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Cultivation of *Furcraea foetida* ([L.] Haw.) under different nitrogen doses and sources

Cultivo de *Furcraea foetida* ([L.] Haw.) bajo diferentes dosis y fuentes de nitrógeno

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Potted giant false agave seedlings.

Photo: J.F. Meneages (2018)

ABSTRACT

The ornamental plant sector is diversified and demanding in terms of quality, which includes plant nutrition. Thus, the objective of this work was to evaluate the leaf development of *F. foetida* var. Striata cultivated in a greenhouse under different nitrogen dosages and sources. A completely randomized experimental design was used, in a 3×3+1 factorial scheme, nitrogen doses were 100, 200 and 300 mg $L^{-1}$and sources with different nitrogen percentages: calcium nitrate, ammonium nitrate and urea, plus the additional treatment (control: no treatment), with six replications. The number of leaves, length, width and leaf area were evaluated. It was observed that there was full leaf development of plants grown in pots, at 390 days after transplanting, the plants had average parameters of 10.4 leaves/plant, 36.9 cm in leaf length and 6.3 cm leaf width. It was concluded that the different nitrogen doses and sources favored the quality of leaf development of *F. foetida*, preserving their ornamental characteristics in terms of shape and plasticity.

Additional key words: ornamental plants; succulents; fertilization; leaf area; development.

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RESUMEN

El sector de las plantas ornamentales es diversificado y exigente en cuanto a calidad, lo que incluye la nutrición vegetal. Así, el objetivo de este trabajo fue evaluar el desarrollo foliar de *F. foetida* var. Striata cultivada en invernadero bajo diferentes dosis y fuentes de nitrógeno. Se utilizó un diseño experimental completamente al azar, en esquema factorial 3×3+1, las dosis de nitrógeno fueron 100, 200 y 300 mg L^{-1} y las fuentes con diferentes porcentajes de nitrógeno: nitrato de calcio, nitrato de amonio y urea, más el tratamiento adicional (control: sin tratamiento), con seis repeticiones. Se evaluó el número de hojas, longitud, ancho y área foliar. Se observó que hubo pleno desarrollo foliar de las plantas cultivadas en macetas, a los 390 días después del trasplante, las plantas presentaron parámetros promedio de 10,4 hojas/planta, 36,9 cm de largo y 6,3 cm de ancho de hoja. Se concluyó que las diferentes dosis y fuentes de nitrógeno favorecen la calidad del desarrollo foliar de las plantas de *F. foetida*, conservando sus características ornamentales en cuanto a forma y plasticidad.

Palabras clave adicionales: plantas ornamentales; suculentas; fertilización, área foliar, desarrollo.

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INTRODUCTION

The Brazilian floricultural sector is an important branch of agribusiness, which presents a great diversity of commercial products, with the cultivation of approximately 3,000 varieties between cut flowers, potted flowers, foliage and plants for landscaping, such as trees, shrubs and ground cover, with phytosanitary, visual and a esthetic quality (Junqueira and Peetz, 2017; Menegaes*et al*., 2022).

Furcraea foetida (L.) Haw. (Fig. 1) is among ornamental plants which are usually intended for landscaping, with leafy shrub characteristics, which stand out for the beauty and shape of their leaves. Popularly known as giant false agave, pita, piteira, caraguatá-açu and croatá-açu, belonging to the botanical family Asparagaceae, native to coastal regions of South America, including Brazil, it is characterized as a globular subshrub with an average height of 1.5 m and average diameter of 2.0 m. Its leaves are linear-lanceolate to oblanceolate (1.0-2.0 m × 18-20 cm) arranged in a rosette, fleshy, fibrous, long, flattened, dark green in color, with an acute tip (Lorenzi and Souza, 1999; Lorenzi, 2013; Lopes, 2017).

In the horticultural variety Striata, the leaves have white and green bands, and its whitish inflorescences are not very ornamental. This species multiplies easily through the numerous bulbils that form after the development of the flowers (Lorenziand Souza, 1999; Lorenzi, 2013; Lopes, 2017).

