Enhancement of Growth, Flowering and Corm Freesia Hybrida Plant via Rice Organic Residue Application and Chelated Zinc Spray

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Abstract

A pot trial was conducted to identify the effect of adding rice organic residues (ROR) to the potting soil and spraying chelated zinc (CZn) on the growth, flowering, and corm characteristics of the Freesia hybrida plant. An RCBD experiment was adopted with two factors and three replicates. ROR comprised three levels (0, 4, and 8%), and CZn included three concentrations (0, 20, and 40) mg.L⁻¹. The findings revealed that applying ROR at 8% and spraying CZn at 20 mg.L⁻¹ significantly increased leaf number, shoot dry weight, total chlorophyll content in fresh leaves, and total soluble carbohydrate content in dry leaves (6.66 leaves.plant⁻¹, 8.76 g DW, 48.79 mg.100 g⁻¹ FW, and 1.50 g DW) respectively. Also, the same treatment combination realized significant results for the number of florets per inflorescence, floret diameter, floret vase life, number of corms per plant, and corm diameter by (12.85 florets.inflorescence⁻¹, 7.03 cm, 8 days, 3.66 corms.plant⁻¹, and 2.33 cm) consecutively. Further, adding ROR at 8% and spraying CZn at 40 mg.L⁻¹ significantly increased the number of inflorescences (5.33 inflorescences.plant⁻¹) and inflorescence length (39.10 cm).

Keywords: Freesia plant, Rice organic residues, Chelated Zinc.

1. Introduction

Freesia hybrida are perennial winter plants classified in the Iridaceae family and originated from South Africa and grown in private or public gardens in pots or ground. Freesia plants are one of the most significant bulbs for cut flowers on the globe [1], since they have attractive and aromatic inflorescence that make them a potential container crop for commercial purposes. Their flowers have multiple colors like yellow, red, white, and violet, and the big corms without any infection are best for planting at a depth of 5-7 cm [2]. Freesia is cultivated in regions free of frost with high humidity and soil enriched with organic matter to enhance the growth and flowering characteristics and the quality and quantity of new corms [3]. Organic matter is a group of biological substances derived from a natural or modified source, whether the source is living or non-living [4,5]. Further, organic matter enriched in nutrients and hormones can adjust the soil pH as a result of the release of CO2 gas, which decomposes, thus improving soil features [6]. Organic matter also boosts the content of total chlorophyll and increases the carbohydrates in plants [7,8]. According to the researchers [9], organic fertilizers containing amino acids, vitamins, and growth regulators (e.g. auxins) can improve plant growth and quality. Also, the authors [10] noted that the mixture of organic fertilizer with soil containing ROR in ratio 1:1 planted with Rosa hybrid L. realized a significant increment in leaf area, leaf number, flower diameter, and flower number. Additionally, mixing compost with soil in a ratio of 12.5% for the Pelargonium pelatum L. plant resulted in a significant increase in the number of leaves and branches, leaf area, number of florets, and floret diameter [11].

Zinc is one of the critical macronutrient elements for the growth and development of plants. It is necessary for the assimilation of chlorophyll and photosynthesis in the plant via its roles in forming RNA essential for protein synthesis, tryptophan responsible for indole acetic acid (IAA) biosynthesis, which is necessary for cell division and elongation [12]. In the study of [13], the authors concluded that zinc improves corm growth and increases its number in Gladiolus spp plants. Moreover, spraying of zinc sulfate ZnSO₄ on petunia hybrid plants resulted in a significant increase in plant height, leaf area index, flower number, and a decrease in the day until opening the first flower [14].

For the importance of the freesia plant as a commercial cut flower [15], along with decreasing the pollution problems of soil, this current research aimed to improve flowering, growth characteristics and increase the reproduction of the corms by applying ROR to the soil and spraying CZn with different concentrations on the freesia plants grown in pots.
2. Materials and Methods

This study was carried out at the lath house and the laboratory belonging to the University of Kufa, Faculty of Agriculture, Najaf, Iraq, during the growing season 2017-2018. The *Freesia hybrida* plants used in this research were produced from De Ree Holland Inc. Freesia plants were cultivated on 15-10-2017 in pots with a diameter of 25 cm containing sandy soil with 2 L size. The physical and chemical properties of pot soil are presented in Table 1. The product ROR was obtained from the Organic Agriculture Center, Ministry of Agriculture, Najaf, Iraq. All agricultural procedures such as irrigation were performed as needed.

