Effects of Different Mulching and Different Percentage of Watering on The Growth and Flowering of African Marigold (*Tagetes Erecta* L.)

Mooner Ramadan Yasin[1], Chanar Salih Mohammed[2], Layla Shaaban Mohammed[3] and Ban Jibrael Khoshaba[4]

[1]Food Production and Technologies Department, Technical College of Duhok, Duhok Polytechnic University, Kurdistan, Iraq
[2,3,4] Department of Horticulture, College of Agriculture Engineering Sciences, University of Duhok, Kurdistan region, Iraq
E-mail: mooner.yasin@dpu.edu.krd, chanarmohammed@uod.ac, layla.mohammed@uod.ac and ban.khoshaba@uod.ac

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Abstract: The present work entitled as effect of watering levels and different mulching on vegetative and flowering characters of marigold plant under lathhouse conditions. 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 factors (watering levels and mulching). All flowering and yield parameters. The early flower bud emergence (78.176 and 74.583 days) was observed in treatment un-mulch and when watering with 50% respectively and it was significantly compared to other triads, followed by (71.667 day) obtain in treatment without much with 50% watering. Flower bud anthesis (39.389and 40.500 days) was observed in treatment un-mulch and when watering with 50% respectively and it was significantly compared to other triads, followed by (36.667 day) obtain in treatment without much with 50% watering. The interaction between two factors of mulch and watering shows the highly significant value of plant height (74.667 cm) obtained when plants mulched with green grass with 100% irrigation. While the interaction between two factors of mulch and watering shows the high significant value of number of branches (9.056) obtained when plant mulched with green grass with 100% irrigation Whilst the mix between the mulch and watering levels show that the best significant result of proline content (122.000 µmol.g-1 FW) was found when plant mulch by green grass with 50% watering compared to all treatment.

Keyword: African Marigold plant, Water levels, and Mulches.

1. Introduction

An annual herbaceous attractive plant, the African marigold (*Tagetes erecta* L.) is indigenous to Central and South America, particularly Mexico; it is a member of the Asteraceae family (**Singh *et al*., 2015**). It is one of the most widely grown ornamental plants that produces loose flowers and is frequently utilized in many forms for both religious and social uses (**Idan *et al*., 2014**). The French marigold (*Tagetes patula* L.) and the African marigold (*Tagetes erecta* L.) are the two major varieties of marigold that are grown. African marigolds may be used as potted plants, bedding, edging, and to make garlands (**Harithanaidu *et al*., 2014**), whereas French marigolds are perfect for

rockeries, edging, hanging baskets, and window boxes (**Subhash, 2007**).

Marigolds are used as bedding plants, cut flowers, or as a coloring ingredient in chicken feed to produce yellow yolks for eggs; they have fragrant, pinnately split leaves **(Dole and Wilkins, 2005)**. *Tagetes erecta* is utilized for its nematicide, cosmetic, and medicinal uses in addition to its beautiful purpose. Antioxidants present in the flower's essential oil can also be used by the pharmaceutical, cosmetic, soap, and fragrance industries (**Pérez Gutierrez *et al*., 2006**). **Swathi (2007)** Flowers beautifully reflect the most tender, loving, and sensitive emotions that words cannot communicate. It gives life purpose and enhances one's belief in the natural world. Its amazing show of colors graces the earth's surface, and its beautiful aroma fills all the atmosphere (**Narayanaswamy, 2006**).

Mulching improves the soil's chemical and physical qualities, controls weeds, and raises soil temperature and moisture content, all of which increases crop productivity. In the age of decreasing resources, farmers must be able to use precision farming technologies that have a lower water footprint per unit of crop produce. Consequently, the objective of the current study was to investigate how marigold produce is affected by irrigation and mulching. In research that investigated the impact of mulching materials on African marigold development and blooming (**Ibrahim *et al*., 2023**), seedlings mulched with 20 g of *Cynodon dactylon* grass produced more flower buds (8 and 9), as well as flowers (12 and 16).

