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Research Article
Zinc Nutrition and its Activated Roles on Growth, Inflorescences Attributes and Some Physiological Parameters of *Tagetes erecta* L. Plants

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Abstract

Background and Objective: There are scarcity scientific reports on the response of medicinal plants to zinc nutrition, despite its remarkable role in growth, cell division, photosynthesis and tryptophan formation, which is involved auxin (IAA) synthesis. Therefore, further studies are required to understand the effects of zinc on one of these important plants, marigold plant. **Materials and Methods:** For this, a greenhouse experiment was conducted to evaluate the promoting impacts of zinc-nutrition (0, 50, 75, 100 mg L^{-1}) on marigold growth, plant height, branch number, herb and root fresh mass (FM), herb and root dry mass (DM), flowering attributes, inflorescence number/plant (IN), inflorescence diameter (ID), inflorescence (IW) weight (fresh and dry), days to first bud emergence, leaf relative water content (RWC) as well as some physiological responses, pigments, total carbohydrate, N, P, K, Zn contents of marigold plants. **Results:** The results indicated that zinc-fertilizer at 100 mg L^{-1} was the superior treatment in improving the previous parameters relative to the other levels and control. Supplying Zn significantly enhanced growth parameters, flower attributes, RWC as well as nutrient contents of marigold leaves. Chlorophyll, carotenoids content and carbohydrates (%) were enhanced due to suppling Zn. Zn treatments raised the contents of N, P, K and Zn in leaves relative to unfertilized ones. A comparison of the usage treatments showed that the higher dose of Zn was better than the lower one or control but insignificant differences were observed between this treatment and the intermediate one (75 mg L^{-1}) for some studies parameters. **Conclusion:** The obtained results suggest that exogenous application of Zn could be essentially for the nutrition program of marigold plants to provide plants by the optimum dose of Zn-fertilizer for improving the growth and, quantity and quality of inflorescence parameters.

Key words: Zinc-fertilizer, inflorescence production, carbohydrates, RWC, carotenoids, marigold

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Tagetes erecta L. plant belongs to the Asteraceae family, which are important plants for landscape as bedding plant, cut flowers and as a coloring agent in poultry feed for obtaining yellow egg yolks, especially in the absence of well-pigmented yellow maize in the feed[1,2]. Marigold flowers have helenien dye, it has a demand from several universal companies. In the same context, marigold flowers are a rich source for lutein extract, this dyes a common yellow/orange food color[3]. Moreover, marigold used for several medicinal usages because it has thiophenes, natural phytochemicals that include sulfur-containing rings, it consider as an active ingredients that used for kill gram negative and gram positive bacteria *in vitro*. Marigold plant help protect certain plants from nematode when planted in field associated with this crops[4]. The marigold oil may be added to perfumes to infuse an apple scent into them.

Micronutrients function a protagonist role in enhancing growth and productivity of many crops[5], Brady and Weil[6] revealed that micronutrients can cause a disturb in physiological and metabolic processes if reduced even in small amounts during plant growth. Furthermore, micronutrients play a vital role for plant enzyme systems[7]. From micronutrient, Zn consider one of the most prominent ones, it is a element that acts as a metal ingredient of several enzymes or regulatory cofactors, for auxin synthesis, cell division, photosynthesis and consequently maintenance of membrane structure and function[8]. Moreover, Khalil and El-Sherbeny[9] reported that micronutrients improved the growth and yield of *Mentha* species. Thereupon, Rao and Rajput[10] elucidated that herb weight and volatile oil (%) of palmarosa (*Cymbopogon martinii*) improved due to Zn application. Overtime, Zn is essential for enhancing the growth and plant production of *Lycopersicon esculentum* L.[11]. Exogenous application of Zn improved flower characteristics, i.e., flower number, flower yield and its weight of *Rosa damascena* Mill and it considerably influenced the quantitative and qualitative constituents of the oil[12]. Further, Drissi *et al.*[13] revealed that Zn supply significantly increased plant height and improved the dry matter accumulation of maize and rice[14,15]. In the same direction, Mousa *et al.*[16] on *Nigella sativa* L. and Said-Al Ahl and Omer[17] on *Coriandrum sativum* L. reported that Zn treatments remarkably increased growth and yield. In radish plants, Zn nutrient improved growth parameters and chemical composition increment relative to control[18]. Otherwise, that zinc treatments enhanced the impact of N-fertilizers. On *Tagetes erecta*, L. Khalil and El-Sherbeny[9] elucidated that Zn-fertilizer raised growth, herb weight and flower productivity. Moreover, Yang *et al.*[19] expounded that Zn resulted in increased flower yield of *Brassica napus* L. Zn as foliar spray improved considerably flower yield and oil content of *Matricaria chamomilla* L. grown in calcareous soils[20]. *Tagetes erecta* L. plant supplemented by Zn and /or iron increased growth parameters and augmented herb produce and flower yield. Likewise, these treatments raised N, P, K, Zn, Mn and Fe contents as well as carotenoids and carbohydrate contents[9].

