful because it enhanced the growth and flower production of the plants. It has been reported that the practice of covering the soil around plants results in favorable conditions for better growth, development and effective crop production (Nagalakshmi *et al.*, 2002). However, the seedlings that were not mulched had little growth but could not be compared with the seedlings that were not mulched had little growth but could not be compared with the seedlings. This result was in line with the opinion of Younis *et al*., 2012 who says; in soil management, mulch act as a protective cover placed over the soil to hold moisture, improve nutrients, moderate erosion, support seed germination and suppress weed germination.

This is probably due to the different mulches by providing favorable moister and temperature to the plants. Similar results were also reported by Nagaich *et al.* (2003), Acharya and Dashora (2004) found in Marigold. Dubey (2005) in Gladiolus, Das and Mishra (2005) in Marigold were also observed similar result in their experiments. The possible reason highest number of days taken for bud initiation by the nu-mulch and decreasing water treatment with control may be due to the promotion of less vegetative growth by no mulch and results in delaying in bud initiation. Similar results were also reported by Ahamd et al. (2010) in Marigold. The diameter of the flower was found to beminimum in treatment nu-mulch and decreasing water. Similar results were also reported by Acharya and Dashora (2004) found in marigold, Gaikwad *et al.* (2004) in China aster, Singh *et al.* (2008) in Lily were also observed similar result in their experiments. Also, the number of flowers per plant was found to be minimum nu-mulch and decreasing water treatment. Similar results were also reported by Gaikwad *et al.* (2004) found in China asterAmong the most significant environmental stresses affecting the growth and development of agricultural products are climate change and abnormal weather conditions such as drought, long- term hot temperatures, and storms (Wang *et al.*, 2018). Ornamental bedding plants are commonly impacted by drought, which has a negative impact on plant growth and flowering and, ultimately, on their aesthetic value. To avoid losing their attractive qualities, plants that can withstand water scarcity must be chosen. In order to choose the best plants for urban environments and to develop new cultivars that would be better suited to urban conditions, ornamental growers and breeding programs may benefit from experiments for drought tolerance that are based on measurements of certain factors relevant to the plant's water status. Leaf cell membrane stability, relative water content, and proline content areimportant factors for evaluating plant reactions to drought stress (Gzik 1996; Quilambo 2004; Grant 2012). Here, we describe an effort to measure the morphological responses of marigold popular bedding plants to an imposed water stress. The goal was to determine which of these bedding plants can respond better to water deficit conditions for urban settings. Our investigations on bedding plants support previous findings that different plant species respond differently to drought (Volaire 2003; Kumar *et al.*, 2018). The diameter of the flower and the number of flowers is the most significant factors that influence the drought tolerance of bedding plants. Marigold requires 75% for optimal flower development, there is a close relationship between the morphological characteristics of plants and their drought tolerance (Bhusal *et al*., 2021). A decrease in the growth rate of plant organs due to increased drought stress can also be the result of depressed biosynthesis of growth hormones and induction of inhibitors such as abscisic acid (Keyghobadi *et al*., 2020). However, the increase in the level of compatible metabolites, i.e., proline, concurrently with the increase in the level of drought stress (Table 7, 8), prompted another biochemical reaction of bedding plants, known as osmotic adjustment (Mahajan and Tuteja, 2005), to maintain the plant's stability and absorption capability under low water levels of the substrate, i.e., 25 and 50 % levels.

CONCLUSION

The growth and flower production observed in seedlings that were not mulched was minimal compared to the growth performance of the mulched seedlings. It is therefore concluded that mulching the seedlings of marigold with green grass would be effective for its production. The layer of green grass was optimal for growth and flower yield. The changes in growth parameters, and flower quality were monitored to investigate the response mechanism of marigold cultivars to drought stress. During drought exposure, marigold cultivars showed adaptive changes to water limitation. At the physiological level, marigold cultivars responded to the drought stress by reducing growth parameters and biomass, increasing the levels of proline content.

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