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INFLUENCE OF SOME FERTILIZERS ON THE GROWTH AND FLOWERING OF *CROSSANDRA INFUNDIBULIFORMIS* (L.) NEES PLANTS

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Abstract

Crossandra infundibuliformis (L.) Nees is a highly valued ornamental perennial species, with attractive orange flowers and dark green leaves, cultivated in temperate regions as an indoor plant. The objective of this study was to evaluate the influence of three fertilizers, in concentration of 0.2% (Bionat Plus, Green Feed and Cropmax), on vegetative growth and flowering of plants. The results indicated that the foliar application of these fertilizers caused a significant increase in most of the studied morphological parameters, compared to the control plants. The highest values of plant height (40.35 cm), number of shoots per plant (7.81), leaf length (8.78 cm), leaf width (4.63 cm), number of flowers per spike (18.93), and spike length (8.62 cm) were recorded in plants sprayed with Bionat Plus. Plants fertilization with Cropmax increased the number of spikes per plant, and also promoted the earlier flowering, recording the lowest number of days from planting to flowering (81.33 days).

Key words*: Crossandra, foliar fertilization, growth, flowering.*

INTRODUCTION

Crossandra infundibuliformis (L.) Nees is a beautiful and popular perennial species in the Acanthaceae family. It is also known as the firecracker plant, which grows as a subshrub up to 1 m tall. The leaves are simple, ovate to lanceolate, opposite, glossy, 3-12 cm long and deep-green in colour, with wavy edges. The attractive, delicate fan-shaped flowers, with five asymmetrical petals, in various shades of orange, yellow, red or pink, depending on the cultivar, are arranged in dense terminal spike inflorescences, consisting of prominent, hairy, overlapping, ovate-oblong, green bracts. The flowers are unscented and begin to open gradually from the base of the spike. The plants typically bloom from spring to autumn, but in warm, tropical climates, the flowering occurs abundantly throughout the year.

Crossandra prefers light, fertile soils, rich in organic matter, moist, well-drained, with a pH ranging from 5.8 to 6.5, in full sun to partial shade.

It requires optimal light and temperatures conditions, such as 4-6 hours of direct sunlight daily and between 20-30°C, for vigorous vegetative growth and blooming. The plants are sensitive to low temperature and frost, and do not tolerate lack of humidity.

This species is propagated through seeds in spring, and vegetatively by stem or shoot tip cuttings of 8-10 cm length, during early spring or late summer. For successful rooting, it is recommended to treat the cuttings with some rooting hormones. Rehana et al. (2020; 2023) obtained the best results, in terms of rooting percentage, root and shoot formation, and subsequently for various growth and flowering parameters, in Crossandra var. 'Arka Shravya', using terminal cuttings treated with 3000 ppm IBA, in quick dip method.

Crossandra can also be multiplied through micropropagation, from axillary and apical buds (Girija et al., 1999), callus and shoot tips cultures (Hewawasam et al., 2001; 2004), nodal segments (Kalaivani et al., 2019). The performance of different genotypes cultivated in various regions exhibits variability depending on the climatic conditions, growth habitat and genetic potential (Gowsika et al., 2019). Therefore, it is important to evaluate and estimate the magnitude of variation among the different genotypes concerning the morphological and yield traits, to develop new cultivars of Crossandra (Bhosale et al., 2018;

Dhivya & Balakirshnan, 2019; Vinodh & Kannan, 2020; Hosagoudar et al., 2022; Srinivasulu et al., 2023).

Adequate fertilisation is essential for promoting optimal growth and flowering of the plants, and as well as for achieving maximum yield and quality. Therefore, to maintain vigorous plants with healthy foliage and to stimulate blooming, it is necessary to identify the nutrient deficiencies, which can cause various problems affecting the plant growth and development. Nitrogen, phosphorus and potassium are the main macronutrients that plants require throughout their growth cycle. Micronutrients are also essential for plant growth and flowering, and for various physiological processes, but in smaller quantities. To choosing the right fertilizers with micronutrients will take into account the plants requirement, soil conditions and specific nutrient deficiencies identified. The foliar application of macronutrients and different micronutrient combinations has shown positive effect on plant growth, yield and quality of flowers in gladiolus (Fahad et al., 2014), dahlia (Kashif et al., 2014), tuberose (Patel et al., 2017), and rose (Hafiz et al., 2020).

Integrated nutrient management plays an important role in maximizing the biological potential for improving floricultural crop productivity, by using adequate amounts of fertilizers in balanced proportions (Kumar & Chaudhary, 2018). The optimum quantity and nutrient application method should be determined based on soil fertility status and local conditions (Niu et al., 2021).

Numerous researches have been conducted on the nutrition of crossandra plants with the aim to investigate the effects of different levels of organic and chemical fertilizers (Aruna et al., 2007; Gowthami et al., 2018; Priyanka et al., 2018; Gowtham & Karuppaiah, 2024), as well as biofertilizers (Vaingankar & Rodrigues, 2015; Vithu et al., 2018; Bhavanisanker & Vanangamudi, 1999) on growth, flowering, yield, and quality attributes. The results showed that various types of fertilizers, applied both as foliar sprays and on soil significantly improved all these studied parameters.