Although marigold is one of the important medicinal plants, which is characterized by its inflorescences contain natural pigments of color and widely used in food but there are insufficient studies regarding the effects of micronutrients, especially zinc on the growth and productivity of inflorescences and natural dyes. So this experiment examined the impacts of Zn as foliar nutrition on growth characters, flower component and some chemical and physiological characters of marigold. Thus, at the end of this experiment we expect to introduce a new technique concerning the nutrition of marigold plants and how can we improve the plant growth and production through the nutrient elements especially the micro ones.

MATERIALS AND METHODS

A pot experiment was undertaken at 2018/19 season in the greenhouse of Faculty of Science, Taif University, Saudi Arabia, to investigate the impact of Zn foliar application on marigold (*Tagetes erecta* L.). On October 1st, healthy and homogenous seed of marigold were sown into the agricultural trays containing peat moss and perlite in a proportion of 3:1 (v/v) substrate and after the completion of the germination and when the height of the seedlings is reached 8-10 cm, the seedlings were transferred to 20×30 cm pots filled with local soil surface:peat:perlite in a proportion of 3:1:1 (v/v/v) substrate. The experiment was designed as completely randomized design (CRD) and each treatment had 4 replicates. Foliar application of $ZnSO_4$ at 0, 50, 75 and 100 mg L^{-1} was applied with a manual pump 4 times, the first after 15 days from transplanting and then at 2-weekly intervals. A constant dose (5 g/pot) of NPK, 15:15:15 was added to all plants. Normal agricultural practices were done as usual.

Growth and inflorescence attributes: By the end of the flowering season, plant height (cm), the length of main stem from soil surface to the plant apex was recorded to obtain plant height (cm), main and secondary branch numbers/plant and mass (g) of herb and root (FM and DM) were recorded.

Sample of fresh weight of herb and roots were oven-dried at70°C for 48 h till constant weight to determine the DM. DFBA, days to first bud appearance were registered and Inflorescences from each plant were periodically harvested, counted, its diameter was measured, thereafter fresh (FM) and dry (DM) mass (g) of inflorescence were recorded and total IN were determined.

Chlorophyll and carotenoids content: Random samples of fresh leaves were isolated from the mid-part of plants of each treatment in early morning for chlorophyll a, b and carotenoids determination. Extraction in acetone (80%) was repeated until all pigments were extracted. Chlorophyll content was measured in marigold samples as mentioned by Sadasivam and Manickam[21]. The plant pigments were measured by a spectrophotometer at wave length of 663, 644 and 452.5 nm. Taking into consideration the dilution factor, it was possible to determine the concentration of pigment fractions (chlorophyll a, b and carotenoids) using the following Eq.:

$$\text{Chl a} = 10.3_{E663} - 0.918_{E644} = \mu g\ mL^{-1}$$

$$\text{Chl b} = 19.7_{E644} - 3.87_{E663} = \mu g\ mL^{-1}$$

$$\text{Carotenoids} = 4.2_{E452.5} - (0.0264\ \text{Chl a} + 0.426\ \text{Chl b}) = \mu g\ mL^{-1}$$

Finally, the pigment fractions were calculated as mg g^{-1} FW using a spectrophotometer (Pharmacia, LKB-Novaspec II).

