

Research Article

Effect of zinc and iron on growth, flowering and shelf life of marigold under the agro-climatic conditions of Sawabi

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Abstract

A field experiment on the “Effect of zinc and iron on growth, flowering and shelf life of marigold” was carried out at Agricultural Research Station Swabi during 2018, to determine the optimum level of zinc and Iron on growth, flowering and shelf life of marigold flower, for the purpose to fulfill the demand of cut and loose flowers in local market. The experiment was laid out in Randomized Complete Block Design (RCBD) having three replications. Two factors were used in the experiment i.e. Four levels of zinc (0, 0.2, 0.4 and 0.6 %). And three levels of iron (0, 0.3 and 0.6 %). Zinc sulphate and iron sulphate were used as source for zinc and iron application. The results of the experiment showed that the maximum number of branches plant⁻¹ (17.33), number of flowers plant⁻¹ (10.11), flower diameter (9.10 cm), fresh flower weight (17.51 g), dry flower weight (3.06 g), shelf life (5.22 days) and minimum days to flowering (16.67 days) was observed on 0.6 % application of zinc as a foliar spray. Maximum plant height (49.04 cm) and stem diameter (1.12 cm) was noted on 0.4% of zinc foliar application. In case of iron maximum number of branches plant⁻¹ (18.58), numbers of flowers plant⁻¹ (10.79), flower diameter (9.48 cm), fresh flower weight (19.36 g), dry flower weight (3.40 g), shelf life (5.67 days) and minimum days to flowering (15.42 days) was recorded on 0.6 % application of iron. Maximum plant height (51.22 cm) and stem diameter (1.19 cm) was observed on 0.3% of iron foliar application. From the results of the experiment it has been concluded that the application of zinc and iron at the rate of 0.6% gave maximum growth and better quality flowers of marigold in district Swabi and hence recommended for the agro climatic condition of Swabi.

Keywords: Flowering; Growth; Iron; Marigold; Shelf life; Zinc

Introduction

Marigold (*Tagetes erecta* L.) is a beautiful commercial flower of Asteraceae family. The genus of annual and perennial plants which

belongs to sunflower family (Asteraceae or Compositeae) is *Tagetes*. Its genus was designated by Linnaeus in 1753. The genus of marigold is originated from South and

North America. But some genus is adopted throughout the world. The market value and demand of marigold in the subcontinent is very high due to its high range of adaptation. In some areas of the world some species of marigold such as *Tagetes minuta* is known to be toxic and harmful [1].

The height of *Tagetes* family ranges from 0.1 to 2.2 m. The leaves of most species are green and pinnate. The natural colors of bloom marigold flowers are orange, yellow, golden, white and having maroon color highlights. The floral head diameter of marigold flower ranges from 4 to 6 cm, usually with both disc florets and ray florets. The most popular species of marigold which are grown such as *Tagete spatula* L. and *Tagetes erecta* L. are originated from South Africa and Mexico correspondingly. *Tagetes erecta* L. is generally famous as African marigold, while *T. patula* as French marigold. Although the origin of African marigold *T. erecta* is Mexico, it is presumed to be of Indian origin, due to its adaptability, popularity and wide cultivation in India. Marigold is generally popular because of its easy cultivation, the adaptability to varying soil and climatic conditions, long flowering duration, wide range of attractive colors and good keeping quality of flowers. Due to these reasons, marigold is used as cut flower and in garden displays, garlands, bouquets and stage decorations [2].

The African marigold (*Tagetes erecta* L.) produced flowers having orange or yellow color and having big size of flowers [3]. The demand of the cut flowers is very high because of the beautification and attraction of the flower [4]. Due to modern technology new colors have been presented in the cultivars of cut flower as a result of which the market value and demand of the marigold flowers improved [5].