Photosynthesis is one of the many physiological processes that depend on water (**Ojo *et al*., 2021)**. Availability of water has a significant impact on the development and quality of ornamental plants (**Crillo *et al*., 2017; Zulfigar *et al*., 2020)**. Stress is frequently observed at the total plant level as a reduction in photosynthesis and plant development, and it is linked to changes in the metabolism of carbon and nitrogen (**Cornic and Massacci, 1996**). The world's freshwater supplies have been significantly deteriorated by factors such as population increase, growing water demands, excessive utilization of the environment, climate change, and degradation of the environment. The purpose of this study was to determine the optimum water rate that would promote marigold development and flowering as well as to evaluate the way marigold plants responded to water stress. **Raja Babu *et al*. (2018)** observed in a study that among irrigation treatments, the highest values were recorded for parameters like plant height (47.98 cm), primary branches (7.73), days to flower bud initiation (34.05 days), and flower diameter (5.57 cm).

2. 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. So, the experiment includes (3×3×3×4= 108) 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 marigold plants, three different mulch (un-mulch, hay and green grasses) and water rate (50, 75 and 100) % per weeks. **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.

3. 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 $P \leq 0.05$ using program (**SAS**).

4. Results

Effect of watering levels and different mulch on day number from planting to flowers bud emergence and anthesis of marigold plants.

The results of the present investigation showed that the watering levels and different mulch markedly influenced the flowering characters of marigold. Among the various treatment combinations, mulch with different levels of irrigate was considered as the best treatment in terms of all flowering and yield parameters. The early flower bud emergence (78.176 and 74.583 days) was observed in treatment un-mulch and when watering with 50% respectively and it was significantly compared to other triads, followed by (71.667 day) was obtain in treatment without much with 50% watering also it was significantly compared with all triads (Table 1).While the maximum day for the flower bud emergence (81.972 and 83.287 days) was observed in triad when use green grass mulch with 100% irrigate alone . About interaction between mulch and watering, the maximum reached (85.917 days) was found in plants where green grass mulch with 100% irrigation and which gave highest significant value compared with all treatment was irrigated with 50% and with or without mulch.

Table (1): Effect of different levels of water and different mulch on Day number from planting to flowers Bud emergence and Day number from flowers Bud emergence to anthesis of marigold plants.

Day number from planting to flowers Bud emergence				
Water % / mulch	50	75	100	Mean effect of mulch
Un-mulch	71.667^{c}	80.028^{ab}	82.833^{ab}	78.176^{a}
hay	75.806^{bc}	80.611^{ab}	81.111^{ab}	79.176^{a}
green grass	76.278^{bc}	83.722^{ab}	85.917^{a}	81.972^{a}
Mean effect of water%	74.583^{b}	81.454^{a}	83.287^{a}	
Day number from flowers Bud emergence to anthesis				
Water % / mulch	50	75	100	Mean effect of mulch
Un-mulch	36.667^{b}	43.083^{ab}	38.417^{b}	39.389^{b}
hay	42.611^{ab}	45.611^{a}	46.111^{a}	44.778^{a}
green grass	42.222^{ab}	48.722^{a}	49.500^{a}	46.815^{a}
Mean effect of water%	40.500^{b}	45.806^{a}	44.676^{a}	

Regarding the early flower bud anthesis (39.389and 40.500 days) was observed in treatment un-mulch and when watering with 50% respectively and it was significantly compared to other triads, followed by (36.667 day) was obtain in treatment without much with 50% watering also it was significantly compared with all triads (Table 1).While the maximum day for the flower bud anthesis (46.815 and 45.806 days) was observed in triad when use green grass mulch with 75% irrigate. About interaction between mulch and watering, the maximum reached (49.500 days) was found in plants when use green grass mulch with 100% irrigation and which gave highest significant value compared with all treatment when was irrigated with 100% and with or without mulch.

Effect of watering levels and different mulch on the number of flowers and flower diameter of marigold plants.

Effect of mulching materials and watering levels on the number of flowers per plant and flower diameter of African marigold was significant (Table 2). plants mulched with green grass statistically had the highest number of flowers (3.926) than those mulched with hay which had the least (79.176) compared to un-mulch which give (3.593 flower) but it is not significant. About the level of watering, the highest number of flowers (4.352 flowers) was observed when the plant irrigated with 100% and it was significant compared to the 50% watering reached (2.906). However, the interaction between mulch and watering, the maximum number of flowers (4.611 flowers) was given when using green grass with 100% watering.