Relative water content (RWC): Water content in the plant tissue could be expressed by more than one way, including the content of water/unit fresh or dry weight and per unit weight of water at full hydration. While, the FW seems to be the less accurate of them to measure water content in tissues because of its highly affected by changes in tissue dry weight[22]. The RWC stated by Slatyer[23] is a useful indicator of the state of water balance of a plant essentially because it expresses the absolute amount of water, which the plant requires to reach artificial full saturation. The RWC express the WC (%) at a given time as related to the WC at full turgor. Saturation of the tissue portions at 4°C inhibits satisfactorily the growth, then using the following equation:

$$RWC = \frac{FW\text{-}DW}{SW\text{-}DW} \times 100$$

whereas, SW (saturated with distilled water for 24 h at 4°C), DW (oven-dry at 70°C for 48 h).

Total carbohydrates: The leaves were dried in an electric oven at 70°C for 24 h according to AOAC[24]. Then, the fine powder was used to determine total carbohydrates (%) using the anthrone sulphuric acid method[25].

Nutrient elements: Samples of fresh leaves were randomly isolated from the mid-part of plants of each treatment and cleaned with distilled water, the samples were dried in an electric oven at 70°C for 24 h until a constant weight then the dried leaves were ground into homogenous fine powder subsequently, digested using sulphuric and perchloric acids method for mineral nutrients determination[26]. The wet digestion procedure was conducted by addition of 5 mL concentrated sulphuric acid to 0.2 g dried sample. The mixture was heated for 10 min and then 0.5 mL perchloric acid was added and continually heated until a clear solution was obtained. The digested solution was qualitatively transferred to a 100 mL volumetric flask using deionized water for the following determinations: nutrient elements determination, total nitrogen in leaves were measured in the digestion using the micro-Kjeldahl digestion method as described by Nelson and Sommers[27]. Phosphorus percentage, was calorimetrically determined using the stannous chloride phosphomolybdic-sulfuric acid system and measured at 660 nm wavelength according to Jackson[28]. Potassium percentage, was determined using a flame photometer as described by Jackson[28]. Zn content in leaves was determined using the method of Kumar *et al.*[12]. Briefly, 1 g leaf sample was digested in a 250 mL glass tube with 15 mL of nitric acid (HNO_3) at 140°C for 2 h. The contents were cooled to room temperature and directly dried. The sample was then treated with 3 mL of $HClO_4$ for further oxidation for 30 min at 240°C. The sample was diluted using 10 mL of distilled water, filtered and made up to 100 mL using distilled water. The analysis of Zn was performed using atomic absorption.

Statistical analysis: The obtained data were subjected to statistical analysis and ANOVA was performed and data were analyzed using SPSS 13.3 program with the means compared by Duncan multiple range test at the p = 0.05 level. Where indicated, the results were expressed as mean values (±SD) of the 2 experiments.

RESULTS

Impacts of Zn-fertilizer doses on growth and flowering characteristics: Relative to no Zn-fertilizer treatment, Zn treatments significantly ($p \leq 0.05$) promoted growth parameters (Table 1 and 2). Zn doses at 50 or 75 mg L^{-1}

Table 1: Zn nutrition and its role on plant height, branch number/plant of marigold plants

Treatments	Plant height (cm)	Main branch number/plant	Secondary branch number/plant
Control	62.56±1.59^{c}	9.33±0.38^{d}	27.02±1.58^{c}
50 mg L^{-1} Zn	70.69±2.06^{b}	10.54±0.43^{c}	27.89±1.33^{c}
75 mg L^{-1} Zn	77.55±2.28^{a}	11.97±0.18^{b}	29.65±1.34^{b}
100 mg L^{-1} Zn	78.95±2.32^{a}	12.71±0.43^{a}	32.12±1.78^{a}

Values are Means±SD (n = 8), means within a column with different letters are significantly different from each other according to Duncan multiple range test at $p \leq 0.05$

