Growth of leopard flower (*Belamcanda chinensis*) with humics acids in nursery garden

Crescimento da flor leopardo (*Belamcanda chinensis*) com ácidos húmicos em viveiro

Crescimento de la flor del leopardo (*Belamcanda chinenses*) com ácidos húmicos e nuno vivero

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**Abstract**

Humic acids constitute a fraction of organic matter that either has direct effects on the growth and development of ornamental plants. The present study aimed to evaluate the differential growth of the leopard flower (*Belamcanda chinensis*) from the application of humic acids extracted from poultry litter (HA_{PL}) and bovine manure (HA_{BM}) during the nursery garden phase. The seeds were immersed in solutions of 0, 10, 20, 30 and 40 mmol L\(^{-1}\) of C in HA_{PL} and in the same way for HA_{BM}. After 150 days, the plants were collected and measured the number of leaves, plant height, fresh matter of the aerial part, dry matter of the root, total fresh matter, and dry matter of the aerial part, dry matter of the root and total dry matter. The use of the correct concentration of humic acids stimulates the growth and accumulation of total dry material in the leopard plant in the order of 33% to 58% for HA_{PL} and HA_{BM} respectively.

**Keywords:** *Belamcanda chinensis*; Humic substances; Organic matter.

**Resumo**

Os ácidos húmicos, constituem uma fração da matéria orgânica que apresenta efeitos diretos no crescimento e desenvolvimento de plantas ornamentais. O presente trabalho teve por objetivo avaliar o crescimento diferencial da flor leopardo (*Belamcanda chinensis*) a partir da aplicação de ácidos húmicos extraídos de cama de frango (HA_{PL}) e de esterco bovino (HA_{BM}) durante a fase de viveiro. As sementes foram imersas em soluções de 0, 10, 20, 30 e 40 mmol L\(^{-1}\) de C no HA_{PL} e da mesma forma para o HA_{BM}. Após 150 dias as plantas foram coletadas e feitas às medições do número de folhas, altura das plantas, matéria fresca da parte aérea, matéria seca da raiz, matéria fresca total, matéria seca da parte aérea, matéria seca da raiz e matéria seca total. A utilização da concentração correta dos ácidos húmicos estimula o crescimento e o acúmulo de material seco total na planta de leopardo na ordem de 33% a 58% para HA_{PL} e HA_{BM} respectivamente.

**Palavras-chave:** *Belamcanda chinensis*; Substâncias húmicas; Matéria orgânica.
Resumen

Los ácidos húmicos constituyen una fracción de la materia orgánica que tiene efectos directos sobre el crecimiento y desarrollo de las plantas ornamentales. El presente trabajo tuvo como objetivo evaluar el crecimiento diferencial de la flor de leopardo (*Belamcanda chinensis*) a partir de la aplicación de ácidos húmicos extraídos de gallinero (HA<sub>PL</sub>) y estiércol bovino (HA<sub>BM</sub>) durante la fase de vivero. Las semillas se sumergieron en soluciones de 0, 10, 20, 30 y 40 mmol L<sup>-1</sup> de C en HA<sub>PL</sub> y de la misma forma para HA<sub>BM</sub>. A los 150 días se recolectaron las plantas y se tomaron para medir el número de hojas, altura de la planta, materia fresca de la parte aérea, materia seca de la raíz, materia fresca total, materia seca de la parte aérea, materia seca de la raíz y total materia seca. El uso de la concentración correcta de ácidos húmicos estimula el crecimiento y acumulación de materia seca total en la planta de leopardo en el orden de 33% a 58% para HA<sub>PL</sub> y HA<sub>BM</sub> respectivamente.

**Palabras clave:** *Belamcanda chinensis*; Sustancias húmicas; Materia orgánica.

1. Introducción

El mundo producción de flores ocupa aproximadamente 190 mil hectáreas y genera un ingreso aproximado de 16 billones de dólares en términos de producción y 44 billones de dólares en términos de comercio al por menor (Benschop et al. 2010; Weber et al. 2017; Mikovski et al. 2019). Gracias a la diversidad de especies que posee Brasil, muchas especies nativas y introducidas florecen con un alto potencial de explotación económica (Ibraflor, 2012), una de estas es conocida como la flor de leopardo (*Belamcanda chinensis*). Familia de Plantas “Iridaceae”, herbácea, perenne, florífera y nativa de China y Japón, de altura 50-90 cm, plana, larga y dispuesta en el tallo en forma de pétalos, su inflorescencia es erecta, ramificada, con flores amarillo-naranja con puntos amarillos (Lorenzi, 2008; Szandruk et al. 2018; Song et al. 2018; Téllez et al. 2020).