Table (2): Effect of different levels of water and different mulch on Number of flowers per plant and Flower diameter of marigold plants.

Number of flowers per plant				
Water % / mulch	50	75	100	Mean effect of mulch
Un-mulch	3.000^{c}	3.667^{b}	4.111^{ab}	3.593^{a}
hay	2.800^{c}	3.917^{b}	4.333^{ab}	3.683^{a}
green grass	2.917^{c}	4.250^{ab}	4.611^{a}	3.926^{a}
Mean effect of water%	2.906^{c}	3.944^{b}	4.352^{a}	
Flower diameter				
Water % / mulch	50	75	100	Mean effect of mulch
Un-mulch	3.070^{d}	3.459^{d}	3.605^{cd}	3.378^{b}
hay	3.932^{bcd}	5.064^{ab}	5.677^{a}	4.891^{a}
green grass	4.855^{abc}	5.576^{a}	6.175^{a}	5.535^{a}
Mean effect of water%	3.952^{b}	4.699^{a}	5.152^{a}	

Also, the flower diameter was significantly influenced by different mulch and irrigation levels. Flower diameter recorded highest values (5.535 and 5.152 cm) were observed in plants when using green grass and irrigated with 100% respectively, and it was significant compared to the un-mulch with 50% watering reached (3.378 and 3.952 cm) alone respectively. Wherever, the interaction between mulch and watering, the

maximum number of flowers (6.175 cm) was given when using green grass with 100% watering.

Effect of watering levels and different mulch on plant high and number of branches of marigold plants.

All the growth parameters, viz, plant height, number of branches were significantly differed from plant growth in the marigold. (Table 3) The maximum plant height (57.778 cm and 68.500 cm respectively) was observed in the plants which were treated with green grass mulch and watering with 100% alone compared with un-mulch and irrigate with 50% (55.333cm and 47.389 cm respectively). However, the interaction between two factors of mulch and watering shows the high significant value of plant height (74.667 cm) obtained when plant mulched with green grass with 100% irrigation compared with the minimum plant height (43.333 cm) was found in plant with green grass mulch with 50% watering.

Likewise, the number of branches (7.222) were also giving the maximum value in green grass mulch followed by treated hay mulch (6.667) compared with lower number of branches (6.148) in plants without mulch. Whereas the number of branches (7.222) were also giving maximum value (8.259) when the plant watering by 100% compared with the lowest number of branches (4.463) when adding 50% water in plants. While the interaction between two factors of mulch and watering shows the high significant value of number of branches (9.056) obtained when plant mulched with green grass with 100% irrigation compared with the minimum number of branches (4.278) was found in plant with green grass mulch with 50% watering.

Table (3): Effect of different levels of water and different mulch on Plant high and Number of branches of marigold plants.

Plant high (cm)				
Water % / mulch	50	75	100	Mean effect of mulch
Un-mulch	51.667^{def}	50.833^{def}	63.500^{bc}	55.333^{a}
hay	47.167^{ef}	57.667^{cd}	67.333^{ab}	57.389^{a}
green grass	43.333^{f}	55.333^{cde}	74.667^{a}	57.778^{a}
Mean effect of water%	47.389^{c}	54.611^{b}	68.500^{a}	
Number of branches				
Water % / mulch	50	75	100	Mean effect of mulch
Un-mulch	4.278^{e}	6.667^{d}	7.500^{bcd}	6.148^{c}
hay	4.500^{e}	7.278^{cd}	8.222^{ab}	6.667^{b}
green grass	4.611^{e}	8.000^{bc}	9.056^{a}	7.222^{a}
Mean effect of water%	4.463^{c}	7.315^{b}	8.259^{a}	

Effect of watering levels and different mulch on plant dry weight and root dry weight of marigold plants.