Plants from the genus Furcraea are characterized by the multiplicity of economic uses, from the production of fibers for clothing, packaging, agrochemical (insecticide and fungicide) and pharmacological uses to ornamental industries (Lopes, 2017; Murillo-Serna *et al*., 2018). The latter becomes important as long as they have a balanced nutrition, so that their beauty is fully expressed. According to Menegaes *et al.* (2022), fertilizer recommendations for floriculture, in general, are scarce, requiring this form of studies, mainly for species whose leaves are the part of the plant that stand out for their beautiful and ornamental appearance. The full development of cultivated plants is the result of the interaction of genetic factors (genotype), environment and management, resulting in the phenotype. This way, the quantification of the environmental factors that affect these processes makes it possible to improve the techniques applied to production (Floss, 2004; Fagundes *et al*., 2007).

Mineral nutrition is an important factor in agricultural crops. Nitrogen (N) is the most required mineral nutrient by plants, influencing on various plant growth and development characteristics. For some species, atmospheric N_2 is not directly utilized by plants, requiring supplementation in the form of soil fertilization (Epstein and Bloom, 2006; Prado, 2020).

The high dependence of N in plant metabolism is because it participates as a constituent of chlorophyll

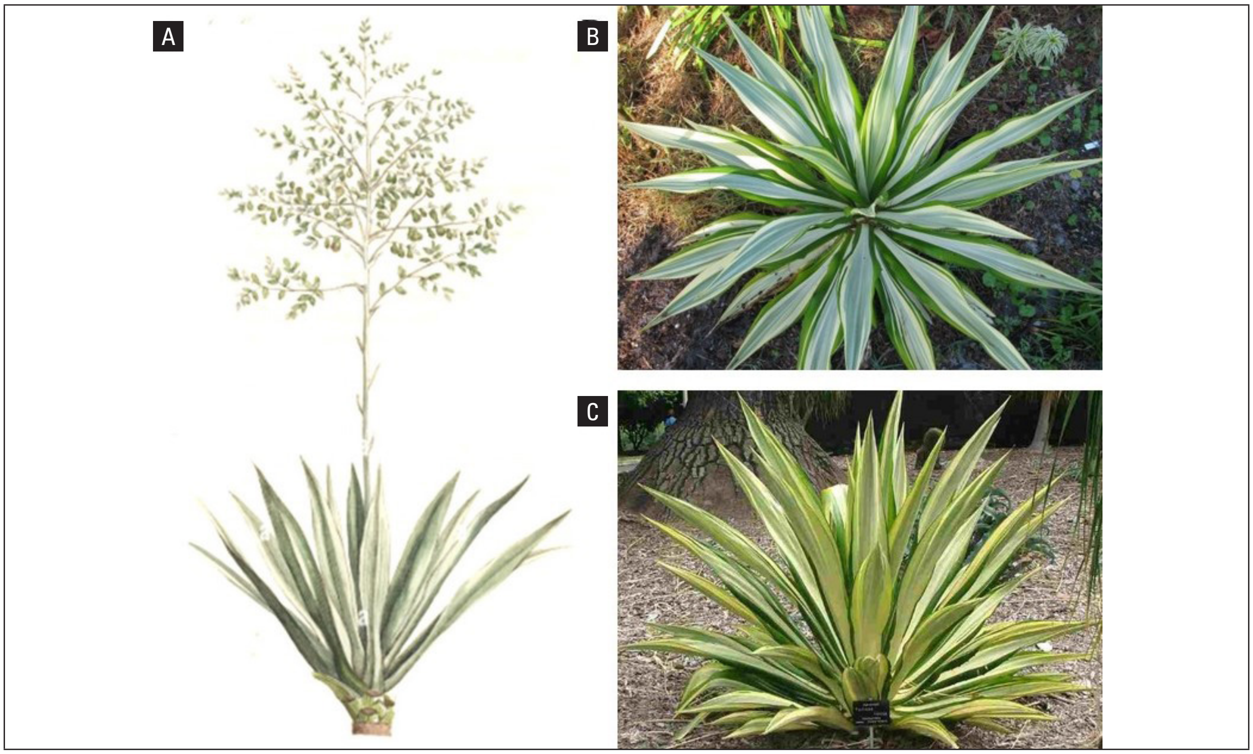

Figure 1. ***Furcraea foetida*** **(L.) Haw. A: botanical drawing adapted from Florilegius (2012), B: top view of the plant (Dutchlady, 2012) and C: side view of the plant (Navie, 2016).**