| Table 1. Chemical and physical analyses of the potting soil. |
|-------------------------------------------------------------|
| Profile                  | (%)           |
| The texture of potting soil (Sandy soil) Clay | 2.00 |
|                             Silt | 5.30 |
|                             Sand | 92.70 |
| Chemical analysis          | Unit          | Quantity |
| pH                        |              | 7.45 |
| Electric Conductivity (Ec) | Ds.M⁻¹       | 2.71 |
| N                         | Mg.L⁻¹       | 0.55 |
| P                         | Mg.L⁻¹       | 2.55 |
| K⁺                       | Mg.L⁻¹       | 33.59 |
| Orange matter (OM)        | %            | 0.95 |

| Table 2. Chemical analyses of rice organic residues (ROR). |
|-----------------------------------------------------------|
| Chemical analyses | Unit | Quantity |
| pH                 |       | 7.82 |
| Electric Conductivity (Ec) | Ds.M⁻¹ | 2.53 |
| N                  | %     | 2.24 |
| P                  | %     | 0.102 |
| K⁺                 | %     | 1.45 |
| Mg++               | %     | 19.0 |
| Organic matter     | %     | 12.43 |
| Humic acid         | %     | 5.87 |
| Fulvic acid        | %     | 4.54 |
| Humin              | %     | 1.2 |

The growing media was prepared according to the studied levels based on (volume of ROR/volume of soil), for example, level 4% was prepared by adding 80 ml of ROR. The control contained only river sandy soil. The CZn was sprayed three times; the first spray was done when plants reached 2-3 true leaves, the second spray was after 15 days from the first one, and the third spray after 15 days from the second one. This trial was set up as a Randomized Complete Block Design (RCBD) with two factors and three replicates. The first factor was rice organic residues (ROR) with three levels (0, 4, and 8) % of pot soil volume, and the second factor was the foliar spray of Chelated Zinc (CZn) with three concentrations (0, 20, and 40) mg.L⁻¹. Comparison of means for all studied parameters was analyzed by the least significant difference (LSD) at the probability level of 0.05 [16].

At the end of the trial on 12-02-2018, the subsequent characteristics were determined; the number of leaves (leaf.plant⁻¹), shoot dry weight (g). Total chlorophyll content in leaves, fresh weight basis, (mg.100g⁻¹ FW) was determined as described by [17]. Total soluble carbohydrates in leaves, dry weight basis (mg.g⁻¹ DW) were recorded according to [18]. Number of inflorescence per plant (inflorescence.plant⁻¹), number of floret per inflorescence (floret.inflorescence⁻¹), inflorescence length (cm), floret diameter (cm), number of corms per plant, corm diameter (cm), corm weight (g), and vase life of florets were recorded. Further, the inflorescences were sampled with a sterilized knife in the morning, collecting 2-4 florets [19], then carried out directly to the laboratory to set it in bottles containing one liter of water, one tablet of aspirin, and 2g of sugar, until all samples reached the complete wilting of the inflorescence.

3. Results

Data presented in Table 3 showed that adding ROR at 8% significantly increased leaf number per plant to 6.00 leaves.plant⁻¹, shoot dry weight to 1.46 g, total chlorophyll in leaves to 48.02 mg.100g⁻¹ FW, total soluble carbohydrates to 8.55 mg.g⁻¹ DW, number of corms per plant to 3.22 corm.plant⁻¹, and diameter of corms to 2.24 cm. In contrast, the control treatment which
gave the lowest values for the same parameters (3.11 leaf.plant\textsuperscript{-1}, 1.07 g, 44.65 mg.100g\textsuperscript{-1} FW, 7.28 mg.g\textsuperscript{-1} DW, 1.33 corm.plant\textsuperscript{-1}, and 1.57 cm) respectively. Spraying CZn at 40 mg.L\textsuperscript{-1} also significantly increased leaf number per plant to 4.66 leaves,plant\textsuperscript{-1}, shoot dry weight to 1.28 g, total chlorophyll in leaves to 46.50 mg.100g\textsuperscript{-1} FW, total soluble carbohydrates to 8.10 mg.g\textsuperscript{-1} DW, number of corms per plant to 2.55 corm.plant\textsuperscript{-1}, and diameter of corms to 2.01 cm. However, the treatment sprayed with distilled water (control) had the minimum values for the studied parameters (4.11 leaf.plant\textsuperscript{-1}, 1.21 g, 45.62 mg.100g\textsuperscript{-1} FW, 7.82 mg.g\textsuperscript{-1} DW, 2.00 corm.plant\textsuperscript{-1}, and 1.84cm) respectively (Table 3). In addition, the interaction between the two factors showed that adding ROR at 8% and spraying CZn at 40 mg L\textsuperscript{-1} significantly increased leaf number per plant 6.66 leaves,plant\textsuperscript{-1}, shoot dry weight 1.50 g, total chlorophyll content in leaves 48.79 mg.100g\textsuperscript{-1} FW, total soluble carbohydrates 8.76 mg.g\textsuperscript{-1} DW, number of corms per plant 3.66 corm.plant\textsuperscript{-1}, and the diameter of corms 2.33 cm. On the contrarily, the non-sprayed plants (control) which showed the lowest values for the same parameters ( 3.00 leaf.plant\textsuperscript{-1}, 1.05 g, 44.53 mg.100g\textsuperscript{-1} FW, 7.16 mg.g\textsuperscript{-1} DW, 1.00 corm.plant\textsuperscript{-1}, and 1.53 cm) respectively (Table 3). Nevertheless, there was no significant effect of adding ROR or spraying CZn or their interaction on the weight of corms.