Crossandra infundibuliformis is a popular ornamental plant appreciated for its bright orange flowers with an interesting shape, as well as for the glossy dark green foliage. This plant is grown outdoors in the tropical climates, in parks and gardens, and it is used in flowerbeds, borders, mass plantings, and in containers on patios. Additionally, it can be cultivated in pots as an indoor plant. The appearance and architecture of the plant have an important role at the plants cultivated in pots. Crossandra has an irregular growth habit, therefore to produce dwarf and marketable potted plants, various cultural techniques are required for a compact growth such as pinching (Bharathi et al., 2018) and/or application of plant growth regulators (Sundar et al., 2008; Beese & Sarvanan, 2020; Sreekala et al., 2000; Meghana et al., 2022, 2023). In India, the loose flowers of crossandra, either alone or in combination with jasmine, marigold and scented rose flowers are commonly used in garlands, and as hair adornments (Naveena & Thamaraiselvi, 2020; Remya et al., 2022).

Many ornamental species including crossandra have medicinal properties and can be used in complementary and alternative medicine (Mangroliya et al., 2022). The plant contains various bioactive compounds such as alkaloids, flavonoids, phenolic acids, glycosides, tannins, saponins, carbohydrates, terpenoids, minerals and other nutrients with therapeutic benefits (Sumalatha, 2012; Sangekar & Devarkar, 2017; Selvakumar, 2015; Selvakumar et al., 2016; Vasantha et al., 2022; Krupa & Hegde, 2024; Sajeena et al., 2024). It has been used in traditional medicine in India and many other countries around the world for the treatment of several diseases (Hari Vishva et al., 2022; Chavhan et al., 2023). Numerous studies have shown that the ethanolic and methanolic extracts of different parts of the plant (leaves, flowers and roots) presented significant pharmacological activities, such as antioxidant (Sharmila & Gomathi, 2011; Patil et al., 2014), antibacterial and antifungal (Elamathi et al., 2011; Madhumitha & Saral, 2011; Pulipati et al., 2013; Kumar et al., 2018), anti-inflammatory (Dhamija et. al, 2015), anti-arthritic (Sanakattula et al., 2019), antidiabetic, anthelmintic and anticancer (Vadivel & Panwal, 2016; Vasantha et al., 2023; Remya et al., 2023) activity.

Silver nanoparticles biosynthesized using aqueous flower extracts have demonstrated

anticancer properties (Manivasagan et al., 2019). The objective of this study was to investigate the influence of three fertilizers foliar application, on the growth and flowering of *Crossandra infundibuliformis*, to produce potted plants with high aesthetic value.

MATERIALS AND METHODS

The research on the influence of foliar application of fertilizers on vegetative growth and flowering of crossandra potted plants was carried out in the Floriculture Research Area, Faculty of Horticulture, University of Craiova, under greenhouse conditions. The biological material used consisted of rooted shoot tip cuttings, that were transplanted into 14 cm diameter plastic pots (1 plant/pot), filled with a mixture of peat and perlite (3:1), in May 2023. The cuttings were pinched after planting in pots to stimulate branching and obtain more compact plants. Three fertilizers were applied foliarly, bimonthly, until the flowering stage. The experimental variants were: T_1 (untreated control plants), T_2 (Green Feed 0.2%), T_3 (Bionat Plus 0.2%) and T_4 (Cropmax 0.2%). The foliar applications were carried out early in the morning, for maximum absorption of nutrients by the plants. The experiment was laid out in a randomized complete block design with three replications and four treatments.

The observations and measurements on the growth and flowering characteristics of the plants, such as plant height (cm), number of branches per plant, length and width of the leaves (cm), spike length (cm), number of spikes per plant, number of flowers per spike, and the number of days from planting to flowering were recorded. The obtained data were statistically analysed using one-way analysis of variance, and differences between treatments applied were compared by Duncan's multiple range test at the 5% probability level.

RESULTS AND DISCUSSIONS

Vegetative growth parameters

Foliar fertilizers have an important role in improving the quality, yield and metabolism of plants. The efficiency of foliar application of nutrients is influenced by many factors such as physico-chemical properties of spray solutions, environmental conditions (temperature, light, humidity, soil nutrition), the physiological status and the characteristics of the plants (Fernández et al., 2013). Foliar fertilization has the advantage as nutrients can be applied in controlled amounts and at specific growth stages, being absorbed through the leaves. It serves as a complementary fertilization strategy to enhance nutrient efficiency, minimize negative soil impacts, and correct nutritional deficiencies (Bindraban et al., 2015; Niu et al., 2021).