El mercado de plantas ornamentales es internacionalmente competitivo y se caracteriza por periodos de alta demanda y otros de calma inferior (Asocolflores, 2005). La producción y comercialización de flores concentradas en dos actores principales, los Países Bajos y Colombia, cada uno con 58.2% y 13.4% de participación en el mercado mundial (Fao, 2004). Otros países que tienen una presencia fuerte son Italia, Dinamarca, Francia, Ecuador, y México (Fao, 2004). La producción de la flor de leopardo se evalúa principalmente por la altura de la planta y la calidad comercial de la inflorescencia (Yang et al. 2012; Ji et al. 2020; Santos-Silva et al. 2020). Así, diferentes factores influyen en estas variables como el clima y las condiciones del suelo, la nutrición mineral, la calidad del agua, y la aplicación de reguladores de crecimiento de las plantas (Maciel et al. 2013; Silva et al. 2013; Li et al. 2018).

En este contexto, el tratamiento del corte de raíces con sustancias húmicas que directamente afectan el crecimiento y desarrollo de las plantas ornamentales, puede ser una alternativa para aumentar la producción y calidad de la flor de leopardo (*Belamcanda chinensis*). (Baldotto et al. 2012, 2013, 2015).

Los ácidos húmicos representan una pequeña parte del material orgánico correspondiente a la fracción de los ácidos húmicos solubles en medios alcalinos. La aplicación de ácidos húmicos puede acelerar la germinación y mejorar las calidades de altura, área de hoja, peso del material seco del tallo y raíz y la floricultura especies de cultivo (Arancon et al., 2003; Primo et al., 2011; Baldotto et al., 2014). Aunque en el mercado hay productos comerciales que tienen el mismo trabajo que los HA, que proporcionan macronutrientes y micronutrientes para la planta, aumentan el enraizamiento y el desarrollo vegetativo (Bezerra et al., 2007), con altos costos que no permiten a los productores pequeños acceder a estos productos.

El presente trabajo tiene como objetivo evaluar el crecimiento de un especie floral con potencial comercial Leopard flower (*Belamcanda chinensis*), como una respuesta a la aplicación de cinco concentraciones de HA obtenidas de desperdicios de gallinero y cinco concentraciones de HA obtenidas de estiércol bovino controlada en el vivero.

2. Metodología

El experimento se llevó a cabo en el jardín de la Floricultura del Departamento de Floricultura de la Universidad Federal de Viçosa, en la ciudad Florestal, estado de Minas Gerais, Brasil (19°53’57” S latitud 44°26’38” W) a 780 msnm. Los 10 tratamientos se distribuyeron en el siguiente orden (Tabla 1).
The HA was previously isolated and evaluated by Baldotto et al. (2014). The leopard flower seeds (*Belamcanda chinensis*) were immersed in the solutions of the treatment for 24 hours. Previously they were seeded in 130 cm$^3$ tube containing soil, chemically characterized by having pH= 4.84; P 34 mg dm$^{-3}$; K= 486.5 mg dm$^{-3}$; Ca$^{2+}$= 3.63; Mg$^{2+}$= 3.73; Al$^{3+}$= 0.29; Al+H= 7; Sb= 8.56; CEC= 8.86 (all previous values are cmol/dm$^{-3}$).

The experimental unit consisted of two plants per tube, which remained in the nursery garden covered by 50% shade.

The design used was completely randomized with ten treatments and 15 replications for each treatment, five different concentrations of HA of two different types: humic acid extracted from poultry litter and bovine manure.

The analyzed variables were: the number of leaves (LN) by plant for each of the repetition, the height of the plant from it base until it apex with a measuring tape; also the measure of fresh matter shoot (FMS), fresh matter root (FMR) and fresh matter total (FMT) using the scale Shimadzu AY 200; subsequently, the samples were placed to dry in a forced air oven at 60º for 7 days and measurements of dry matter shoot (DMS), dry matter root (DMR) and the fresh matter total (FMT) were performed.

### 3. Results and Discussion

The results of the analysis of growth and production of ornamental plants of leopard (*Belamcanda chinensis*) in response to the increased concentration of the application of humic acids (HAPL and HABM) showed a difference in the performance of rooting and development of the aerial part, as shown in the table below (Table 2). The studied variables were positively influenced by the treatment of leopard flower with humic acids.