Table 2: Zn nutrition and its role on herb and root weights (fresh and dry) of marigold plants

Treatments	Herb FW (g)	Herb DW (g)	Root FW (g)	Root DW (g)
Control	163.12±1.19^{d}	41.98±1.41^{d}	10.14±0.03^{c}	3.33±0.10^{c}
50 mg L^{-1} Zn	165.93±1.70^{c}	46.51±1.37^{c}	10.76±0.38^{b}	3.64±0.08^{b}
75 mg L^{-1} Zn	167.44±1.20^{b}	48.35±1.03^{b}	16.60±0.27^{a}	3.95±0.05^{a}
100 mg L^{-1} Zn	169.16±1.22^{a}	49.87±1.44^{a}	17.02±0.65^{a}	5.04±0.06^{a}

Values are Means±SD (n = 8), means within a column with different letters are significantly different from each other according to Duncan multiple range test at $p \leq 0.05$

significantly improved plant height, branch number/plant (main and secondary), herb and root weight (FM and DM) relative to control with significant differences between them. Obviously, the superior treatment that enhanced the growth characters was 100 mg L^{-1}, the greatest improvements and the maximum values of growth parameters were obtained by applying this dose.

Impacts of Zn-fertilizer doses on inflorescence parameters: With an increase in Zn-fertilizer doses, results of this study that illustrated in Fig. 1, 2 and 3 clearly characterized that Zn nutrition significantly ($p \leq 0.05$) enhanced the inflorescence attributes compared to the plants grown at the Zn-free treatment. IN, first inflorescence opening, ID and IW (fresh and dry) considerably and gradually raised with increasing Zn levels and reached its highest values with 100 mg L^{-1} treatment, with significant differences between this treatment and 75 mg L^{-1} except ID that showed an opposite manner. Further, the time needed as the first inflorescence emergence was reduced due to various Zn treatments relative to unfertilized plants (Fig. 1a). The early flowering emergence (45.00 day obtained with 100 mg L^{-1} treatment and 50.75 day with control) was significant with 75 mg L^{-1} treatment relative to control but the higher dose (100 mg L^{-1}) insignificance relative to 75 mg L^{-1} treatment in this concern.

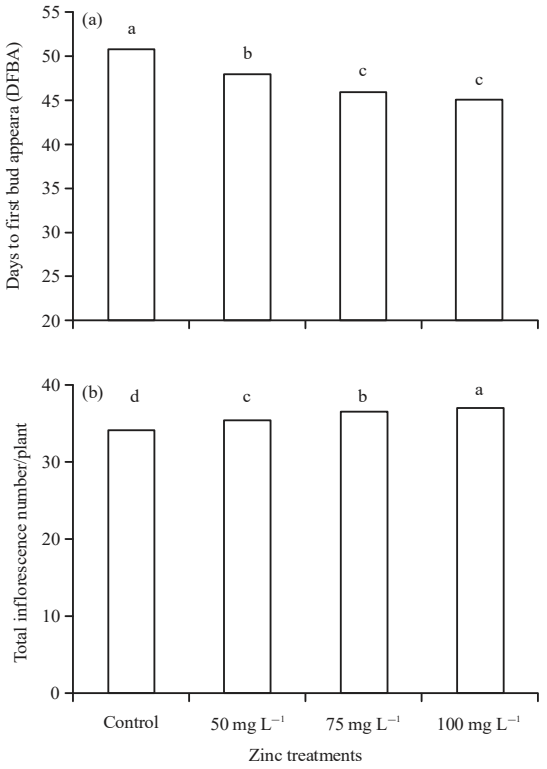

Fig. 1(a-b): Zn nutrition and its role on, (a) Days to first bud appearance and (b) Total inflorescence/plant of marigold plant

Bars had different letters are significantly differ from each other according to Duncan multiple range test at $p \leq 0.05$ (n = 8)

Chlorophyll and carotenoids content: The total chlorophyll content of marigold leaves was gradually increased with increasing Zn doses from 50-100 mg L^{-1}, however, applying the highest level increased the chlorophyll content compared the lowest one (Fig. 4a). Mostly, the appropriate rates of Zn-nutrition that increasing chlorophyll content in leaves was 75 mg L^{-1} compared with all other concentrations. In a related, carotenoids content appeared a similar manner where foliar application of Zn increased carotenoids compared to untreated plants and the high concentration of Zn showed a clear superiority compared to other rates. The treatment of 100 mg L^{-1} significantly enhanced carotenoids content compared to the control or other doses used (Fig. 4b).