molecules, nucleic acids, amino acids and proteins, enzymes and coenzymes, vitamins, glycoproteins, lipoproteins, pigments, among others. Thus, the absorption of mineral N will depend on the form of fertilization and its interactions in the soil-plant-atmosphere system, resulting in the use of this nutrient by the plants or even in its loss through the processes of leaching, volatilization, denitrification, among others (Taiz and Zeiger, 2013; Mota *et al*., 2015).

During the soil fertilization process, it is observed that compounds containing nitrates (NO_3^-) and ammonia (N-NH_3) present great N loss by leaching and volatilization, respectively. When in pot cultivation, the dosage must be well calculated to avoid this loss. Among nitrogen fertilizers, urea becomes a source of N which is easy to handle and with high agronomic efficiency (Epstein and Bloom, 2006; Mota *et al*., 2015).

Given the above, the objective of this work was to evaluate leaf development of *F. foetida* var. Striata under different nitrogen doses and sources.

MATERIALS AND METHODS

The experiment was carried out from August 2017 to September 2018, in a greenhouse of the Floriculture Sector, Department of Phytotechnics, at the Federal University of Santa Maria, in Santa Maria, Brazil (29°43' S; 53°43' W and altitude of 95 m). The climate in the region is classified as humid subtropical (Cfa), according to the Köppen-Geiger classification, with average annual rainfall of 1,769 mm, average annual temperature close to 19.2°C and air humidity around 78.4% (Alvares *et al*., 2013).

A completely randomized experimental design was used, in a 3×3+1 factorial scheme (doses, sources and additional treatment), the doses were 100, 200 and 300 mg L^{-1}; the nitrogen sources presented different percentages of nitrogen (N): calcium nitrate ($CaNO_3$ with 15.5% N), ammonium nitrate (NH_4NO_3 with 34.0% N) and urea (CH_4N_2O with 42.0% N); plus the additional treatment (control: no treatment); with six repetitions. Each experimental unit consisted of a vase containing a *F. foetida* seedling.

The seedlings were obtained from the bulbils of mother plants from the Floriculture Sector itself. The well-developed seedlings, containing five leaves (16.4 × 6.3 cm), after 60 days of propagation, were transplanted into 8 L plastic pots in black color, containing Arenic Dystrophic Red Argisol soil. The soil was collected at a depth of 20 cm, and the chemical analysis report of the soil before cultivation, carried out at the UFSM Soil Laboratory, presented the following characteristics: clay 26%; organic matter 2.2%; water pH (1:1) 5.9; SMP index 6.1; CTC efet. 8.9; CTC pH 7, 10.6; base saturation 80.5%; zero Al saturation; Ca 6.3 $cmol_c$ dm^{-3}; Mg 5.8 $cmol_c$ dm^{-3}; S 12.3 mg dm^{-3}; P-Mehlich 52.8 mg dm^{-3}; K 219 mg dm^{-3}; Cu 1.75 mg dm^{-3}; Zn 3.58 mg dm^{-3}; B 0.1 mg dm^{-3}.

The nitrogen fertilizations were divided into five times, the first fertilization occurred on the day of transplanting the seedlings into the pots and the others took place with an interval of 75 d, with the fertilizations on days: 0, 75, 150, 225 and 300 days after transplanting (DAT). Leaf development is understood by the average number of leaves (live and senescent) per branch by the method of counting, width and length of leaves using a millimeter rule, every 30 DAT, according to leaf emission based on figure 2. Irrigation was carried out via drip tape every 2 d.

Total leaf area (AF) was determined using the methodology described by INRA (1970), expressed in the equation $LA = \sum_1^n (W*C) *k$, in which: W: leaf width; L: leaf length; n: number of total leaves; k: correction factor calculated from the angular coefficient of the linear equation between leaf width and length by the methodology of Moraes *et al*. (2013), k=0.664.

