Open Access Research Journal of
Life Sciences
Journals home page: https://oarjpublication/journals/oarjls/
ISSN: 2783-025X (Online)

OARJ OPEN ACCESS RESEARCH JOURNALS

(Research Article)

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Response of *Ruellia simplex* plants grown under water intervals and anti-transpirant treatments

Sami Ali Metwally [1, *], Bedour Helmy Abou-Leila [2], Nermeen Mahdy Taha [1] and Sharbat Leithy Mohamed [2]

[1] *Department of Ornamental Plant and Woody Trees, National Research Centre, Dokki, Cairo, Egypt.*
[2] *Department of Water Relation and Field Irrigation, National Research Centre, Dokki, Cairo, Egypt.*

Open Access Research Journal of Life Sciences, 2022, 04(02), 036–042

Publication history: Received on 07 October 2022; revised on 17 November 2022; accepted on 19 November 2022

Article DOI: https://doi.org/10.53022/oarjls.2022.4.2.0076

Abstract

Ruellia is herbaceous perennials are described as colorful groundcovers and it is very popular landscape plant cuttings of *Ruellia* plant were planted in pots. In the National Research Centre's greenhouse in Dokki, Giza, Egypt. A pot experiment was conducted in July 2020 and 2022 to examine the influence of KCl spraying and duration of irrigation on *Ruellia* plant growth and chemical contents. The current study compares the growth parameters of plants treated with KCl in three sprays at concentrations (0, 50 and 100 ppm) and water regime (3, 6 and 9 days) to those of control plants. However, increasing irrigation intervals for *Ruellia* plants there had no significant on growth parameters (plant height, branches number, root length, stem diameter and fresh and dry weight of shoots), while increasing irrigation intervals from 3days up to 9 days, increased flower number and delayed flowering. In addition, it is evident that N% was the highest by increasing irrigation intervals up to 9 days while P% showed a constant content, however the lower N% was recorded with the low irrigation intervals. Carbohydrate % as well as protein and photosynthetic pigments saved the same trend percentage. It can be concluded that, the increasing KCl concentration level up to 100 ppm caused an increase in previous mentioned vegetative growth parameters, flower number, flowering date, and chemical constituents (total chlorophyll, carbohydrate, protein%, carotenoids and mineral elements (N, P and K) concentrations compared with control and other KCl treatments. The purpose of this study is to learn more about the effects of KCl and water intervals on plant development and chemical components.

Keywords: Growth stimulant; KCl; Water intervals; Ornamental plants; *Ruellia*

1. Introduction

Ruellia simplex (Mexican petunia), for four flower colors, appears to be copious widespread [1]. It is found in sunny areas and flower colors are attributable primarily to flavonoids and carotenoid, anthocyanin pigments and sugar moieties, [2].Meanwhile, it is belongs to the Acanthaceae family, [3]. Recently, it recorded has taxonomic priority and reduces the latter. Furthermore, herbaceous perennials are described as colorful groundcovers and it is very popular landscape plant and is inferred to serve to attract pollinators [4]. it can also spread underground stems or rhizomes production, able to tolerate variations in light, temperature and moisture and resprout from crowns or rootstocks when cut back.

Potassium (K) is an essential plant that plays very important roles in plant growth and development. Its role is well documented in photosynthesis, increasing enzyme activity, improving synthesis of protein, carbohydrates and fats, translocation of photosynthetic, enabling their ability to resist pests and diseases. Also, potassium is considered as a major osmotically active cation of plant cell [5] Various sources of K salts are used such as potassium chloride (KCl), caused very good results to improve the growth and yield of plants under saline conditions and stress resistance and

* Corresponding author: Sami Ali Metwally
Department of Ornamental Plant and Woody Trees, National Research Centre, Dokki, Cairo, Egypt.

tolerance [6],[7],and[8] Salt stress has significantly reduced stem diameter in several other different plant species. The effect of potassium chloride (KCl) stress on stem breadth was slightly adverse.

However, over, or insufficient irrigation may bring about the leaching of nutrients and decrease production yield [9],[10]. Growing plants under water deficit could reduce the growth and respiration rates and divert a larger percentage of carbohydrates to storage and stomatal closure [11]. Water stress is one of the reduction by 24–50% [12],[13]. The sensitivity and the short-term water during the vegetative of plant usually does not significantly reduce yield [14]. Drought at the seedling stage could promote deep rooting, which was beneficial to the development, but it would increase the water demand at the flowering-podding stage [14].

