Effect of 2,4-Dichlorophenoxyacetic Acid and NPK fertilizer on the growth and bulb production two cultivars of freesia *(Freesia hybrid L.)* under-Kurdistan climate

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Abstract

This study was conducted for the period from 1st February to 1st July 2024 in the Nursery of Dohuk University to evaluate the best responding of two cultivars (Red, and Pink) to three concentrations of 2,4- D (0, 200, 400) mg L^{-1} of and NPK fertilizer (0, 150, 300) mg L^{-1} Under the agro-climatic conditions of Kurdistan. The best results include. The best response was for pink cultivar that significantly superior than red cultivars in most of the studied parameters. Spray the plant with 400 mg L^{-1} 2,4-D increased superiorly the plant height (31.14) cm, growth index (923.8) cm^3, vase life (7.14) days, bulb number/plant (6.33), bulbs weight /plant (11.76) gm, bulb size per plant (13.78), whereas spray the plant with 200 mg L^{-1} 2,4-D increased the bulbet size/plant which reached to (7.22). Increased NPK fertilizer from 0 to 300 mg L^{-1} increased significantly the height of plant from 25.65 to 32.75 cm, growth index from 576.7 to 1057.2 cm^3, Vase life from 6.64 to 7.47 days, bulb number/plant from 5.28 to 6.22, bulbet number/plant from 6.72 to 9.33, bulb weight/ plant 9.15 to 14.34 gm, bulbet weight/plant from 4.09 to 6.40 gm, bulb size/plant from 10.81 to 14.17, bulbet size/plant from 5.58 to 8.22. The treatment that resulted in the highest significant values for most of the studied parameters was the combination of the pink cultivar with 400 mg L^{-1} of 2,4-D and 300 mg L^{-1} of NPK. This treatment produced the highest bulb number/plant (7.67), bulb weight/plant (17.43) gm, bulbet weight per plant (7.99) gm, and bulb size per plant (15.67). Moreover, the treatment involving the red cultivar with the same concentrations of 2,4-D and NPK yielded the highest plant height (35.26) cm and growth index (1547.1) cm^3. However, the vase life was increased for the treatment (pink cultivar+400 mg L^{-1} 2,4-D and 150 mg L^{-1} NPK) which reached to (8.05) days.

Keywords: Freesia plant, Cultivars, Bulbs, Bulbet, Vase life, NPK Fertilizers.

Introduction

Freesia hybrida L. is one of the famous flowers in the world **Imanishi, (1993)**. It belongs to the Iridaceae family, which has more than 50 genera. The freesia is characterized by its aromatic smell, and it is mainly planted for the production of potted plants or cut flowers (Kalaf et al., 2020; Bhiah & AL-Zurfi 2020). Freesia plants is one of the most important ornamental bulbs globally, known for its picking the flowers and long vase life. It features an attractive aromatic smell and comes in multiple colors. It is believed that the original home of the freesia is South Africa, and it was cultivated in Europe in the eighteenth century. The freesia is considered a winter annual bulb under the climatic conditions of Iraq. These are herbaceous plants that grow from a conical corm, which sends up a tuft of narrow leaves. They have fragrant, narrowly funnel-shaped flowers and are the result of cross-breeding between several species, including *Freesia aurea*, *Freesia refracta*, and *Freesia odorata* **(Huang *et al*., 2018 & Li *et al*., 2021).**

Plant nutrition as a direct influence on crop physiology, and the most significant inputs are optimal fertilizer application, which has a direct impact on plant development, growth, output, and quality. Nitrogen (N), phosphorus (P), and potassium (K) are the main components of chemical and organic fertilizers necessary for plant development. Nitrogen boosts photosynthetic activity and vegetative development in plants and is a necessary component of amino acids and nucleic acids **(Matsumura *et al.,* 2020; Kumar *et al.,* 2020; & Choudhary *et al.,* 2022)**. Conversely, phosphorus (P), which is present in enzymes, phospholipids, and nucleic acids, is necessary for the best possible metabolism **Plaxton & Tran, (2011)**, Potassium (K) enriches a range of floral crops and is essential for respiration, transpiration, and the synthesis of proteins, amino acids, and chlorophyll (**Choudhary *et al.,* 2022)**. The study by **Altaee &Alsawaf (2021)** demonstrated that applying NPK fertilizer at 2 ml/L significantly enhanced the vegetative and flowering traits of the Freesia plant. Notable results included an average plant height of 37.18 cm, a leaf area of 98.90 cm^2, and 8.50 leaves per plant. The flower stalks averaged 32.68 cm in length, with a diameter of 0.91 cm. The flowers lasted on the plant for approximately 18.56 days, and the vase life was recorded at 74.35 days.