The results were statistically evaluated by means of analysis of variance (ANOVA), with the individual effects of treatments by regression (P<0.05) as a function of the period during the 390-d experiment, being carried out with the aid of the SISVAR software (Ferreira, 2014).

RESULTS AND DISCUSSION

It was observed that the variables of total number of leaves and expansion of *F. foetida* leaf length and width (Fig. 3) were similar for all doses and sources of nitrogen fertilization. During the evaluations, 390 DAT, it was observed that the overall average number was 10.4 leaves/plant.

Foliar emission averages were, for all treatments, 5.5; 6.8; 8.1; 9.0; 9.9; 10.8; 11.1; 11.6; 11.4; 12.5; 12.5; 13.0 and 13.3 leaves for 30; 60; 90; 120; 150; 180; 210; 240; 270; 300; 330; 360 and 390 DAT, in that order. Throughout the experiment, averages of 10.0; 9.7; 9.9; 10.3; 10.1; 11.0; 11.0; 10.1; 10.8 and 11.2 leaves issued for the control treatments (additional one); 100; 200 and 300 mg L^{-1} calcium nitrate, 100; 200 and 300 mg L^{-1} ammonium nitrate and 100; 200 and 300 mg L^{-1} urea, respectively.

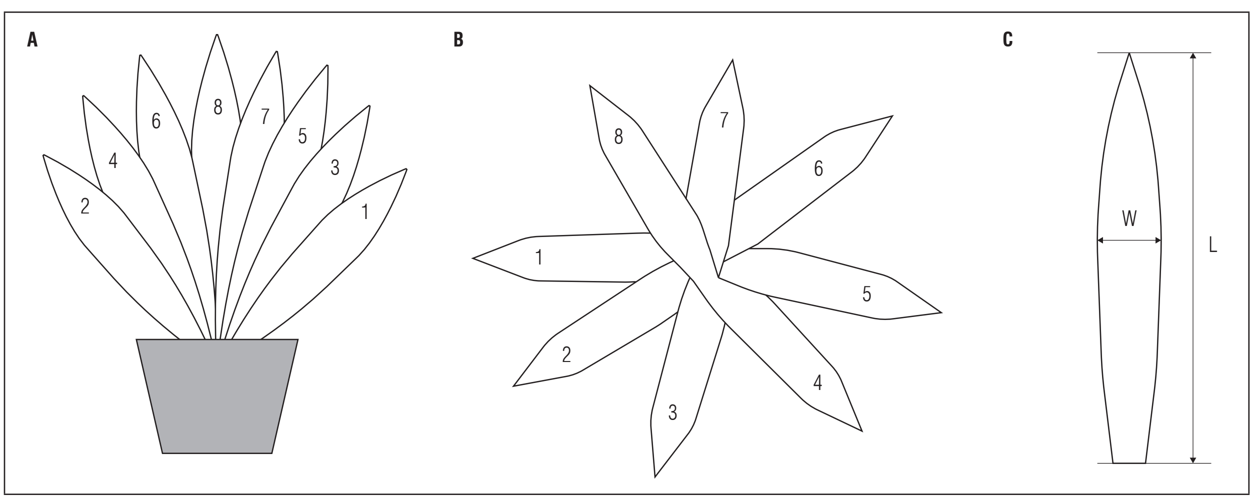

Figure 2. Schematic representation of the leaf emission of *F. foetida* in the form of a rosette in front view (A), top view (B) and factors for calculating the leaf area (C) in which W: leaf width and L: leaf length. Source: Menegaes (2018).