The aim of this study to evaluate the response of *Ruellia simplex* to antitranspirant (KCl) treatments under different water intervals.

2. Material and methods

Pots experiment was carried out at the greenhouse of National Research Centre, Dokki, Cairo, Egypt, during the seasons of 2020-2022. For cultivation plastic pots (30 cm in diameter and 50 cm in depth) field with 10 kg soil were used in this study. The pots were filled with media contains a mixture of sand and clay soil as 1:1 by volume. The experiment included 9 treatments in which the combination of watering intervals 3, 6 and 9 days and one transpirant: potassium chloride with the concentrations of 0, 50 and 100 ppm as aqua's solution.

Chemical analyses of the soil samples were collected from different locations in the plantation at 0-30 cm depth and analyzed for chemical characters according to the standard procedures that mentioned by (Wilde, *et al*., 1985) Table (1). One homogenous rooted terminal cutting of *Ruellia* plants (7 cm) in length were obtained from nursery of private company. The seedlings were planted at the second week of December in both seasons 2020-2022 as one seedlings/pot 30 cm diameter. Phosphorus fertilizers were added before transplanting and N and K were added to the media with the recommended dose of Ministry of Agriculture after 30 days from transplanting. The irrigation regime was applied after 45 days from transplanting and the quantity of water was adjusted to reach field capacity. After 30 days from transplantation the plants were twice sprayed with KCl antitranspirant (0, 50 and 100 ppm), the first after 21 days from plantation and the second 15 days later. The experiments were set in completely randomized design with 5 replicates.

2.1. The following data was recorded

plant height (cm), stem diameter (mm), leaf area index (cm^2), number of branches/plants (no.), number of leaves/plants (no.), fresh and dry weight of leaves (g), fresh and dry weight of stems (g) and fresh and dry weight of roots (g).

2.2. Chemical constituents

Leaves samples were dried in oven dry at 70°C to constant weight and ground to fine powder and used for detection of N, P, K, Ca, Mg and Na by [15].

Pigments contents (chlorophylls a, b and carotenoids (mg/g f.w.).) were determined according to [16]. Total carbohydrates (% d.w.) were determined according to the method by [17]. Proline content (ug/g) was determined according to the method by [18]. Protine content (mg/g f.w.) were determined according to the method [19].

All obtained data were statistically analyzed using the complete randomized design in factorial arrangement, L.S.D method according to [20].

3. Results and discussion

3.1. Effect of water regime

3.1.1. Growth parameters

Table (1) indicate that, increasing irrigation intervals for *Ruellia* plants there had no significant on growth parameters (plant height, branches number, root length, stem diameter and fresh and dry weight of shoots), while increasing irrigation intervals from 3days up to 9 days, increased flower number and delayed flowering. Also, the data presented in Table (2) also indicate that, the highest values of chemical constituents were recorded from the plants irrigated after 9 days water irrigation intervals in comparison with other water irrigation intervals treatments.

Table 1 Effect of water regime on growth parameters of Ruellia sp. (means of two seasons)

Parameters Treatments	Plant height (cm.)	Branches number	Root length (cm.)	Stem diameter (mm.)	Successors number	Shoots fresh weight (g)	Shoots dry weight (g)	Flowers number	Days number to flowering (days)
3 Day	79.56	14.89	22.00	0.69	4.33	184.22	50.56	20.22	119.00
6 Day	81.33	17.22	24.94	0.72	4.00	130.33	39.00	23.00	124.67
9 Day	82.56	14.89	30.28	0.85	4.22	131.89	45.33	23.67	127.67
L.S.D. 0.05	20.38	7.88	17.81	0.30	2.61	64.79	14.16	2.36	13.61

3.2. Chemical constituents

3.2.1. Photosynthetic pigments

Minerals content

Table (2) recorded increments in total chlorophyll, carotenoids, carbohydrates % and protein %, as irrigation intervals increase, the increments was significant on most cases. *Ruellia* Sp. This may be due to the leaching of the minerals from soil. It is evident that of N% was the highest by increasing irrigation intervals up to 9 days while P% showed a constant content, however the lower N% was recorded with the low irrigation intervals. In agreement with these results concerning irrigation were the results of [21]. on *Taxodium distichum*, [22] on *Matthiola incana* and [23] on *Amaranthus tricolor*.