Relative water content: With each Zn treatment, RWC in marigold leaves was increased significantly as comparison with unfertilized plants (Fig. 5a). Within Zn doses, the

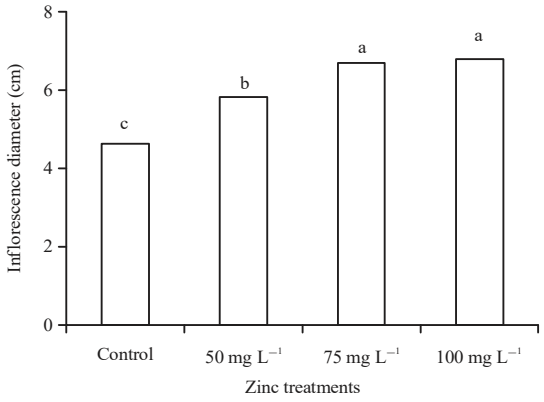

Fig. 2: Zn nutrition and its role on inflorescence diameter (cm) of marigold plant

Bars had different letters are significantly differ from each other according to Duncan multiple range test at $p \leq 0.05$ (n = 8)

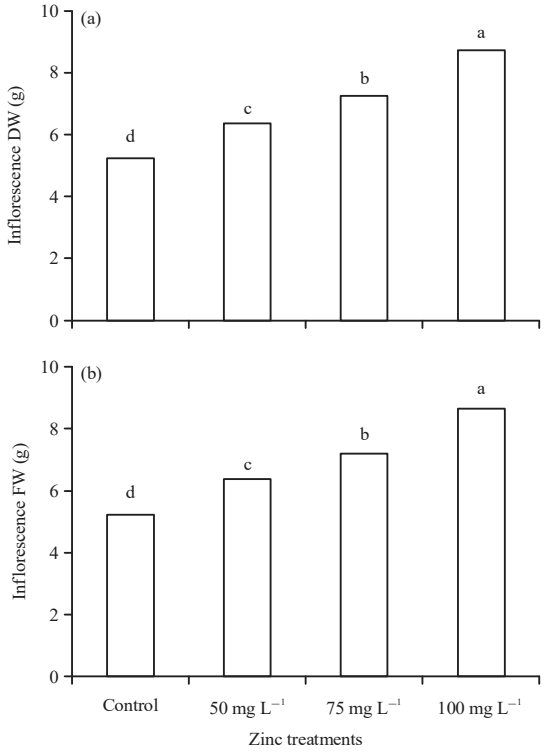

Fig. 3(a-b): Zn nutrition and its role on (a) Inflorescence DW and (b) Inflorescence FW of marigold plant

Bars had different letters are significantly differ from each other according to Duncan multiple range test at $p \leq 0.05$ (n = 8)

treatments of 75 and 100 mg L^{-1} were the superior in increasing RWC in marigold leaves with significant difference with the other treatments but without significance between them.