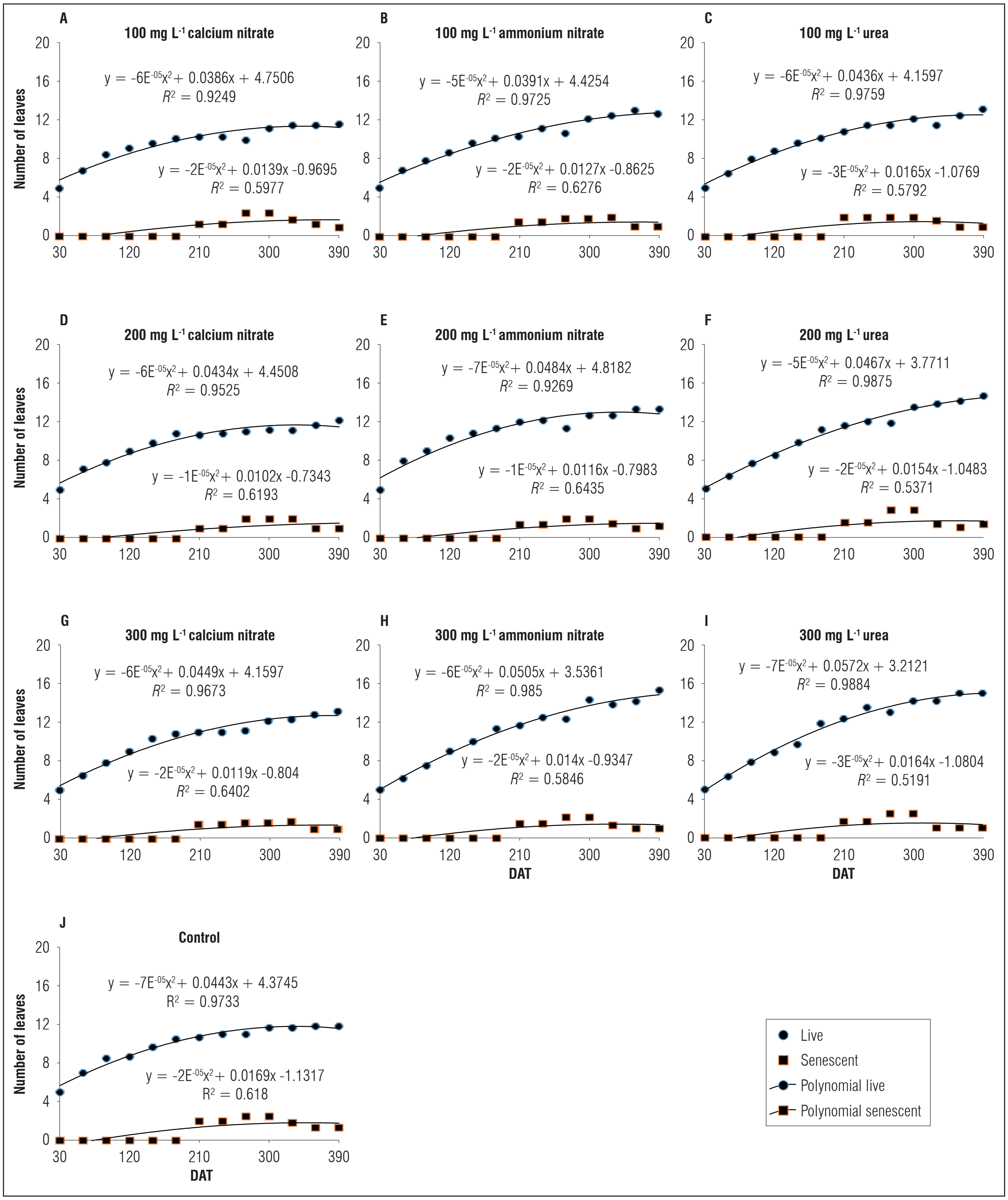

Figure 3. Evolution of the number of leaves (live and senescent) of *F. foetida* var. Striata cultivated under different nitrogen doses and sources. DAT, days after transplanting.a

It was observed that between 30 to 210 DAT there was an increase in the curve for leaf emission, whereas from 330 DAT onwards there was a tendency to stabilize and maintain the number of leaves. Only after 210 DAT did leaf senescence begin with an average of 1.5; 1.5; 2.2; 2.2; 1.6; 1.1 and 1.1 leaves in all treatments for 210; 240; 270; 300; 330; 360 and 390 DAT, in that order. This indicates that *F. foetida* plants have high leaf durability, an important factor for ornamental plants intended for landscaping. Therefore, leaf persistence for long periods helps the plant to preserve its shape and plasticity without major changes. According to Menegaes *et al*. (2022), ornamental plants should maintain beauty, shapes and plasticity in the garden, forming a harmonic visual set.