The results presented in Table 1 revealed that treatments with foliar fertilizers increased all vegetative growth parameters of crossandra plants. Statistical analysis of the data indicated a significant effect of fertilizers applied on plant height. The highest value was recorded in plants treated with Bionat Plus (40.82 cm), followed by Cropmax (38.53 cm), compared to the control variant, which had the lowest plant height value (29.73 cm). There were no significant differences between the treatments, for the other vegetative parameters analyzed. The maximum values for the number of branches per plant (7.81), leaf length (8.78 cm) and leaf width (4.63 cm) were recorded in plants sprayed with Bionat Plus 0.2%, while the minimum values of these growth features were observed in untreated plants.

Karuppaiah (2019) revealed that foliar spray of ferrous sulfate 0.5%, individually or in combination with bioregulators, significantly influenced the growth attributes in *Crossandra infundibuliformis* plants. Biju et al. (2020) reported that all vegetative and yield characteristics of crossandra plants recorded the highest values, compared to the control, by foliar application of $MnSO_4$ (0.5%) and $FeSO_4$ (0.5%) micronutrient mixture. Similarly, Lenin et al. (2021) studied the effect of micronutrients on the growth of crossandra cv. 'Delhi' and obtained the best results in plants sprayed with $ZnSO_4$ (0.5%) + $FeSO_4$ (0.5%).

Foliar fertilization is used to improve the visual quality and productivity of many ornamental plants. El-Nashar & El-Tony (2020) reported a significant increase in various vegetative growth characteristics, such as plant height, number of branches and leaves per plant, and stem diameter, as well as in flowering parameters in carnation plants grown in pots

and sprayed with chemical fertilizer solutions at the level of 4 $g \cdot L^{-1}$. Sharaf & El-Naggar (2003) evaluated the response of carnation plants to phosphorus and boron foliar fertilization under greenhouse conditions and concluded that the best growth and flowering results were achieved through foliar application of 200 mg/L^{-1} P_2O_5 in combination with 50 mg/L^{-1} B. The foliar application of the inorganic fertilizer Growmore on Syngonium plants at the concentration of 2.0 ml/L, significantly increased all growth parameters, pigment content, and nitrogen, phosphorus, and potassium ions content in the leaves (El-Quesni et al., 2010). Artur et al. (2022) showed that nitrogen foliar fertilization at a concentration of 20 $g \cdot L^{-1}$ applied twice a month, increased the height and diameter of *Anthurium maricense* plants grown in pots.

Table 1. The effect of foliar application of fertilizers on the growth of *Crossandra infundibuliformis* plants

Treatment	Plant height (cm)	Number of branches/ plant	Leaf length (cm)	Leaf width (cm)
T_1	29.73 c	5.66 a	6.93 a	3.85 a
T_2	32.61 bc	6.24 a	7.56 a	4.12 a
T_3	40.35 a	7.81 a	8.78 a	4.63 a
T_4	37.86 ab	6.13 a	8.61 a	4.41 a

Means with same letter(s) in a column are statistically non-significant at the 5% significance level according to Duncan's multiple range test.

Flowering parameters

The influence of foliar fertilizers on the number of spikes per plant, spike length, number of flowers per spike and the number of days to flowering is presented in Table 2. Foliar fertilization had a positive effect on the quality indicators of crossandra plants. The results indicated significant differences among the treatments, regarding the number of spikes per plant. The maximum value (8.27) was observed in T_4 (Cropmax 0.2%), while the minimum value (4.13) was recorded in the control plants. Application of foliar nutrients significantly increased the spike length for T_3 (8.62 cm), followed by T_2 (7.83 cm). The lowest average value of this parameter (6.47 cm) was observed in T_1 (untreated plants). The number of flowers per spike was also increased as a result of the foliar nutrition and ranged from 13.66 in control plants to 18.93 in plants that were treated with Bionat Plus 0.2%.

The plants sprayed with foliar fertilizers had an earlier flowering compared to the control plants. The analysis of the obtained data showed significant differences for the number of days from the planting in pots to flowering, in the treatment with Cropmax 0.2%, where the minimum value (81.33 days) was recorded.

Table 2. The effect of foliar application of fertilizers on flowering of *Crossandra infundibuliformis* plants

Treatment	Number of days to flowering	Number of spikes per plant	Spike length (cm)	Number of flowers per spike
T_1	92.16 b	4.13 c	6.47 b	13.66 b
T_2	89.65 b	6.25 b	7.83 a	17.51 a
T_3	87.42 ab	6.31 b	8.62 a	18.93 a
T_4	81.33 a	8.27 a	7.56 ab	14.25 b

Means with same letter(s) in a column are statistically non-significant at the 5% significance level according to Duncan's multiple range test.

CONCLUSIONS

The results indicated that the used foliar fertilizers improved various growth and flowering parameters of crossandra potted plants. Foliar application of Bionat Plus 0.2%, significantly increased the plant height, spike length and the number of flowers per spike, compared to the control variant. The plants sprayed with Cropmax 0.2% had the highest number of spikes per plant and bloomed earlier.

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