There is a plenty possibility to improve the production of Marigold by implementing appropriate crop managing methods. In order

to achieve good quality and maximum production of marigold flowers, we have to improve production and to reduce the physical and biological diseases, submission of main and micronutrients are unavoidable. Now-a-days, micronutrients particularly zinc and irons are slowly achievement impetus amongst the flower cultivators for the reason that, their useful nutritious maintenance and to confirm healthier yield and revenues. Best responses of African marigold for small quantities of micronutrients have been demonstrated by [6]. An appropriate micronutrient amount, period and technique of application will positively increase the productivity and flowers quality [7].

Zinc is an important micro nutrient for plant and plays a vital role in various processes in plants. Zinc is helpful for the production of proteins in plants and a major constituent of ribosomes and important for its development. Zinc is an active nutrient in various biological and chemical processes and has interaction with other elements due to which the uptake of other elements increased. The production of auxin also related with zinc which plays a vital role in plant growth [8]. Zinc is also involved in the production of carbohydrates, absorption of phosphorus and production of RNA. It has noted that zinc is an essential factor of various enzymes and is an important element for the growth and development of plant. Zinc is also known as an important constituent for many growth promoting substances such as for the synthesis of tryptophan and a precursor of indole acetic acid. It has been reported that the essential oil percentage, oil yield and flowers yield of chamomile was increased with the application of zinc [9].

Iron is also important micro nutrients which plays an important role in the respiration and photosynthesis and also affects its properties. Studies showed that iron is an important nutrient for the growth of plant tissues [10]. The shortage of iron can cause several

physiological abnormalities such as chlorosis, scorching and resetting etc. [11]. Iron is also related with the establishment of chlorophyll. Iron has also a key character in the activation of several enzymes [12]. The studies showed that the application of iron and zinc play a role in the physiological growth the flowers and reduced the amount of ethylene and abscisic acid and as a result of which the shelf life and visual attraction of the flowers increased [13].

Keeping in view the importance of zinc and iron an experiment was conducted to determine the impact of zinc and iron on growth, flowering and shelf life of marigold flowers in the conditions of district Swabi having the objectives to determine the

optimum level of zinc on growth, flowering and shelf life of marigold flower and to investigate the optimum level of Iron on growth, flowering and shelf life of marigold flower.

Materials and methods

An experiment “Effect of zinc and iron on growth, flowering and shelf life of marigold” was carried out at Agricultural Research Station Swabi, during 2018. The research was aimed to find out the growth, flowering and shelf life of marigold flowers. The research was arranged in Randomized Complete Block Design (RCBD). Total treatments were 12 and all treatments were replicated three times i.e., control, zinc, iron and their interaction (Table 1).

Table 1. Distribution of factors, treatments and their levels

Factor A (Iron)	Factor B (Zinc)
I ₁ = Control (0)	Z ₁ = Control (0)
I ₂ = 0.3%	Z ₂ = 0.2%
I ₃ = 0.6%	Z ₃ = 0.4%
	Z ₄ = 0.6%

Preparation of field

Before sowing of plants, field was ploughed thoroughly and leveled. Field was cultivated with the help of mechanical Cultivator. Soil was fine graded and pulverized. All cultural practices i.e., irrigation, weeding and crop protection was adopted according to the need till the trial end.

Planting materials

Hybrid variety (Inca 2 yellow) *Tagetes erecta* was selected. Seedlings were taken from Agriculture research station swabi. Seedlings were transplanted to plot in the mid of September 2018, when reached to 4-5 leaves stage with 40 X 30 cm plant spacing. Zinc and iron was applied before emergence of flower buds. Zinc sulphate and iron sulphate was taken as source for foliar application of zinc and iron.

Study parameters

The subsequent parameters were recorded.

Plant height (cm)

Data on plant height were recorded with the help of measuring tape from the base of plant to top of plant. From each treatment plants were selected randomly in each replication and mean data was noted.

Number of branches plant⁻¹

The data on numbers of branches were calculated by calculating the amount of branches of every treatment in all of the replication. For this purpose five plants were randomly selected in all treatment and in every replication and their number of branches plant⁻¹ was counted and then their mean was calculated.