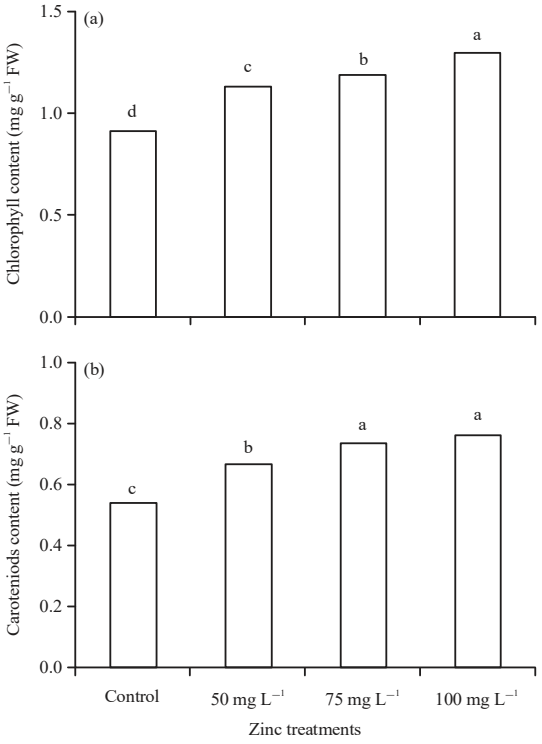

Fig. 4(a-b): Zn nutrition and its role on (a) Chlorophyll content (mg g^{-1} FW) and (b) Carotenoids content (mg g^{-1} FW) of marigold plant

Bars had different letters are significantly differ from each other according to Duncan multiple range test at $p \leq 0.05$ (n = 8)

Total carbohydrates (%): The effect of various doses of Zn on leaf content of carbohydrate (%) is illustrated in (Fig. 5b). Significant increases in carbohydrates were observed with plants fertilized by Zn relative to unfertilized plants where Zn at 100 mg L^{-1} significantly increased carbohydrate content compared the other treatments whereas this treatment resulted in the highest values. Otherwise, the intermediate rate showed a significant increase in carbohydrate content in comparison with the lower rate.

Nutrient elements: Shoot concentration of N, P, K and Zn significantly enhanced with exogenously applications of Zn doses (Table 3). The values of the previous nutrients were rising with increasing Zn rates, in most cases. Zn at high level improved N, P, K and Zn percentages relative to the lower ones. Higher values were recorded when a higher level of Zn was supplied. Generally, the treatment of 100 mg L^{-1} was the superior in raising the percentages of above elements compared with the other ones.

Table 3: Zn nutrition and its role on leaf nutrients of marigold plants

Treatments	N (%)	P (%)	K (%)	Zn (ppm)
Control	2.29±0.41^{c}	0.35±0.01^{c}	2.20±0.09^{c}	35.24±1.01^{d}
50 mg L^{-1} Zn	2.72±0.26^{b}	0.44±0.01^{ab}	2.36±0.05^{b}	42.79±1.29^{c}
75 mg L^{-1} Zn	2.91±0.18^{ab}	0.46±0.02^{a}	2.43±0.02^{a}	52.82±0.93^{b}
100 mg L^{-1} Zn	2.93±0.05^{a}	0.47±0.01^{a}	2.47±0.01^{a}	55.07±0.91^{a}

Values are Means±SD (n = 8), means within a column with different letters are significantly different from each other according to Duncan multiple range test at $p \leq 0.05$

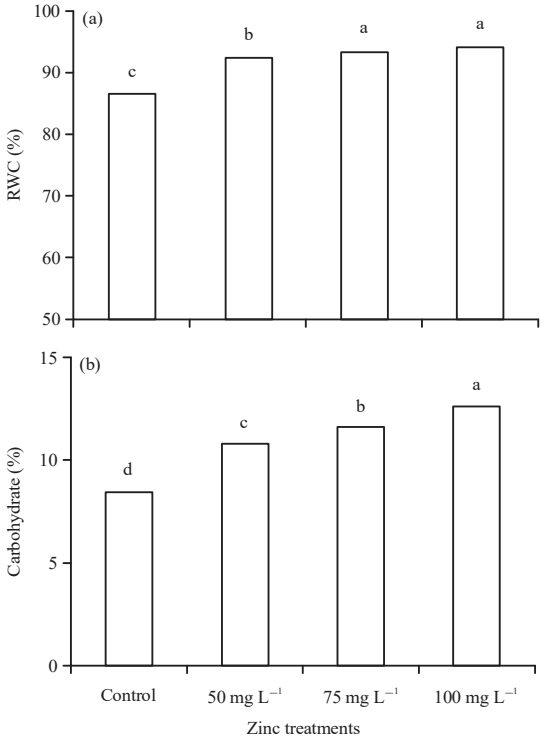

Fig. 5(a-b): Zn nutrition and its role on (a) Relative water content (%) and (b) Carbohydrate (%) of marigold plant