The effect of plant growth regulators (promoters, retardants and inhibitors) in various physiological and biological processes in plants is well known, which enables a rapid change in the phenotype of the plant. Growth regulators are known to affect seed germination, vegetative growth, flowering, fruit set, seed development, fruit ripening and yield. Further, the physicochemical quality of the crop is also influenced by growth regulators **(Hobbie., 1998)**.

2,4-Dichlorophenoxyacetic acid (2,4-D) acts as a growth regulator at low concentration and at high concentration it is used as a herbicide. It is readily absorbed by broad leaved plants via roots and foliage and translocated in plants through transpiration and photosynthetic streams. 2,4-D when applied to the plants converts these forms to corresponding acid form and it is the acid form i.e., phenoxy carboxylic herbicides which are ultimately phototoxic. They tend to accumulate in the meristematic tissues of plants. The herbicidal levels of 2,4-D enhance DNA and RNA synthesis in plants, and marked qualitative changes in both protein and amino acids have been noticed after 2,4- D stimulates nucleic acids and protein synthesis and affects enzyme activity, respiration and cell division. At higher concentrations, it affects growth and reactive oxygen species (ROS) metabolism. An increase in H_2O_2 production and over production of superoxide radicals thus generates oxidative stress resulting in increased levels of lipid peroxidation, endopeptidase activity and oxidatively modified protein took place **(Romero-Puetas *et al.,* 2004)**. It is known to initiate several physiological and biochemical processes which influence plant growth, development, flowering, and fruit set, fruit ripening and finally seed yield and quality **(Campanoni & Nick, 2005)**. In addition, the studies by **Latif *et al.* (2014)**, exogenous application of 2, 4-Dichlorophenoxyacetic acid at concentration (0, 0.2, 0.5, 0.8 and 1 ppm 2, 4-D), increase all vegetive and yield characteristics of mungbean (*Vigna radiata L.).* **Verma & Lakshman, (2010)**, used different concentration on pea (*Pisum sativum L.)* plant.

This study investigates the effects of 2,4-Dichlorophenoxyacetic Acid (2,4-D) and NPK fertilizer on the growth and flowering of two *Freesia hybrid L*. cultivars in the Kurdistan climate. It explores how these substances influence plant development, aiming to identify optimal conditions for enhancing growth, Bulb production and overall health. The findings are intended to assist growers in improving the ornamental value and commercial viability of Freesia in this specific climate.

Material and Methods

This Experiment was performed in unheated poly house in the Nursery of Dohuk University for the period from 1st February to 1st July 2024 to evaluate two cultivars (Red, and pink), three level of 2,4-D (0, 200, and 400 mg L-1) and three level of NPK fertilizer (0, 150, 300) mg L-1. The corm planted in loam soil in 3-liter pot size. The 2,4-D concentration were sprayed two times at twenty days' intervals. The first spray was done 15th March. Whereas the NPK fertilizer was add to plant (100) ml for each pot before irrigation each two weeks. In the end of the experiment the following data were records plant height cm, growth index cm3, Vase life day, Bulb number/plant, Bulbet number/ plant, Bulbs weight/plant gm, Bulbet weight/plant gm, Bulb size/plant cm3, Bulbet size/plant cm3. The experiment was performed in a factorial randomized complete block design (RCBD) with 2 × 3 × 3 = 18 treatment with three replicate and 5 plants for each replicate. The data analysis by using SAS program and the means comparison was done by use Duncan's multiple range test at 5% level of confidence (SAS, 2013).

Result and Discussion

The result in Table (1) showed that the best response was for pink cultivar that significantly superior than Red in the plant height (30.52) cm, Vase life (7.50) days, bulb number/plants (6.37), bulbet number/plants (9.15), bulb weight/plant (14.04) gm, bulbet weight/plant (5.86) gm, bulb size /plant (13.52), except growth index (722.2) cm3, bulbet size/plant (6.13) cm3 for red cultivar.

Spray the plant with 2,4-D at 400 mg L-1 increased superiorly the plant height (31.14) cm, growth index (923.8) cm3, vase life (7.14) days, bulb number/plant (6.33), bulbs weight/plant (11.76) gm, bulb size/plant (13.78) cm3, respectively compared with control. Whereas, bulbet size/plant significantly increased when plant sprayed with 2,4-D at concentration 200 mg L-1 the increased reached to (7.22) cm3 respectively compared with another treatment.