Stem diameter (cm)

Stem diameter data were taken through the use of Vernier caliper. In each treatment and every replication five plants were randomly selected and their stem diameter was

calculated and then their mean was calculated for further statistical analysis.

Days to 1st flowering

Days to 1st flowering were recorded from plant sowing to emergence of 1st flowering. And days were counted after emergence of more than 50 percent plants and then their average was calculated.

Flower diameter (cm)

Data of flower diameter were recorded with the help of Vernier caliper. Randomly five flowers were selected in each treatment and each replication and then their diameter was calculated. After that their average was noted for further analysis.

Flower fresh weight (g)

Data were taken by weighting fresh flower with the help of digital scale. Five randomly flowers were selected in every treatment and every replicates and their weight was noted and their mean was studied for further analysis.

Flower dry weight (g)

Randomly five plants were selected and then dried in oven. After that their weight was calculated by using electronic scale and then their average was noted.

Total number of flowers plant⁻¹

Five plants were randomly selected in every treatment of the trial and then their flowers were counted. And then their average was calculated for further analysis.

Flower shelf life (Day)

For shelf life of marigold five flowers were selected and was kept at room temperature, their shelf life data were noted and then their average was calculated for further statistical analysis.

Statistical procedure

The data noted from the experiment was analyzed through analysis of variance method. Significant data were further analyzed through simple least significant differences (LSD) test. For all this calculation statistical software “Statistix 8.1” was used [14].

Results and discussion

The results obtained of different parameters are discussed as below

Plant height (cm)

Mean table (2) revealed that height of plant marigold was significantly affected by zinc and iron application amounts. However the interaction of these treatments was found non-significant. Maximum plant height of marigold (49.04 cm) was recorded on 0.4 % of zinc application followed by 0.6 % of zinc application (47.86 cm), while the smallest height of plant (46.18 cm) was observed in local. In case of iron application, the maximum plant height (51.22 cm) of marigold was noted on 0.3 % application of iron while the smallest plant height (43.77 cm) was recorded in control.

Zinc has a key role in the absorption of auxin [15]. Zinc application also has a main part in the activation of several enzymes, construction of tryptophan, structure of protein and also an originator of plant growth hormones due to which the plant height of the plant increased [16]. Our experiment results are similar with the result of [17] who noted that the use of zinc at the rate of 0.4 % increased the plant height of the plants. Iron is an important structural and functional component of many enzymes. The applications of iron at the rate of 2 % increased photosynthesis of the plant which result in improve growth [18].

Table 2. Plant height (cm) of marigold as affected by application of zinc and iron levels

Zinc Levels (%)	Iron levels (%)			Mean
	0	0.3	0.6	
0	42.12	46.62	49.80	46.18c
0.2	43.38	46.68	50.51	46.86c
0.4	44.92	47.22	51.44	49.04a
0.6	44.67	49.34	53.11	47.86b
Mean	43.77c	51.22a	47.47b	

LSD value at 5 % probability levels for zinc: 0.71

LSD value for 5 % probability levels for iron: 0.62

Number of branches plant⁻¹

Mean table (3) indicated that the foliar application of zinc and iron significantly affected the number of branches plant⁻¹, while the interaction of treatments was non-significant. The highest numbers of branches per plant (17.33) of marigold was recorded in those plots which were treated with 0.6 % application of zinc which was followed by 0.4 % of zinc application (16.56). However the minimum number of branches per plant (14.89) was recorded in control plots. In case of iron application, the highest number of branches per plant (18.58) was recorded on 0.6 % application of iron as a foliar spray, while the minimum number of branches plant⁻¹ (13.83) was noted in control plots. Increase in number of branches plant⁻¹ may be due to the reason that zinc is an important micronutrient for growth and development of

plant. It has been reported that zinc is a part of numerous enzymes in the plant body. High concentration of zinc increased the rate of photosynthesis due to which increase occur in plant development [19]. Our result is similar to the result of [20] who noted that significant increase occur in number of branches per plant of marigold due to foliar application of 0.5 % zinc. The deficiency of iron causes chlorosis in the plants. Iron also increased the rate of chlorophyll due to which the development of the plant increased [21]. Similar results was noted by [22]. Who stated that the foliar application of iron at the rate of 0.75 % significantly increase the number of branches in chrysanthemum plant. In another study [23] concluded that the application of iron at the rate of 0.5 % increased the number of branches of chrysanthemum.