In figure 4, it was verified that the average leaf length of *F. foetida* was favored by the increase in nitrogen doses in relation to the control (additional) treatment, which at 390 DAT presented an average leaf length of 34.9 cm, in relation to the other treatments that presented averages of 35.5; 37.6; 35.2; 35.1; 39.1; 37.6; 37.4; 37.5 and 39.0 cm for treatments of 100; 200 and 300 mg L^{-1} calcium nitrate, 100; 200 and 300 mg L^{-1} ammonium nitrate and 100; 200 and 300 mg L^{-1} urea, respectively.

It was observed that the leaf width of *F. foetida* showed little variation over the 390 DAT evaluations (Fig. 4), regardless of the doses and nitrogen sources offered as fertilizer for the plants, obtaining averages of 1.5; 1.6; 2.0; 2.4; 2.8; 3.2; 4.1; 4.8; 4.9; 5.1; 5.6; 6.0 and 6.3 cm at 30; 60; 90; 120; 150; 180; 210; 240; 270; 300; 330; 360 and 390 DAT, in that order.

According to Lopes (2017), *F. foetida* presents leaf length and width between 1.0-2.0 m and 18-20 cm, respectively, when the plant is adult. However, in our experiment, *F. foetida* was cultivated in an 8 L pot, at 390 DAT, with averages of 36.9 cm in length and 6.3 cm in leaf width. This can be attributed to the fertilization adopted in this experiment.

The results for total leaf area were observed, being similar for all doses and sources of nitrogen fertilization (Fig. 5), varying according to the evolution of the leaf area, for all treatments of 62.0; 75.8; 90.6; 106.8; 132.9; 162.4; 197.7; 229.4; 233.6; 273.4; 300.4; 299.2 and 309.9 cm^2 at 30; 60; 90; 120; 150; 180; 210; 240; 270; 300; 330; 360 and 390 DAT, in that order. The treatments obtained averages of 263.3; 249.2; 296.3; 304.2; 268.6; 340.7; 375.8; 320.1; 367.4 and 313.0 cm^2 at 390 DAT; in control, 100; 200 and 300 mg L^{-1} calcium nitrate, 100; 200 and 300 mg L^{-1} ammonium nitrate and 100; 200 and 300 mg L^{-1} urea, respectively.

According to Mainardi *et al.* (2004) and Taiz and Zeiger (2013), the leaf area of a plant is related to the emission of new leaves, with a direct correlation between the forms of fertilization and light intensity, thus favoring the fixation of energy as by-products for photosynthesis. Menegaes *et al.* (2016) found that the increase in leaf area of chrysanthemum (*Dendranthema grandiflora* Tzelev) cv. Snowdon is favored by light intensity (long days).

It should also be noted that these values are within acceptable averages for *F. foetida* at this age, another point to consider is that this species is very rustic and well adapted to the region under study and that the different doses of nitrogen fertilization were very close and, therefore, there was no significant difference for the variables mentioned above.

Freitas *et al*. (2010), studying nitrogen fertilization (nitrate and ammonium) in anthurium (*Anthurium andraeanum* Linden.), observed results that are similar to ours for the number of leaves. The same authors also clarify that the prominence of anthurium as an ornamental plant is due to the exuberant foliage, information which is likewise accepted for *F. foetida*. Therefore, adequate nitrogen nutrition is important to avoid an imbalance in the synthesis of phytohormones, which can lead to accelerated growth due to N retention in the plant, however, the deficiency of this nutrient anticipates leaf senescence.

Also, Santos *et al.* (2015), evaluating the effect of N doses on the vegetative development and nutrient content in leaves of bromeliads *Nidularium fulgens* Lem., found that there was an increase in plant height when increasing doses of nitrogen were applied. An important point to highlight in relation to nitrogen fertilization is moderation in the applied doses. According to Camargo *et al*. (2008), it is necessary to be careful with high N fertilizations in order not to reduce the production of flowers in soils with high fertility, as shown by the results of their experiment with aster (*Aster ericoides* L.).