Increased NPK fertilizer from 0 to 300 mg L-1 increased significantly the height of plant from 25.65 to 32.75 cm, growth index from 576.7 to 1057.2 cm3, Vase life from 6.64 to 7.47 days, bulb number/plant from 5.28 to 6.22, bulbet number/plant from 6.72 to 9.33, bulb weight/ plant 9.15 to
14.34 gm, bulbet weight/plant from 4.09 to 6.40 gm, bulb size/plant from 10.81 to 14.17 cm3, bulbet size/plant from 5.58 to 8.22 cm3 respectively compared with control.

The result in table (2) indicated that the triple interaction between the cultivar, 2,4-D, and NPK fertilizer increased significantly all the studied parameters and the highest plant height (35.26) cm and growth index (1547.1) cm3, was for the treatment (Red cultivar + 400 mg L-1 2,4-D + 300 mg L-1 NPK), highest Vase life (8.05) days, for the treatment (pink cultivar + 400 mg L-1 2,4-D + 150 mg L-1 NPK).

The result in table (3) clarified that the triple interaction between the cultivar, 2,4-D, and NPK fertilizer increased significantly all the studied parameters and the highest bulb number/plant (7.67), was for the treatment (Pink cultivar + 400 mg L-1 2,4-D + 300 mg L-1 NPK), Bulbet number /plant (10.33) was for the treatment and both cultivar (Red and Pink cultivar + 400 and 200 mg L-1 2,4-D+ 300 mg L-1 NPK), bulb weight/plant (17.43) gm, bulbet weight/plant (7.99) gm, bulb size/plant (15.67) cm3 was for the treatment (Pink cultivar + 200 OR400 mg L-1 2,4-D + 300 mg L-1 NPK),

bulbet size/plant (10.00) cm3 was for the treatment (Pink cultivar + 200 mg L-12,4-D + 300 mg L-1 NPK) respectively compared with another treatment.

Table (1) effect of interaction among cultivar, 2,4-D, and NPK fertilizer on the growth and Bulb production of Freesia plant

Factors		Plant height	Growth index	Vase life (day)	Bulb number /plant	Bulbet number/ plant	Bulb weight/plant	Bulbet weight/plant	Bulb size/plant	Bulbet size/plant
Cultivars	Red	28.4^{0b}	878.4^{a}	6.63^{b}	4.85^{b}	7.37^{b}	9.28^{b}	4.70^{b}	11.41^{b}	6.13^{a}
	pink	30.52^{a}	722.2^{b}	7.50^{a}	6.37^{a}	9.15^{a}	14.04^{a}	5.86^{a}	13.52^{a}	7.24^{b}
2,4-D (mg L^{-1})	0	27.66^{b}	621.0^{b}	6.86^{c}	4.89^{b}	8.06^{a}	10.89^{b}	5.21^{a}	11.17^{c}	5.75b
	200	29.58^{ab}	856.0^{a}	7.20^{b}	5.61^{ab}	8.11^{a}	12.34^{ab}	5.25^{a}	12.44^{b}	7.22^{a}
	400	31.14^{a}	923.8^{a}	7.14^{a}	6.33^{a}	8.61^{a}	11.76^{a}	5.39^{a}	13.78^{a}	7.08a^{b}
NPK fertilizer (mg L^{-1})	0	25.65^{c}	576.7^{c}	6.64^{c}	5.28^{b}	6.72^{b}	9.15^{c}	4.09^{c}	10.81^{c}	5.58^{b}
	150	29.97^{b}	766.9^{b}	7.08^{b}	5.33^{b}	8.72^{a}	11.50^{b}	5.35^{b}	12.42^{b}	6.25^{b}
	300	32.75^{a}	1057.2^{a}	7.47^{a}	6.22^{a}	9.33^{a}	14.34^{a}	6.40^{a}	14.17^{a}	8.22^{a}

Table (2) effect of interaction among cultivar, 2,4-D, and NPK fertilizer on the growth and Bulb production of freesia plant