Table 3. Number of branches plant⁻¹ of marigold as affected by application of zinc and iron levels

Zinc Levels (%)	Iron levels (%)			Mean
	0	0.3	0.6	
0	12.00	15.67	17.00	14.89d
0.2	14.00	15.67	17.67	15.78bc
0.4	14.67	16.00	19.00	16.56ab
0.6	14.67	16.67	20.67	17.33a
Mean	13.83c	16.00b	18.58a	

LSD value at 5 % probability levels for zinc: 1.01

LSD value for 5 % probability levels for iron: 0.88

Stem diameter (cm)

Mean table (4) indicated that stem diameter of marigold was significantly affected by foliar application of zinc and iron, while the

interaction of the treatments was found non-significant. The highest stem diameter (1.12 cm) of marigold was noted on 0.4 % foliar application of zinc, whereas the minimum

stem diameter (1.02) of marigold was recorded in control plot. Stem diameter of marigold was also significantly increased with the application of iron. The maximum stem diameter of marigold (1.19 cm) recorded on 0.3 % application of iron as a foliar spray, while the minimum stem diameter (0.94 cm) was recorded on control. Zinc is an essential nutrient for the growth and production of plant [24]. It has been noted that zinc is important constituent of ribosome and is essential for their production. The addition of zinc to plants can increase the accumulation of amino acid in the plant tissues and also enhanced the formation of protein as a result of which plant growth increased [25]. Similar result was presented

by [26] who reported that zinc application at the rate of 1 % significantly improved the stem diameter of marigold. Iron is an important constituent of various proteinase, peptides, dehydrogenase and also enhance plant growth hormones which improve plant growth. All these hormones increased cell division, cell differentiation and cell multiplication due to which the rate of photosynthesis increased which results increased in stem diameter [27]. Similar result was noted by [28] who reported that the diameter of stem was improved with the application of zinc and iron. Shah *et al.* (2015) [20] also reported that the maximum stem diameter was noted on 0.5 % iron sulphate application.

Table 4. Stem diameter (cm) of marigold as affected by application of zinc and iron levels

Zinc Levels (%)	Iron levels (%)			Mean
	0	0.3	0.6	
0	0.89	1.14	1.02	1.02d
0.2	0.94	1.18	1.07	1.06c
0.4	0.99	1.24	1.12	1.12a
0.6	0.94	1.21	1.10	1.08b
Mean	0.94c	1.19a	1.08b	

LSD value at 5 % probability levels for zinc: 0.011

LSD value for 5 % probability levels for iron: 0.009

Days to flowering

Mean table (5) revealed that days to flowering of marigold was significantly affected by foliar application of zinc and iron levels. However the treatments interaction was non-significant. The minimum days to flowering of marigold (16.67 days) was recorded on 0.6 % foliar application of zinc which was statistically similar with 0.40 % application of zinc (17.11 days). The maximum days to flowering (18.11 days) was recorded on control. In case of foliar application of iron, the minimum days to flowering of marigold (15.42 days) was observed on 0.6 % application of iron as a foliar spray, whereas the maximum days to flowering (20.0 days) was recorded in control plots.