Bars had different letters are significantly differ from each other according to Duncan multiple range test at $p \leq 0.05$ (n = 8)

DISCUSSION

In the current study, Zn-fertilizer promotes the growth and inflorescence characters in marigold plants. The superior treatment in this concern was 100 mg L^{-1} followed by 75 mg L^{-1}. Zn fertilizer plays a crucial role in growth and yield of various crops[16,29] as well as in photosynthetic processes, i.e., raises in chlorophyll content and net photosynthetic rate[30]. This advancement may be due to the considerable role of micronutrients in enhancing the plant growth through rising cell division and optimized nutrient, regulate hormone level, water uptake, the cavity of enzymes, inhibition, changes in membrane permeability, tryptophan formation and stimulation of IAA enzyme synthesis that contributes to auxins biosynthesis, especially with Zn application and finally the activation of biomass production and improve the growth [31-34]. Further, Marschner[8] revealed a more pronounced of plant response to Zn that play a vital role regulating auxins rates in tissues by activating the auxin oxidase system, then the volume of root system in plant increase and also improved the growth and branching. The findings of the aforementioned studies are consistent with those of our study[13,14,35-39]. The improve in inflorescences measurements in response to supplying Zn in our study agrees with Kumar *et al.*[12], who revealed that Zn as foliar spraying promoted inflorescence yield/plant, relative to the control. A comparable finding was recorded on *Matricaria chamomilla*[20,40]. Further, a significant increase in inflorescences attributes in iris as a result of Zn supply as mentioned by Khalifa *et al.*[36]. Chlorophyll content is adversely influenced by nutrient deficiencies, which minimizes photosynthetic function. The photosynthetic apparatus is directly affected by the biosynthesis and functioning of key photosynthetic components[41]. Our data indicated that, Zn treatments significantly increased chlorophyll content in marigold leaves. In this concern, Zn helps chlorophyll in leaves for rising. The growth reductions in untreated plants could be reduced photosynthetic function as a result of Zn deficiencies, which decreased growth and assimilate translocation[42,43]. In addition, Zn enhances the photosynthetic and other metabolic activities that increase the various plant metabolites such as protein synthesis and structure of many enzymes required for activating cell division and enlargement[8,37]. Furthermore, Zhao *et al.*[44] revealed that Zn nutrition enhanced leaf net photosynthetic rate, which had remarkable implications for nutrient accumulation. Furthermore, the different plants species and the application methods of zinc significantly affect the efficiency of nutrition on the growth and productivity of these species[45].

The promotion influence of Zn on chlorophyll may be also referred to its considerable role in carbonic anhydrase, various dehydrogenases and in auxin production and CO_2 assimilation[17]. Further, Zn enhanced photosynthesis, chlorophyll synthesis and carbon anhydrase activity of maize plant [35,36]. In a similar direction, Wang *et al.*[46] revealed that under well-watered condition, Zn deficiency strongly reduced the photosynthetic performance in maize leaves.

In the current study, RWC was increased with increasing Zn doses. The RWC is a appropriate indicator of water turgor in plants and Zn may play an important role in this regard because its effect on IAA synthesis through tryptophan, consequently increasing the root system the more effective in water absorption from soil, then enhancing cell turgor through osmotic adjustment. Moreover, increasing RWC due to Zn-fertilizer could be ascribed to its role in enhancing stomatal conductance that reflected in maintaining RWC[47]. Such decrease in RWC was greater in nil Zn treatment suggesting that Zn was protective against osmotic changes in rosemary plant[48]. Water makes up most of the mass of plant cells[49]. In each cell, cytoplasm makes up only 5-10 % of the cell volume and the remainder is a large water-filled vacuole[49]. There is a strong correlation between alterations in leaf protoplast volume and changes in leaf photosynthetic activity. Photosynthetic pigments were improved in marigold tissue as this study results showed, consequently there are a positive relationship between Zn nutrition and leaf turgor measuring by RWC. While, in some cases a decreases in tissue water content may be more important than decreases in water potential or pressure potential in terms of influencing growth[49].