Table 2 Effect of water regime on chemical constituents of *Ruellia* sp. (means of two seasons)

Parameters Treatments	Carotenoids %	Total chlorophyll (mg/g/f.w.)	Carbohydrates %	Protein %	Na %	P %	K %	N %
3 Day	2.24	1.81	3.67	08.80	1.13	0.25	3.59	1.32
6 Day	2.20	1.71	3.78	09.79	1.27	0.24	3.93	1.57
9 Day	2.52	2.03	4.01	11.09	1.25	0.24	3.86	1.78
L.S.D. 0.05	0.32	0.13	0.14	0.39	0.27	0.18	0.41	0.14

Data in Table (2) indicated that, the content of photosynthetic pigments (chlorophyll a, b, a+b and carotenoids was increased by increasing irrigation intervals up to 9 days intervals. Accordingly, it can be stated that irrigation every 9 days was the most effective irrigation treatments for promoting the synthesis and accumulation of the photosynthetic pigments. These results are in accordance with those obtained [24] on Bauhinia variegate, [22] on Amarathus tricolor.

3.3. Carbohydrates percentage

Data in Table (2) indicated that, carbohydrates percentage took the same trend like photosynthetic pigments in regard to the influence of irrigation treatments. Total carbohydrates and protein percentages were gradually augmented as the irrigation was sloping downward. Carbohydrate % as well as protein and photosynthetic pigments samed the same trend, the highest % were recorded by increasing irrigation intervals up to 9 days. This may be due to the fact that during the course of drought stress active solute accumulation of compatibles duels such as carbohydrates and protein are claimed to be an effective stress tolerance mechanism [25].

From the given data in Tables (3 and 4) it can be concluded that, the increasing KCl concentration level up to 100 ppm caused an increase in previous mentioned vegetative growth parameters, as flowers number, flowering date, and chemical constituents (as total chlorophyll, carbohydrates, protein %, carotenoids and mineral elements (N, P and K) concentrations compared with control and other KCl treatments. In this connection, the positive effect of potassium chloride can be suggested that these adequate amounts of K can enhance the total dry mass accumulation of crop plants under drought stress in comparison to lower K concentrations [26]. This finding might be attributable to stomatal regulation by K^+ and corresponding higher rates of photosynthesis [27]. [28] on mango trees, revealed that, potassium increased leaf area, improves leaf mineral content, enhancing yield as well as physical and chemical properties. Moreover, spraying onion plants with potassium markedly increased vegetative growth, yield, and bulb quality and bulb chemical composition. Potassium chloride at all used concentrations caused an increased N, P, K % in comparison with those untreated seedling, Table (4).

Table 3 Effect of antitranspirant (KCl) on growth parameters and flowering characters of *Ruellia* sp. (means of two seasons)

Parameters Treatments	Plant height (cm)	Root length (cm)	Branches number	Stem diameter (mm)	Successors number	Shoots fresh weight (g)	Shoots dry weight (g)	Flowers number	Day number to flowering (days)
0 ppm	64.78	26.22	07.44	0.59	3.11	043.22	22.00	18.44	134.67
50 ppm	84.22	27.28	18.78	0.81	4.56	176.78	53.33	23.00	117.00
100 ppm	94.44	23.72	20.78	0.85	4.89	226.44	59.56	25.44	119.67
L.S.D. 0.05	8.06	7.50	5.86	0.09	1.65	69.50	22.35	1.20	9.07

Table 4 Effect of antitranspirant (KCl) on chemical constituents of *Ruellia* sp. (means of two seasons)

Parameters Treatments	Carotenoids %	Total chlorophyll (Mg/g/f.w.)	Carbohydrates%	Protein %	Na %	P %	K %	N %
0 ppm	1.97	1.74	3.61	9.85	0.26	2.95	1.48	0.87
50 ppm	2.14	1.66	3.72	9.93	0.24	4.08	1.60	1.35
100 ppm	2.84	2.16	4.13	9.89	0.22	4.35	1.58	1.42
L.S.D. 0.05	0.24	0.09	0.09	0.26	0.14	0.41	0.10	0.16

Table 5 Interaction effect between water regime and potassium chloride on growth parameters of Ruellia sp. (means of two seasons)