The foliar application of zinc enhanced the metabolic activities of the plant which increased cell enlargement and cell elongation due to which the rate of photosynthesis increased and plant produced early flowering [29]. Our result is related with the result of [30]. Who concluded that the foliar application of zinc at the rate of 0.6 % significantly affected days to flowering of gerbera. It has been reported that the root system of the plant increased with the application of iron as a result of which plant utilize more water and nutrients which increase plant growth and leads toward reproductive growth [31]. Besides this iron also activates many enzymes such as catalase, peroxidase etc. Iron is also an important factor of the synthesis of

chlorophyll due to which the photosynthesis rate increased and also increased plant growth which leads plant to early flowering [32]. Our result is similar to the findings of [33] who reported that iron application

significantly affected the days to flowering of China aster. [34] Revealed that early flowering was obtained on 0.2 % application of iron sulphate.

Table 5. Days to flowering of marigold as affected by application of zinc and iron levels

Zinc Levels (%)	Iron levels (%)			Mean
	0	0.3	0.6	
0	20.67	17.33	16.33	18.11a
0.2	20.33	17.00	15.67	17.67b
0.4	19.67	16.33	15.33	17.11c
0.6	19.33	16.33	14.33	16.67d
Mean	20.00a	16.75b	15.42c	

LSD value at 5 % probability levels for zinc: 0.55

LSD value for 5 % probability levels for iron: 0.48

Number of flowers plant⁻¹

Mean table (6) revealed that the foliar application of zinc and iron significantly affected the numbers of flowers plant⁻¹, whereas the interaction of these treatments was found-non-significant. The maximum numbers of flowers plant⁻¹ (10.11) of marigold was observed in those plots which were treated with 0.6 % application of zinc which was followed by 0.4 % application of zinc (9.67), whereas the minimum numbers of flowers plant⁻¹(8.56) was observed in control. In case of iron application as a foliar spray, the maximum numbers of flowers plant⁻¹ (10.79) was observed in plots which were treated with 0.6 % foliar application of iron, while the minimum flowers plant⁻¹ (7.79) was recorded in control plots.

The increased in number of flowers plant⁻¹ maybe due to the useful and essential character of zinc in improving the translocation of carbohydrates, water, amino acid and mineral from source to sink particularly on flower as a result of which the number of flowers increased [7]. The similar result was also noted by [6] in African marigold at 0.75 % zinc sulphate. There is a direct effect of iron on the synthesis of chlorophyll as a result of which the photosynthesis rate increased and produced more food, due to which the flower numbers plant⁻¹was increased [13]. Our finding are same with the finding of [23] who concluded that the application of iron the number of flowers plant⁻¹ increased in French marigold.

Table 6. Number of flowers plant⁻¹ of marigold as affected by application of zinc and iron levels

Zinc Levels (%)	Iron levels (%)			Mean
	0	0.3	0.6	
0	6.67	9.33	9.67	8.56c
0.2	7.33	9.83	10.83	9.33b
0.4	8.50	9.50	11.00	9.67ab
0.6	8.67	10.00	11.67	10.11a
Mean	7.79c	9.67b	10.79a	

LSD value at 5% probability levels for zinc: 0.55

LSD value for 5 % probability levels for iron: 0.48

Flower diameter (cm)

Mean table (7) shows that the flower diameter of marigold was significantly affected by the foliar application of zinc, iron and their interaction. The maximum flower diameter (9.10 cm) of marigold was observed on 0.6 % application of zinc. However the minimum flower diameter (8.28 cm) was recorded on control. The maximum flower diameter (9.48 cm) of marigold was recorded on 0.6 % of foliar application of iron, whereas the minimum flower diameter (7.74 cm) was noted in control plot. In case of interaction the maximum flower diameter (9.80 cm) was recorded on 0.6 % zinc application and 0.6 % application of iron, while the minimum flower diameter (7.0 cm) was recorded on control.

Studies showed that zinc is an important micro nutrient for plant growth and development [9]. Several enzymes are activated with the application of zinc such as tryptophan, dehydrogenase etc. Zinc is also an important factor of the formation of chlorophyll and several other physiological due to which the flower diameter increased [35]. [36] Concluded that zinc application at the rate of 0.4 % gave maximum flower diameter of liliium. Iron is related with the formation of chlorophyll. Iron also act as a catalyst in many reactions. It is also important for photosynthesis and respiration [10]. The same result was noted by [37]. Our results are confirmed with the results of [34] who revealed that the application of 0.4 % iron increased the flower diameter of African marigold.