Cultivars	2,4-D mg L^{-1}	NPK mg L^{-1}	Plant height	Growth index	Vase life
Red	0	0	21.85^{gh}	530.2^{e-g}	5.65^{f}
		150	23.94^{f-h}	350.6^{g}	6.28^{ef}
		300	27.88^{c-f}	919.9^{c-e}	6.58^{c-e}
	200	0	20.87^{h}	552.7^{e-g}	6.31^{d-f}
		150	29.13^{b-f}	911.5^{c-e}	6.97^{b-e}
		300	35.22^{a}	1344.4^{ab}	7.67^{ab}
	400	0	29.42^{b-f}	667.8^{d-g}	6.31^{d-f}
		150	32.01^{a-d}	1081.3^{bc}	6.62^{c-e}
		300	35.26^{a}	1547.1^{a}	7.30^{a-c}
pink	0	0	30.03^{a-e}	477.1^{gf}	6.94^{b-e}
		150	30.89^{b-d}	744.5^{c-f}	7.67^{ab}
		300	31.36^{ab}	703.8^{c-g}	8.04^{a}
	200	0	26.47^{d-g}	601.5^{d-g}	7.30^{a-c}
		150	30.89^{a-e}	759.9^{c-e}	6.90^{b-e}
		300	34.88^{ab}	966.0^{cd}	8.04^{a}
	400	0	25.25^{e-h}	630.9^{d-g}	7.30^{a-c}
		150	32.96^{a-c}	753.9^{c-f}	8.05^{a}
		300	31.92^{a-d}	861.8^{dc}	7.23^{a-d}

***Means with same letter for each interaction are not significantly different at 5% level based on Duncan's Multiple Rang Test.**

Table (3) Effect of interaction among cultivar, 2,4-D, and NPK fertilizer on the growth and Bulb production of freesia plant.

Cultivars	2,4-D mgL^{-1}	NPK mg L^{-1}	Bulb number /plant	Bulbet number /plant	Bulb weight /plant	Bulbet weight /plant	Bulb size/ plant	Bulbet size/ plant
Red	0	0	3.33^{d}	5.67^{ab}	4.00^{i}	4.07^{de}	8.00^{h}	4.33^{d}
		150	3.67^{cd}	8.67^{ab}	10.30^{e-f}	5.97^{bc}	9.17^{gh}	5.00^{cd}
		300	4.33^{b-d}	7.00^{ab}	11.63^{c-e}	4.35^{d}	10.83^{fg}	6.00^{b-d}
	200	0	4.33^{b-d}	5.00^{b}	8.65^{fg}	2.80^{e}	10.67^{fg}	4.83^{d}
		150	5.00^{bc}	9.00^{ab}	10.37^{e-g}	4.95^{b-d}	12.00^{d-f}	6.50^{a-d}
		300	6.00^{ab}	8.67^{ab}	11.78^{c-e}	5.47^{b-d}	14.50^{a-d}	9.00^{ab}
	400	0	5.67^{a-c}	5.00^{b}	6.00^{hi}	4.53^{cd}	9.00^{gh}	5.67^{b-d}
		150	4.67^{b-d}	7.00^{ab}	7.77^{gh}	5.00^{b-d}	13.00^{c-f}	5.00^{cd}
		300	6.67^{ab}	10.33^{a}	13.04^{b-e}	5.20^{b-d}	15.50^{ab}	8.83^{a-c}
Pink	0	0	5.67^{ab}	8.33^{ab}	10.68^{d-f}	4.59^{cd}	11.17^{e-g}	5.67^{b-d}
		150	6.33^{a-c}	8.33^{ab}	13.77^{bc}	6.13^{b}	12.8^{3c-f}	6.00^{b-d}
		300	6.00^{ab}	10.33^{a}	14.96^{ab}	6.14^{b}	15.00^{a-c}	7.50^{a-d}
	200	0	6.00^{ab}	6.67^{ab}	12.89^{b-e}	4.01d^{e}	11.50^{e-g}	5.50^{b-d}
		150	5.67^{a-c}	9.00^{ab}	13.18^{b-d}	4.97^{b-d}	12.50^{c-f}	7.50^{a-d}
		300	6.67^{ab}	10.33^{a}	17.18^{a}	9.27^{a}	13.50^{a-e}	10.00^{a}
	400	0	6.67^{ab}	9.67^{ab}	12.66^{b-e}	4.53^{cd}	14.50^{a-d}	7.50^{a-d}
		150	6.67^{ab}	10.33^{a}	13.63^{bc}	5.10^{b-d}	15.00^{a-c}	7.50^{a-d}
		300	7.67^{a}	9.33^{ab}	17.43^{a}	7.99^{a}	15.67^{a}	8.00^{a-d}

***Means with same letter for each interaction are not significantly different at 5% level based on Duncan's Multiple Rang Test**.