### Table 3. Effect of ROR and CZn on growth and corm parameters of freesia plants.

| Treatments | Leaves No. (leaf.plant\textsuperscript{-1}) | Shoot dry weight (g.) | Total chlorophyll in leaves (mg.100g\textsuperscript{-1} fresh wt.) | Total soluble carbohydrates in leaves (mg. g\textsuperscript{-1} dry wt.) | Corm number (corm. plant\textsuperscript{-1}) | Corm diameter (cm) | Corm weight (g) |
|------------|----------------------|----------------------|-------------------------------------------------|-------------------------------------------------|----------------------|------------------|-----------------|
| ROR (%)    |          |                      |                                                |                                                |                      |                  |                 |
| 0          | 3.11     | 1.07                | 44.65                                          | 7.28                                            | 1.33                 | 1.57             | 1.03            |
| 4          |          |                     |                                                |                                                |                      |                  |                 |
| 8          | 6.00     | 1.46                | 48.02                                          | 8.55                                            | 3.22                 | 2.24             | 1.91            |
| L.S.D 0.05 | 0.408    | 0.051               | 0.369                                          | 0.250                                           | 0.326                | 0.073            | N.S             |
| CZn (mg.L\textsuperscript{-1}) |          |                      |                                                |                                                |                      |                  |                 |
| 0          | 4.11     | 1.21                | 45.62                                          | 7.82                                            | 2.00                 | 1.84             | 1.25            |
| 20         | 4.55     | 1.25                | 46.39                                          | 8.03                                            | 2.33                 | 1.93             | 1.37            |
| 40         | 4.66     | 1.28                | 46.50                                          | 8.10                                            | 2.55                 | 2.01             | 1.39            |
| L.S.D 0.05 | 0.408    | 0.051               | 0.369                                          | 0.250                                           | 0.326                | 0.073            | N.S             |
| ROR × 4    |          |                      |                                                |                                                |                      |                  |                 |
| 0          | 3.00     | 1.05                | 44.53                                          | 7.16                                            | 1.00                 | 1.53             | 1.02            |
| 20         | 3.33     | 1.11                | 44.85                                          | 7.46                                            | 2.00                 | 1.66             | 1.04            |
| 8          | 4.00     | 1.17                | 45.38                                          | 7.83                                            | 2.00                 | 1.83             | 1.05            |
| L.S.D 0.05 | 0.706    | 0.089               | 0.639                                          | 0.434                                           | 0.564                | 0.126            | N.S             |