Table 7. Flower diameter (cm) of marigold as affected by application of zinc and iron levels

Zinc Levels (%)	Iron levels (%)			Mean
	0	0.3	0.6	
0	7.00	8.53	9.30	8.28 d
0.2	7.50	8.77	9.37	8.54 c
0.4	8.13	9.00	9.47	8.87 b
0.6	8.33	9.17	9.80	9.10 a
Mean	7.74 c	8.87 b	9.48 a	

LSD value at 5 % probability levels for zinc: 0.10

LSD value for 5 % probability levels for iron: 0.09

Fresh weight of flower (g)

Mean table (8) shows that fresh flower weight of marigold was significantly affected by foliar application of zinc and iron, the interaction of the treatment was found non-significant. The maximum fresh weight of flower (17.51 g) was observed in those plots which were treated with 0.6% application of zinc as a foliar spray followed by 0.4 % zinc application (16.0 g). The minimum fresh weight (14.18 g) of flower was recorded in control plots. In case of iron application, the maximum fresh weight of flower (19.36 g) was observed on 0.6% application of iron as foliar spray, while the minimum fresh weight

of flower (12.59 g) was recorded in control plots.

Bharracharjee [38] revealed that the foliar application of zinc plays a vital role in plant growth. Zinc is involves in photosynthesis process, metabolism of indole acidic acid and in the formation of protein and auxin. The fresh flower weight was maximum due to cell division, growth and respiration [29]. The similar results were noted by [12] who concluded that the fresh flower weight of gladiolus increased with foliar zinc application. [20] Noted that the 0.5 % application of zinc sulphate gave maximum fresh weight of marigold. Iron plays as a catalyst role in several chemical reactions

and thus enhanced these reactions [39]. Our result is similar to the results of [40] who determined that the foliar application of iron significantly improved the fresh flower weight of tuberose. Our results are similar

with the result of [34] who concluded that the iron sulphate application at the rate of 0.4 % increases the fresh weight of African marigold.

Table 8. Fresh flower weight of marigold (g) as affected by application of zinc and iron levels

Zinc Levels (%)	Iron levels (%)			Mean
	0	0.3	0.6	
0	11.16	14.81	16.56	14.18c
0.2	12.46	14.91	19.22	15.53b
0.4	12.83	15.39	19.77	16.00b
0.6	13.92	16.71	21.90	17.51a
Mean	12.59c	15.45b	19.36a	

LSD value at 5 % probability levels for zinc: 0.18

LSD value for 5 % probability levels for iron: 0.15

Dry weight of flower (g)

Mean table (9) shows that the dry weight of flower was significantly affected by the foliar application of zinc, iron and their interaction. The maximum dry weight of flowers (3.06 g) of marigold was noted in those plots which were treated with 0.6 % foliar application of zinc. The minimum dry weight of flower (2.49 g) was recorded on control. In case of iron application, the maximum dry weight of flower (3.40 g) was recorded on 0.6 % application of iron, whereas the minimum dry weight of flower (2.02 g) was observed in control plots. In terms of interaction between the zinc and iron, the maximum dry weight of flower (3.55 g) was recorded on 0.6 % zinc and 0.6 % iron, while the minimum dry weight of flowers (1.53 g) was observed in control.

A significant variation was observed on dry flower weight of marigold with the foliar

application of zinc. It has been reported that the foliar application of zinc relived chlorosis in the leaves of the plant and produced green and healthy plants. Zinc is also a significant constituent of chlorophyll by which the photosynthesis of the plant increases which resulting maximum flower weight [41]. The same result was noted by [42] who reported that the dry weight of chrysanthemum was increased with zinc application. They noted that the 0.6 % zinc sulphate produce maximum dry weight of flowers. Iron act as a catalyst in several chemical reactions and plays a role in the synthesis of chlorophyll and other physiological activities due to which flower weight and yield may be enhanced [12]. The similar result was noted by [43] who reported that the dry mass of African marigold improved with the application of iron and zinc at the rate of 0.5 % and 0.75 % respectively.