Parameters Treatments	Plant height (cm)	Root length (cm)	Branchs number	Stem diameter (mm)	Successors number	Shoots fresh weight (g)	Shoots dry weight (g)	Flowers number	Day number to flowering (days)
3 Day + 50 ppm	069.00	26.33	09.67	0.58	3.00	051.00	20.67	21.00	136.00
6 Day + 50 ppm	088.67	24.50	21.33	0.73	4.33	157.00	47.67	21.00	117.00
9 Day + 50 ppm	086.33	24.00	20.67	0.83	4.67	183.00	48.67	27.00	121.00
3 Day + 100 ppm	076.00	34.67	08.33	0.77	4.00	050.00	30.33	22.00	145.00
6 Day + 100 ppm	082.33	29.00	15.33	0.88	3.33	133.67	48.33	23.00	117.00
9 Day + 100 ppm	089.33	27.17	21.00	0.90	5.33	212.00	57.33	26.00	121.00
3 Day + 0 ppm	049.33	17.67	04.33	0.43	2.33	028.67	15.00	12.33	123.00
6 Day + 0 ppm	081.67	28.33	19.67	0.83	6.00	239.67	64.00	25.00	117.00
9 Day + 0 ppm	107.67	20.00	20.67	0.82	4.67	284.33	72.67	23.33	117.00
L.S.D. 0.05	13.95	12.99	10.15	0.16	2.87	120.38	38.70	2.08	15.71

Concerning the effect of potassium chloride on photosynthetic pigments, data revealed the positive and active of the potassium chloride on pigments content in leaves of *Ruellia* plants as compared with untreated plants.

Interaction between water intervals with KCl sparing; in Table (5, 6) show that the treatments with 6, 9 days water intervals combined with zero KCl ppm application recorded the highest values as a general on growth, flowering parameters and on minerals elements compared with all interaction treatments. Regarding the interaction of the two factors under study, application of zero and 100 ppm potassium chloride was more effective on pigments content with every 9 days intervals.

Table 6 Interaction effect between water regime and potassium chloride on chemical constituents of *Ruellia* sp. (means of two seasons)

parameters Treatments	Carotenoids %	Total chlorophyll (Mg/g/f.w.)	Carbohydrates %	Protein %	Na %	P %	K %	N %
3 Day + 50 ppm	1.89	2.33	3.79	09.87	0.87	0.22	2.90	1.58
6 Day + 50 ppm	1.56	2.12	3.27	08.61	1.47	0.25	4.48	1.68
9 Day + 50 ppm	1.69	2.14	4.29	10.89	1.47	0.26	4.40	1.74
3 Day + 100 ppm	1.79	2.17	3.68	10.09	0.95	0.21	3.10	1.61
6 Day + 100 ppm	1.99	2.44	4.44	12.50	1.40	0.24	4.00	2.02
9 Day + 100 ppm	2.32	2.94	3.89	10.68	1.40	0.26	4.48	1.71
3 Day + 0 ppm	1.53	1.42	3.35	09.60	0.80	0.34	2.85	1.26
6 Day + 0 ppm	1.43	1.86	3.46	08.68	1.19	0.22	3.16	1.39
9 Day + 0 ppm	2.47	3.45	4.21	08.11	1.40	0.19	4.16	1.30
L.S.D. 0.05	0.15	0.41	0.15	0.45	0.27	0.50	0.70	0.18

In general, increasing irrigation intervals up to 6 days increased carbohydrate and protein % in plants treated with 100 ppm KCl.

4. Conclusion

It can be concluded that, there had no significant increase on growth parameters by increasing irrigation intervals for Ruellia plant. While increasing water intervals from 3 to 9 increased flower number and delayed flowering. The increasing KCl concentration level up to 100 ppm caused an increase in previous mentioned vegetative growth parameters, flower number, flowering date, and chemical constituents (total chlorophyll, carbohydrate, protein%, carotenoids and mineral elements (N, P and K) concentrations compared with control and other KCl treatments. Compliance with ethical standards.

Compliance with ethical standards

Acknowledgments

The authors would like to thank Ornamental Plants and Woody Trees Dept., National Research Centre.

Disclosure of conflict of interest

The authors declare that they have no competing interests.

Statement of ethical approval

The manuscript does not contain studies involving human participants, human or animal data, and animal or human tissue.

Availability of data and material

The authors were collected data of this manuscript together.

Funding

The research was financed by authors.

Authors' contributions

The authors have participated and work on completing this manuscript and approved the final manuscript.

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