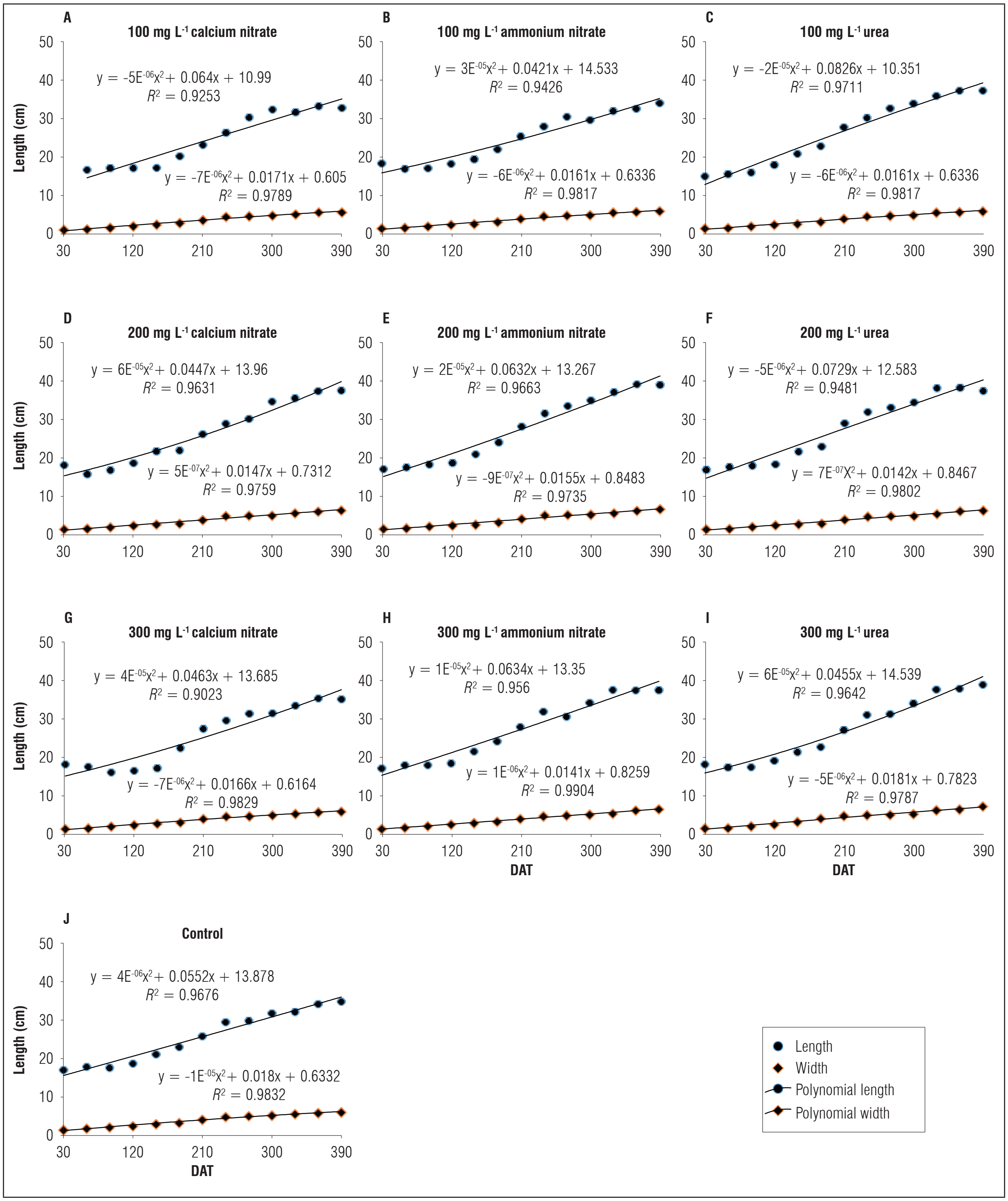

Figure 4. **Evolution of leaf length and width of *F. foetida* var. Striata cultivated in different nitrogen doses and sources.**