Table 9. Dry weight of marigold flower (g) as affected by application of zinc and iron levels

Zinc Levels (%)	Iron levels (%)			Mean
	0	0.3	0.6	
0	1.53	2.68	3.28	2.49d
0.2	1.91	2.85	3.32	2.69c
0.4	2.15	2.98	3.46	2.86b
0.6	2.51	3.13	3.55	3.06a
Mean	2.02c	2.91b	3.40a	

LSD value at 5 % probability levels for zinc: 0.03

LSD value for 5 % probability levels for iron: 0.04

Shelf life (Day)

Mean table (10) revealed that the foliar application of zinc and iron significantly affected the shelf life of marigold flowers, whereas their interaction was non-significant. The maximum shelf life of marigold flower (5.22 days) was recorded on 0.6 % of zinc application, followed by 0.4 % application of zinc (4.67 days). The minimum shelf life of marigold flower (4.44 days) was observed on control. In case of iron application the maximum shelf life of marigold flower (5.67 days) was recorded in those plots which were treated with 0.6 % iron, whereas the minimum shelf life of marigold flower (3.83 days) was recorded on control.

Application of zinc plays an important role to produce good quality flowers and increased the shelf life of flower [25]. [44] Observed that the application of zinc significantly influence the shelf life of gladiolus. [45] Stated that the proper application of zinc significantly enlarged the shelf life of orchid.

Our result is similar to the conclusion of [46] who reported that the shelf life of tuberose improved with the application of zinc. Iron also increased the storage of carbohydrates through the increased in the rate of photosynthesis [47]. Iron also plays an important role in the formation of plant hormones and chlorophyll contents and as a result of this the shelf life of the flower increased [48]. Our results is similar to the result of [6] who stated that the shelf life of African marigold improved with the application of iron. Iron is also related with the establishment of chlorophyll. Iron has also a key character in the activation of several enzymes [12]. The studies showed that the application of iron and zinc play a role in the physiological growth of the flowers and reduced the amount of ethylene and abscisic acid and as a result of which the shelf life and visual attraction of the flowers increased [13].

Table 10. Shelf life (Day) of marigold flower as affected by application of zinc and iron levels

Zinc Levels (%)	Iron levels (%)			Mean
	0	0.3	0.6	
0	3.33	4.67	5.33	4.44b
0.2	4.00	4.33	5.33	4.56b
0.4	3.67	4.67	5.67	4.67b
0.6	4.33	5.00	6.33	5.22a
Mean	3.83c	4.67b	5.67a	

LSD value at 5 % probability levels for zinc: 0.44

LSD value for 5 % probability levels for iron: 0.50

Conclusion

On the basis of above results the following conclusions can be made: The application of zinc at the rate of 0.6 % gave maximum number of branches plant⁻¹, number of flowers plant⁻¹, flower diameter, fresh flower weight, dry flower weight, shelf life and minimum days to flowering. The application of zinc at the rate of 0.4% gave maximum plant height and stem diameter. In case of iron application maximum number of

branches plant⁻¹, number of flowers plant⁻¹, flower diameter, fresh flower weight, dry flower weight, shelf life and minimum days to flowering were recorded on 0.6 % iron. The application of iron at the rate of 0.3% gave maximum plant height and stem diameter.

Authors' contributions

Conceived and designed the experiments: G Nabi & M N Khan, Performed the experiments: A Hussain, Analyzed the data:

W Muhammad, Contributed materials/ analysis/ tools: Y Ali, W Khan, S Zeb & M Hilal, Wrote the paper: M Ilyas.

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