ROR: rice organic residues; CZn: chelated zinc

Results in Table 4 also showed that adding ROR at 8% significantly improved inflorescence number per plant to 4.77 inflorescences.plant\textsuperscript{-1}, inflorescence length to 33.71 cm, and florets number per inflorescence to 9.89 flrets.inflorescence\textsuperscript{-1}, diameter of floret to 6.64 cm, and vase life of inflorescence to 7.33 days. In contrast, the control treatment provided the minimum values (2.11 inflorescence.plant\textsuperscript{-1}, 28.38 cm, and 6.89 flrets.inflorescence\textsuperscript{-1}, 3.67 cm, and 4.33 days) respectively. Moreover, spraying CZn at 40 mg.L\textsuperscript{-1} (Table 3) revealed a significant increment in inflorescence number per plant by 3.77 inflorescences.plant\textsuperscript{-1}, inflorescence length by 33.57 cm, number of flret per inflorescence by 8.11 flrets.inflorescence\textsuperscript{-1}, diameter of floret by 5.36 cm, and vase life of inflorescence by 6.33 days. In comparison, the spraying with distilled water only (control) appeared the lowest means (3.11 inflorescence.plant\textsuperscript{-1}, 30.67 cm, 8.11 flret.inflorescence\textsuperscript{-1}, 4.47 cm, and 5.33 days) respectively. For the interaction, adding ROR at 8% and spraying CZn at 20 mg L\textsuperscript{-1} significantly increased inflorescences number per plant by 5.33 Inflorescence.plant\textsuperscript{-1} and inflorescence length by 39.10. However, adding ROR at 8% and spraying CZn at 40 mg.L\textsuperscript{-1} significantly increased florets number per inflorescence by 12.85 flrets.inflorescence\textsuperscript{-1}, diameter of floret by 7.03 cm, and vase life of inflorescence by 8.00 days, compared with the control which gave the minimum values (2.00 inflorescences. plant\textsuperscript{-1}, 27.53 cm, 6.67 flrets.inflorescence\textsuperscript{-1}, 3.50 cm, and 4 days) respectively (Table 4).
4. Discussion

The significant increase in growth and corm characteristics of Freesia hybrida plants obtained in this study could be attributed to the addition of ROR, improving the biological and chemical properties of the potting soil via boosting the bioactivity of microorganisms within organic residues [20]. In addition, ROR could support the availability of necessary nutrients for growth in various biological stages of plant development [21, 22]. The significant increment in the number of leaves and shoot dry weight when ROR was applied in the current experiment may be due to the role of the nutrients found in the combination of ROR (Table 2) as products for their decomposition, which play a crucial role in the photosynthetic process, nutrition availability and stimulation of plant cell division and elongation [1, 7, 23] and finally improve plant growth characteristics. Also, the increase in leaf number was positively reflected in the increase of chlorophyll content and carbohydrate accumulation in leaves when ROR was applied and consequently enhancing the number, diameter, and weight of the freesia corms [23, 24]. The significant effects in the flowering indicators by applying ROR might be attributed to the chemical profile of ROR rich in nitrogen, potassium, and phosphorus (Table 2), which motivate the photosynthesis process as well as elevate metabolic products such as carbohydrate compounds (Table 3) and hence their transfer from the leaves (source) to the storage compartments as in flowers (sink) [20] lead to improve flowering and corm productivity. In addition, [25] confirmed that the decomposition of organic residues in the soil releases heat then helps accelerate physiological processes and stimulates metabolic products in the plant. Accordingly, increases in pot soil temperature could improve the rate of the plant absorption of nutritional elements such as nitrogen and potassium which both enhance plant growth and development [26].

The significant improvement in the growth parameters of Freesia hybrida plants obtained in this study when spraying with chelated zinc may be attributed to the important role of zinc in stimulating tryptophan formation in the plant which is the basic component of IAA synthesis. IAA is one of the major hormones in the shoot apical meristem functionality and procambium cell and therefore stimulates plant cell division and elongation [24, 27]. In addition to its function in the emergence of shoots and photosynthetic pathways producing nutrition and energy to build new tissues [28]. Moreover, zinc increases the source of energy that is used in the production of chlorophyll and stimulation the enzymes involved in the bioactive processes of chlorophyll formation. In addition, zinc is crucial for RNA which is essential in protein synthesis [12] as well as being an enzymatic cofactor for many key enzymes in photosynthesis, and the processes of converting sugars into starch and protein synthesis [29] finally improve plant growth. Foliar spray of CZn exhibited significant effects on corn characteristics (Table 3) which could be due to its role in enhancing the growth system and stimulating the synthesis of auxin [21]. Besides, auxin plays a significant function in increasing plant cell division and elongation and activation of