In the present investigation, significant difference was observed among all watering levels and mulches providing the scope of improvement on plant dry weight and root dry weight of African marigold (Table 4). The perusal of data clearly reveals that covering of mulches have influenced plant dry weight significantly. The maximum plant dry weight (5.165 g) was observed in the green grass mulch treatment followed by hay mulch

treatment (4.653 g) this treatment was significant compared to the un-mulch. While the levels of watering the maximum plant dry weight (4.964 g) was significant when plant irrigation with 100% compared to the 50% watering gives the minimum of plant dry weight 4.143 g. It is evident from the result that the plant dry weight was clearly affected with mulching combined with watering levels.

The high significant value for plant dry weight (6.002 g) was observed in plants when mulched with green grass combined with 100% irrigation compared with the minimum value for the plant dry weight (3.577 g) in treatment only watering with 50% without mulch. While root dry weight gives the best significant result (3.247g) was found in green grass mulch compared to hay mulch and without mulch treatment (2.747 and 2.132 g) respectively. About the watering levels, the significant increase of root dry weight (3.407 g) was observed in 100% watering than the 75 and 50 % watering reached (2.862 and 1.857 g) respectively. While the interaction between two factors of mulch and watering shows the high significant value of root dry weight (3.907 g) obtained when plant mulched with green grass with 100% irrigation compared with the minimum root dry weight (1.767 g) was found in plant without mulch with 50% watering

Table (4): Effect of different levels of water and different mulch on Plant dry weight (g) and Root dry weight (g) of `marigold plants.

Plant dry weight (g)				
Water % / mulch	50	75	100	Mean effect of mulch
Un-mulch	3.577^{c}	3.855^{bc}	3.947^{bc}	3.793^{b}
hay	4.257^{bc}	4.757^{b}	4.945^{b}	4.653^{a}
green grass	4.597^{bc}	4.897^{b}	6.002^{a}	5.165^{a}
Mean effect of water%	4.143^{b}	4.503^{ab}	4.964^{a}	
Root dry weight (g)				
Water % / mulch	50	75	100	Mean effect of mulch
Un-mulch	1.767^{c}	1.917^{bc}	2.713^{b}	2.132^{c}
hay	1.897^{bc}	2.743^{b}	3.600^{a}	2.747^{b}
green grass	1.907^{bc}	3.927^{a}	3.907^{a}	3.247^{a}
Mean effect of water%	1.857^{c}	2.862^{b}	3.407^{a}	

Effect of watering levels and different mulch on Plant biomass and Proline content of marigold plants.

Mulching and watering level had statistically significant variance for the plant biomass and Proline content parameters (Table 6). The significant result indicates that the maximum plant biomass was noted (35.867 g) when plant mulched by green grass compared to the treatment without mulch (29.382 g). However, increasing watering levels increase plant biomass. The maximum plant biomass (40.788 g) was noted under 100% watering compared to the 75 and 50% watering reaching (35.977 and 23.325 g respectively). Moreover, the combination between two factors mulching and watering levels enhance the plant biomass. The best significant value of plant biomass reach (44.387 g) was observed when plant mulching by green grass with 100% watering compared with treatment containing un-mulch combine with 50% watering reached (21.910 g).

Additionally, proline concentration increased when the watering level decreases and plant un-mulched. The higher significate values of proline content (93.533 µmol.g^{-1} FW) was found in plants without mulch compared to hay mulch which gives (67.200 µmol.g^{-1} FW). While the watering levels, the maximum result show under 50% irrigation (113.133 µmol.g^{-1} FW) in contrast to 75 and 100% irrigation (70.611and 58.033 µmol.g^{-1} FW). Whilst the mix between the mulch and watering levels show that the best significant result of proline content (122.000 µmol.g^{-1} FW) was found when plant mulch by green grass with 50% watering compared to all treatment. but the minimum result for proline content (45.800 µmol.g^{-1} FW) was shown in plant mulch by hay and watering by 100%.

Table (5): Effect of different levels of water and different mulch on Plant biomass cm^3 and Proline content (µmol.g^{-1} FW) of marigold plants.