**Table 1. Treatments used in the test.**

| Treatment | Origin of Humic Acid | Concentration |
|-----------|----------------------|---------------|
| 1         | Poultry Litter       | 0 mmol L$^{-1}$ C |
| 2         | Poultry Litter       | 10 mmol L$^{-1}$ C |
| 3         | Poultry Litter       | 20 mmol L$^{-1}$ C |
| 4         | Poultry Litter       | 30 mmol L$^{-1}$ C |
| 5         | Poultry Litter       | 40 mmol L$^{-1}$ C |
| 6         | Bovine Manure        | 0 mmol L$^{-1}$ C |
| 7         | Bovine Manure        | 10 mmol L$^{-1}$ C |
| 8         | Bovine Manure        | 20 mmol L$^{-1}$ C |
| 9         | Bovine Manure        | 30 mmol L$^{-1}$ C |
| 10        | Bovine Manure        | 40 mmol L$^{-1}$ C |

Source: Authors.
Table 2. Medium, residual mean square (RMS) and coefficients of variation (CV%) for the number of leaves (NL), plant height (PH), fresh matter of shoots (FMS), fresh matter of root (FMR), fresh matter total (FMT), dry matter of shoot (DMS), dry matter of root (DMR) and total dry matter (DMT) as a function of increasing concentrations (0, 10, 20, 30, 40 mmol L\(^{-1}\) of C) isolated humic acid poultry litter (HA\(_{PL}\)) and bovine manure (HA\(_{BM}\)).

| Treatment | NL | PH | FMS | FMR | FMT | DMS | DMR | DMT |
|-----------|----|----|-----|-----|-----|-----|-----|-----|
| HA\(_{PL}\) (0) | 3  | 14 | 0.5304 | 0.1707 | 0.7012 | 0.0906 | 0.0781 | 0.1687 |
| HA\(_{PL}\) (10) | 3  | 15 | 0.6270 | 0.3391 | 0.9662 | 0.1043 | 0.1069 | 0.2112 |
| HA\(_{PL}\) (20) | 3  | 16 | 0.6215 | 0.2257 | 0.8472 | 0.1175 | 0.0907 | 0.2083 |
| HA\(_{PL}\) (30) | 4  | 16 | 0.6609 | 0.2184 | 0.8793 | 0.1206 | 0.1123 | 0.2329 |
| HA\(_{PL}\) (40) | 3  | 15 | 0.6027 | 0.1516 | 0.7544 | 0.1026 | 0.1092 | 0.2118 |
| HA\(_{BM}\) (0) | 3  | 14 | 0.5304 | 0.1707 | 0.7012 | 0.0906 | 0.0781 | 0.1687 |
| HA\(_{BM}\) (10) | 3  | 16 | 0.6471 | 0.2708 | 0.9179 | 0.1171 | 0.1016 | 0.2187 |
| HA\(_{BM}\) (20) | 3  | 16 | 0.6269 | 0.3359 | 0.9628 | 0.1112 | 0.1200 | 0.2313 |
| HA\(_{BM}\) (30) | 4  | 16 | 0.6591 | 0.3669 | 1.0266 | 0.1127 | 0.1119 | 0.2247 |
| HA\(_{BM}\) (40) | 3  | 15 | 0.5831 | 0.2555 | 0.8386 | 0.0955 | 0.0845 | 0.1800 |
| RMS | 0.2711 | 29.894 | 0.0286 | 0.0176 | 0.06944 | 0.000861 | 0.00279 | 0.00488 |
| CV (%) | 15.3 | 11.2 | 27.8 | 53 | 30 | 27.6 | 53.3 | 34 |

Source: Authors.

The curves regarding the response of the application of increasing concentrations of humic acids from bovine manure and poultry litter showed quadratic variation (Table 3). Due to the size of these equations, the concentrations of maximum physical efficiency DMT of the leopard plant were calculated for the concentration of HA\(_{PL}\) and HA\(_{BM}\).
Table 3. Regression equations for the characteristics, number of leaves (NL), plant height (PH), fresh matter of shoots (FMS), fresh matter of root (FMR), fresh matter total (FMT), dry matter of shoot (DMS), dry matter of root (DMR) and total dry matter (DMT) as a function of increasing concentrations (0, 10, 20, 30, 40 mmol L\(^{-1}\) of C) isolated humic acid poultry litter (HA\(_{PL}\)) and bovine manure (HA\(_{BM}\)).