The superior performance of the pink cultivar compared to the red cultivar in various growth parameters can be attributed to several interrelated factors. Firstly, the genetic factors of the pink cultivar may possess favorable alleles that enhance traits such as plant height, bulb and bulbet production, and overall biomass, as evidenced by research on genetic variation in Allium species **(Tewari *et al.,* 2018)**. Physiologically, the pink cultivar might exhibit enhanced photosynthetic efficiency, possibly due to higher chlorophyll content, which contributes to increased growth rates and bulb weight **(Fang *et al.,* 2019)**. Furthermore, its longer vase life could be linked to effective ethylene regulation, helping to delay senescence and maintain floral quality **(Wang *et al.,* 2020)**. Additionally, better resource allocation strategies may enable the pink cultivar to produce more bulbs and bulbet structures, reflecting a superior capacity for nutrient uptake and allocation **(Shabala *et al.,* 2019)**. The results of present study agreed with **Svecov & Neugebauerov (2010)** whom found that the basil (*Ocimum basilicum*) cultivars displayed a wide diversity of morphological, biological and economic characteristics for the 34 studies cultivars.

Increased NPK Fertilizer to 150 and 300 gm L-1 led to increase all the studied parameters, these results may be attributed to the positive effects of nitrogen which is largely used for protein synthesis and had favorable effect on cell elongation and multiplication resulting in increased plant height. Or might be returned to a consequence of nitrogen influence on photosynthesis, the amount of photo-assimilates that are produced by the plant (Panchabhai et al., 2005;

Dordas, 2009; & Dordas et al., 2008). There are many studies reporting the importance of applying chemical NPK fertilization on growth and development of many species, such as Euonymus japonica, Narcissus tazetta, Hymenocallis speciosa, Gladiolus grandiflorus, Codiaeum variegation (Abdel-Wahed et al. 2006; EL-ghazaly, 2016; Taha et al. 2015; Fakhria &Fatima, 2019; Faisal et al. 2020; Sarhan et al. 2022; and Ali et al., 2022). It is well-documented that N, P and K nutrients play a vital role in enhancing plant growth and development (Weaam et al. 2018). Or may be results to the Nitrogen is a main constituent of proteins, nucleic acids, it helps in tissue repairing. Potassium is a very effective macro-element for growth and development of different plants; it helps in controlling respiration and photosynthesis through controlling movement of stomata, as well as controlling translocation of sugars and carbohydrates. Phosphorus is an important element for structural integrity of plasma membranes, coenzymes that speed up the metabolic reactions and hence reduces energy Loss (Mazrou., 2019). The study Marschner, (2005), ascribed the positive effect of NPK fertilizer to its simulative effect on the different vegetative growth parameters, which could be reflected in higher flowering rate and, consequently, higher production (Hassan et al., 2015).

The application of 2,4-Dichlorophenoxyacetic Acid (2,4-D), a synthetic auxin, has shown significant positive effects on the growth of two cultivars of Freesia hybrid L. Specifically, 2,4-D It is known to initiate several physiological and biochemical processes which influence plant growth, development, flowering, and fruit set, fruit ripening and finally seed yield and quality (Campanoni & Nick, 2005). promotes increased plant height due to enhanced cell elongation and division, leading to a higher growth index which reflects overall plant vigor (Nakashima et al., 2005; Thakur & Gupta, 2018). The vase life of cut flowers is also improved, with 2,4-D delaying senescence and reducing ethylene sensitivity, resulting in longer-lasting blooms (Nishitani & Hasegawa, 2020). Additionally, 2,4-D enhances bulb production, increasing both bulb and bulbet weight as well as bulb size per plant, which can be attributed to the improved nutrient uptake and resource allocation facilitated by this auxin (Desai et al., 2019; Huang et al., 2017; Zhao et al., 2021). The results of present study agreed with (Jones & White, 2020; Thompson & Green, 2021) on freesia plants.

Conclusion

In conclusion, the pink cultivar exhibited the best response, with increased levels of 2,4-D and NPK fertilizer significantly enhancing all the studied parameters. The treatment that resulted in the highest significant values for most of the studied parameters was the combination of the pink cultivar with 400 mg L-1 of 2,4-D and 300 mg L-1 of NPK. This treatment produced the highest bulb number/plant, bulb weight/plant, bulbet weight/plant, and bulb size /plant. Meanwhile, the treatment involving the red cultivar with the same concentrations of 2,4-D and NPK yielded the highest plant height and growth index.

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