| Treatments  | Inflorescence number (Inflorescence length cm) | Florets number (Floret. inflorescence-1) | Diameter of floret (cm) | Vase life of inflorescence (day) |
|-------------|---------------------------------------------|-----------------------------------------|------------------------|--------------------------------|
| ROR (%)     | 2.11                                        | 28.38                                   | 6.89                   | 3.67                           | 4.33                           |
|             | 3.33                                        | 31.04                                   | 8.00                   | 5.03                           | 5.66                           |
|             | 4.77                                        | 33.71                                   | 9.89                   | 6.64                           | 7.55                           |
| L.S.D 0.05  | 0.366                                       | 0.485                                   | 0.561                  | 0.281                          | 0.435                          |
| CZn (mg.L-1)| 3.11                                        | 30.67                                   | 8.11                   | 4.74                           | 5.33                           |
| 20          | 3.33                                        | 31.88                                   | 9.22                   | 5.24                           | 5.88                           |
| 40          | 3.77                                        | 33.57                                   | 9.44                   | 5.36                           | 6.33                           |
| L.S.D 0.05  | 0.366                                       | 0.485                                   | 0.561                  | 0.281                          | 0.435                          |
| ROR (%)     | 2.00                                        | 27.53                                   | 6.67                   | 3.50                           | 4.00                           |
| 40          | 2.33                                        | 29.16                                   | 7.00                   | 3.63                           | 4.00                           |
| CZN (mg.L-1)| 3.00                                        | 29.76                                   | 7.67                   | 4.40                           | 5.00                           |
| 20          | 3.33                                        | 30.90                                   | 8.00                   | 5.06                           | 5.66                           |
| 40          | 3.66                                        | 32.46                                   | 8.33                   | 5.63                           | 6.33                           |
| L.S.D 0.05  | 0.634                                       | 0.840                                   | 0.971                  | 0.486                          | 0.754                          |

ROR: rice organic residues;  CZn: chelated zinc

Table 4. Effect of ROR and CZn on flowering parameters of freesia plants.

The significant increase in growth and corm characteristics of Freesia hybrida plants obtained in this study could be attributed to the addition of ROR, improving the biological and chemical properties of the potting soil via boosting the bioactivity of microorganisms within organic residues [20]. In addition, ROR could support the availability of necessary nutrients for growth in various biological stages of plant development [21, 22]. The significant increment in the number of leaves and shoot dry weight when ROR was applied in the current experiment may be due to the role of the nutrients found in the combination of ROR (Table 2) as products for their decomposition, which play a crucial role in the photosynthetic process, nutrition availability and stimulation of plant cell division and elongation [1, 7, 23] and finally improve plant growth characteristics. Also, the increase in leaf number was positively reflected in the increase of chlorophyll content and carbohydrate accumulation in leaves when ROR was applied and consequently enhancing the number, diameter, and weight of the freesia corms [23, 24]. The significant effects in the flowering indicators by applying ROR might be attributed to the chemical profile of ROR rich in nitrogen, potassium, and phosphorus (Table 2), which motivate the photosynthesis process as well as elevate metabolic products such as carbohydrate compounds (Table 3) and hence their transfer from the leaves (source) to the storage compartments as in flowers (sink) [20] lead to improve flowering and corm productivity. In addition, [25] confirmed that the decomposition of organic residues in the soil releases heat then helps accelerate physiological processes and stimulates metabolic products in the plant. Accordingly, increases in pot soil temperature could improve the rate of the plant absorption of nutritional elements such as nitrogen and potassium which both enhance plant growth and development [26].

The significant improvement in the growth parameters of Freesia hybrida plants obtained in this study when spraying with chelated zinc may be attributed to the important role of zinc in stimulating tryptophan formation in the plant which is the basic component of IAA synthesis. IAA is one of the major hormones in the shoot apical meristem functionality and procambium cell and therefore stimulates plant cell division and elongation [24, 27]. In addition to its function in the emergence of shoots and photosynthetic pathways producing nutrition and energy to build new tissues [28]. Moreover, zinc increases the source of energy that is used in the production of chlorophyll and stimulation the enzymes involved in the bioactive processes of chlorophyll formation. In addition, zinc is crucial for RNA which is essential in protein synthesis [12] as well as being an enzymatic cofactor for many key enzymes in photosynthesis, and the processes of converting sugars into starch and protein synthesis [29] finally improve plant growth. Foliar spray of CZn exhibited significant effects on corn characteristics (Table 3) which could be due to its role in enhancing the growth system and stimulating the synthesis of auxin [21]. Besides, auxin plays a significant function in increasing plant cell division and elongation and activation of
photosynthesis leading to increase metabolic products, including carbohydrate content (Table 3). Hence, our findings showed an increase in the number and diameter of corms considering one of the plant stored parts.

It is also noted from the results of Table (4) that there is a significant increase in the flowering characteristics of freesia plants when sprayed with chelated zinc [30]. It is worth mentioning that zinc plays an important role in the synthesis of starch, which ultimately increases the plant’s carbohydrate content [31], in turn, improving flowering characteristics such as vase life of the freesia florets.

**Conclusion**

In conclusion, our results show that the role of adding rice organic residues and foliar spray with chelated zinc enhanced growth and floral parameters and increased the corm productivity of freesia plants. Eventually, it is important to consider the potential to expand the cultivation and agricultural management of the freesia plant as an international cut flower for commercial production.

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