| Variable | AH     | Equation                                                                 | R\(^2\) |
|----------|--------|--------------------------------------------------------------------------|---------|
| NL       | HA\(_{PL}\) | \(\hat{y} = 3,431 - 0,0259 x + 0,0021 x^2 - 0,00004 x^3\)             | 0,9821  |
|          | HA\(_{BM}\) | \(\hat{y} = 3,404 + 0,0137 x - 0,0005 x^2\)                         | 0,6388  |
| HP       | HA\(_{PL}\) | \(\hat{y} = 14,064 + 0,186 x - 0,0042 x^2\)                      | 0,9055  |
|          | HA\(_{BM}\) | \(\hat{y} = 14,306 + 0,2032 x - 0,0045 x^2\)                     | 0,9466  |
| FMS      | HA\(_{PL}\) | \(\hat{y} = 0,535 + 0,0093 x - 0,0002 x^2\)                       | 0,8719  |
|          | HA\(_{BM}\) | \(\hat{y} = 0,5383 + 0,0107 x - 0,0002 x^2\)                      | 0,8354  |
| FMR      | HA\(_{PL}\) | \(\hat{y} = 0,2099 + 0,0088 x - 0,0003 x^2\)                      | 0,5629  |
|          | HA\(_{BM}\) | \(\hat{y} = 0,1615 + 0,0157 x - 0,0003 x^2\)                      | 0,9432  |
| FMT      | HA\(_{PL}\) | \(\hat{y} = 0,7359 + 0,0182 x - 0,0004 x^2\)                      | 0,6490  |
|          | HA\(_{BM}\) | \(\hat{y} = 0,6998 + 0,0264 x - 0,0006 x^2\)                      | 0,9423  |
| DMS      | HA\(_{PL}\) | \(\hat{y} = 0,0886 + 0,0025 x - 0,00005 x^2\)                     | 0,9285  |
|          | HA\(_{BM}\) | \(\hat{y} = 0,0929 + 0,0023 x - 0,00006 x^2\)                     | 0,8506  |
| DMR      | HA\(_{PL}\) | \(\hat{y} = 0,0822 + 0,0014 x - 0,00002 x^2\)                     | 0,5978  |
|          | HA\(_{BM}\) | \(\hat{y} = 0,0763 + 0,0039 x - 0,00009 x^2\)                     | 0,9748  |
| DMT      | HA\(_{PL}\) | \(\hat{y} = 0,1707 + 0,0039 x - 0,00007 x^2\)                     | 0,8607  |
|          | HA\(_{BM}\) | \(\hat{y} = 0,1692 + 0,0062 x - 0,0001 x^2\)                     | 0,9938  |

Source: Authors.

The maximum efficient values of DMT were observed for the HA\(_{PL}\) to a concentration of 28 mmol L\(^{-1}\) of C and a reach weight of 0.2250 grams and for the HA\(_{BM}\) the maximum efficient value was found in a concentration of 31 mmol L\(^{-1}\) of C and 0.2653 g. We can infer that with the use of the correct concentration we can obtain DMT increases of 33% concerning the control. When compared the data with maximum efficiency between HA\(_{PL}\) and HA\(_{BM}\) can be observed that there are no different means between the HA. The decision of which HA will be used will depend on the availability of the material for the producer.

The results corroborate studies of Baldotto et al. (2009) where they observed increases in growth and development of in vitro plantlets of pineapples in response to the application HA. Baldotto et al. (2014) in a test of acclimatization of orchid (Cymbidium sp.) in response to application humic acid, also observed increments in the development and growth of seedlings after application of humic acid. Bernardes et al. (2013), to study the effect of the application of humic substance in tomato seedlings, concluded that HA is accelerator metabolisms of plants favoring a high development and therefore significant increases the DMT. Similar results were also found by Arancon et al. (2003), in the study effects of vermicomposts to tomatoes...
and peppers grown in the field and strawberries under high plastic tunnels. The use of an adequate concentration of HA encourages rooting and plant development.

4. Conclusion

The treatment of ornamental leopard flower cuttings with humic acids increases the number and quality of the flower stems and the concentration range of both evaluated humic acids that induce maximum efficiency in the production and quality of ornamental leopard stems was $5-10 \text{ mmol L}^{-1}$ and $15-30 \text{ mmol L}^{-1}$ for poultry litter and bovine manure respectively. This shows that the application of HA in appropriate concentrations for each species, stimulates the production of seedlings, favoring the of olaceous and flowers sectors.

Thus, the use of humic substances in promoting plant growth is of fundamental importance, since this practice reduces the use of chemical fertilizers that lead to serious environmental problems. Therefore, the development of research aimed at accelerating the production of ornamental plants with the use of organic compounds should be increasingly encouraged to grant improvements in the distribution system of these goods, guaranteeing an expansion of the consumer culture without major associations with the environment.

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