Plant biomass cm^3				
Water % / mulch	50	75	100	Mean effect of mulch
Un-mulch	21.910^{e}	31.220^{d}	35.017^{c}	29.382^{b}
hay	24.425^{e}	37.137^{bc}	42.962^{a}	34.841^{a}
green grass	23.640^{e}	39.573^{b}	44.387^{a}	35.867^{a}
Mean effect of water%	23.325^{c}	35.977^{b}	40.788^{a}	
Proline content (µmol.g^{-1} FW)				
Water % / mulch	50	75	100	Mean effect of mulch
Un-mulch	120.350^{b}	85.550^{d}	74.700^{e}	93.533^{a}
hay	97.050^{c}	58.750^{g}	45.800^{i}	67.200^{c}
green grass	122.000^{a}	67.533^{f}	53.600^{h}	81.044^{b}
Mean effect of water%	113.133^{a}	70.611^{b}	58.033^{c}	

5. Discussion

The results of this study showed the significance of mulching for African marigold development during the study, it was found that African marigold seedlings that were mulched outperformed the non-mulched seedlings in terms of growth and flower performance. This agreed with **Raju and Kendra's (2013)** findings, which demonstrated that organic mulches are used to decrease evaporation, adjust the physical characteristics of the soil surface, control erosion, add organic matter to the soil, regulate soil temperature and retain moisture, and enhance the biological processes of the soil, and all of which increase crop yield. These attributes are probably causing African marigolds with mulch to grow and yield more than those without, so applying 20 g of mulch material was advantageous because it improved the plants' growth and flower production. It has also been noted that covering the soil around plants creates favorable conditions for improved growth, development, and efficient production of crops (**Nagalakshmi *et al*., 2002).** Although the un-mulched seedlings did not grow as much as the mulched seedlings, this result agreed with the findings of **Younis *et al*. (2012),** who indicate that mulch provides a protective cover over the soil to enhance nutrients, maintain moisture, reduce erosion, and prevent weed growth.

100% irrigation performs better across all vegetative measurements because the plant significantly improved when irrigation levels gradually increased. When plants have enough water, they grow and develop, cell division continues to divide and enlarge, and their tissue and primordial cells gradually start to develop.

Similar results were found in **Khanam and Patra (2015**) in Gladiolus, **Khalid *et al*., (2015)** in Zinnia**, Ayyanna *et al*., (2014).** The highest amount of irrigation was recorded among all floral parameter applications because it increased the production of dry matter at each phase and increased the availability of photosynthates for the formation of the reproductive structure of flowers initially, and their growth leads to better flowers initiation and development.

In terms of ornamental growth and production, drought is regarded as one of the main limiting factors. It has a negative impact on the plants' morphological and physiological processes, as well as on the quality of the flowers, biomass accumulation, root growth, and seed germination. Previous research has shown that drought stress inhibits plant development (**Eakes *et al*., 1991; Niu and Rodriguez, 2009**). When a plant responds to lack of water, proline concentrations have been demonstrated to increase (**Nio *et al*., 2011; Wang *et al*., 2017**). However, in the case of a short, severe water deficit, proline levels only partially account for the variation in osmotic potential (**Nio *et al*., 2011**).

Prolines are considered to act as compatible solutes, protecting and stabilizing proteins and membranes, obtaining radical oxygen species in cells under water stress, and changing the osmotic potential of the cytoplasm (~10% of the cell volume) to balance the changes in the osmotic potential of the vacuole (~90% of the cell volume) (**Bohnert and Shen, 1999)**. Additionally, **Kirnak *et al*. (2001)** found that the shoot height of plants under water stress was lower than that of plants that received enough irrigation. Metabolic changes may be the cause of the negative impact on marigold growth and development when exposed to 0.5 L/week.

Lack of water is one of the main obstacles to plant growth and development, which lowers the production of agriculture. Among several adaptation techniques, plants close their stomata to limit transpiration and prevent water loss (**Park, 2019**). Marigold exposed to 0.75 and 1 L/week had greater shoot height, branches, flowers, and flower results than marigold exposed to 0.5 L/week. These findings support research by **Riaz *et al*. (2016)** that showed dryness significantly impacted *Conocarpus erectus* vegetative development.

6. 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 African marigold with green grass would be effective for its production. The flowering characteristics and, the growth parameter give the best results were show when the plant mulched by the hay and green grass with irrigation by 100 and 75 % compared with all flowering and growth parameter which observed the minimum result in 50% watering with un-mulch.

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