Zn supplying significantly increased carbohydrate (%) in marigold leaves relative unsprayed plants. However, the higher dose of Zn recorded the highest content. Current study results support the findings of Khalifa *et al.*[36], who reported a significant improvement in carbohydrate with Zn supply. Similarly, Sarrwy *et al.*[50] revealed that carbohydrate in mandarin leaves was improved significantly with foliar application of Zn. Obviously, any factor causes increase in plant pigments rising carbohydrate content. The results of this study reported that, Zn-fertilizer increased N, P, K and Zn contents in marigold leaves relative to unfertilized plants. These increases in carbohydrate content are likely due to the role of K in carbohydrate metabolism[51]. The current resulted also suggested that Zn increased N content in marigold leaves, since Zn affects N assimilation, an increase in protein content and a decrease in free amino acid content were expected. These results are in accordance with those of Hisamitsu *et al.*[52] who observed a significant increase in protein content in maize with Zn application. The increase in K content due to Zn supply changing in the distribution of nitrogenous compounds and their transformation changed. In this regard, Zn is required as a structural and catalytic component of proteins and enzymes for normal growth and development[53]. Zn is also involved in physiological processes including protein synthesis[35]. Additionally, K is essential for motivating plasmalemma ATPase that produces the necessary conditions for metabolites, such as sucrose[11]. The increased in flower attributes could be due to the role of K in increase the branching and hence inflorescence number/plant. In this context, Kumar *et al.*[54] recorded that K-fertilizer increased flower attributes of damask rose. Moreover, K activates several enzymes, including those involved in carbohydrate synthesis and is involved in organic acid neutralization and cell division promotion[55]. The increasing in chlorophyll content maybe it's because the function of K in biochemical pathways, which increases the photosynthetic rate and CO_2 assimilation and facilitates carbon movement[56]. A similar findings has been reported in other species[37,43,44]. Similar results have been previously reported[38,43,57]. These results agree with those of Khalifa *et al.*[36] and El-Azab[39], who found that foliar application of Zn significantly increased N, P, K and Zn, relative to the control. Havlin *et al.*[58] credited the increased nutrient levels in leaves to the role of Zn in sugar regulation and the enzymes that control plant growth. The increased Zn percentage leaves may be attributed to the availability of Zn sprayed on leaves[17]. The greatest increases in N, P, K and Zn content in leaves in the combined application of Zn and K is supported by several others[32,51,57,59-61]. It could concluded the results obtained from this study by applying Zn at 75 or 100 mg L^{-1} for enhancing the growth and productivity of marigold plant. Further, from the above mentioned, the reasons underlying the differences among micronutrients such as Zn because of its effects on many aspects of several medicinal and aromatic plants need to be studied further.

Through the previous discussion of the results of current study, it is recommended to spraying the marigold plants with zinc at a rate of 75 or 100 mg L^{-1} to obtain the best growth and inflorescence measurements.

CONCLUSION

Growth and flower attributes in marigold plant were improved by exogenously application of Zn related to unfertilized control. RWC, Ch content, carbohydrate percentage also promoted significantly. At the same time, N, P, K and Zn contents in marigold leaves were increased relative to nil Zn treatment. From the obtained results of current trail, foliar application of Zn at 75 mg L^{-1} is recommended for obtaining the best growth and the highest inflorescences yield of marigold plants.

SIGNIFICANCE STATEMENT

This study is substantial because it discovered the role Zn nutrition on marigold plant whereas, Zn is one of the

indispensable element because of its great importance in marigold nutrition as it is a source of tryptophan synthesis, which is a major source of IAA syntheses, which enhance the root system, consequently improve the growth and inflorescence production. Moreover, this study discovered the role of Zn on increasing the natural pigments that can be using in several industries. This study will help the researchers to uncover the importance of plant nutrition with other micronutrients which the plant suffers from lack in its growth media. Thus a new theory on plant nutrition may be arrived at several researchers.

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