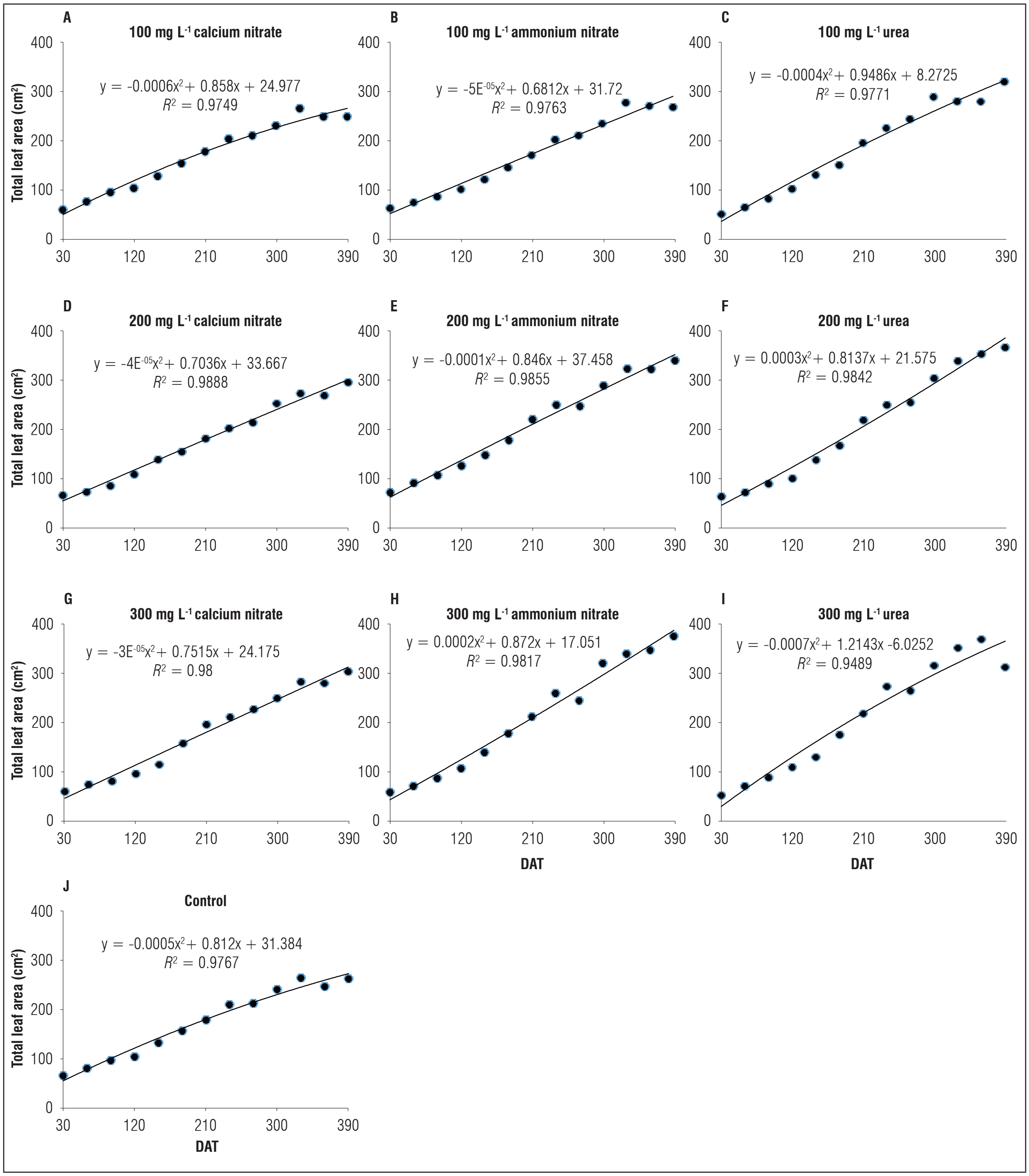

Figure 5. Total leaf area of *F. foetida* var. Striata cultivated in different nitrogen doses and sources.

CONCLUSION

The different nitrogen doses and sources studied in this experiment favored the quality of leaf development of giant *F. foetida* var. Striata, grown in pots for 390 days after transplanting the seedlings. The ornamental characteristics of shape and plasticity were maintained throughout the cultivation, with averages of 10.4 leaves/plant, 36.9 cm in leaf length and 6.3 cm in leaf width.

Conflict of interests: The manuscript was prepared and reviewed with the participation of the authors, who declare that there exists no conflict of interest that puts at risk the validity of the presented results.

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