

Effects of varying doses and timing of humic acid application on growth and flowering of *Zinnia elegans*

Abstract

Aims: The aim of this work was to investigate the effect of humic acid, applied at different concentrations and time intervals, on the vegetative and flowering characters of *Zinnia elegans*.

Study design: The experiment was designed as a complete randomized design with three replications and a total of nine treatments.

Place and Duration of Study: The experiment was conducted at the Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab. The study was carried out over a specific duration in 2022.

Methodology: The study was conducted in a shaded area, where *Zinnia elegans* plants were subjected to foliar spraying of humic acid at three different concentrations (2.5, 3.5, and 5.0 mL/L) and at different intervals (10, 30 and 10 and 30 days both after transplanting) after transplanting. Various aspects of plant growth, including plant height, leaf area, root length, branching, and flowering parameters such as days to flower, blooming period, flower size, and number of flowers per plant were observed.

Results: The results showed that foliar application of humic acid at a concentration of 3.5 mL/L in 10 and 30 days after planting significantly increased plant height, leaf area, root length, branching, flower size, and number of flowers per plant. Plants treated with 3.5 mL/L of humic acid exhibited the highest values for these parameters compared to other treatments and the control (water spray). The days taken to flower were also reduced in plants treated with higher concentrations of humic acid.

Conclusion: The findings of this study indicate that foliar application of humic acid, particularly at a concentration of 3.5 mL/L in 10 and 30 days after planting, positively influenced the vegetative and flowering dimensions of *Zinnia elegans*.

Key words: *Zinnia elegans*, Humic acid, Plant Growth, Flowering

1. INTRODUCTION

Asteraceae, the family of plants that comprises *Zinnia* species, includes both annual and perennial plants. *Zinnia elegans* L. is said to be the most widely known summer annual. It is a significant summer flowering crop planted in Egypt for its beauty and various landscaping applications. It blooms from May to October with a variety of flower forms and a lovely bloom in diverse flower varieties. The plant performs well in a variety of settings and has a long vase life. It's great for walk ways and borders. It is utilized for bedding, mass plantings, and cut flowers in gardens as well as in containers and as ground coverings (Kessler, 2008).

The most well-known species and a representative of hot and humid climates is the zinnia. For cut flowers, taller zinnia cultivars are typically utilized in beds and borders, while dwarf varieties

are used in window pots and other containers (Jana and Pal, 1991). Zinnias are grown from seeds, which are first seeded directly in pots before being transplanted into the ground. Zinnia needed a temperature of 23–27°C to germinate in five to seven days. when seedlings are transplanted onto a field or beds when they are 3–6 weeks old (Schoellhorn *et al.*, 2004).

According to Nardi *et al.*, (2004), humic acid is a bio-stimulant that has a systematic binding effect on plant growth and development and increases yield. The organic, chemical, and physical properties of soil are improved by humic acid (Varanimi *et al.*, 1995; Keeling *et al.*, 2003; Mikkelsen, 2005). Humic acid is an organic compound derived from plant and animal residues and microbial cells with long-term physical, chemical, and biological processes, and it is also a natural material that improves the efficiency of phosphate fertilizers (Memon *et al.*, 2014; Mukhtar *et al.*, 2016; Jing *et al.*, 2020)

2. Material and methods

An experiment was conducted at the Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab in 2022 to study the effect of Humic acid and time of application on the growth and yield of *Zinnia elegans*. The experiment was designed as a complete randomized design with three replications and a total of nine treatments. The treatments consisted of three different concentrations of humic acid (2.5, 3.5, and 5.0 ml/L of water) applied at different times: a single spray at an early stage (10 days after transplanting), a single spray at 30 days after transplanting, and a double spray after 10 and 30 days after transplanting. The control treatment involved spraying water.

The experiment began by sowing *Zinnia elegans* seeds in modulated trays placed in a regulated high take greenhouse to facilitate germination. Germination greenhouse or vegetation house with a temperature of -25 ± 2 °C.

The sowing media consisted of a mixture of Soil :FYM : Cocopeat (2:1:1), which was chosen to enhance germination. Once the seedlings reached the 6 to 7 leaf stage, they were transplanted into plastic pots filled with a mix of Soil :FYM : Cocopeat (2:1:1). At the predetermined time points of 10 and 30 days after transplanting, the respective concentrations of humic acid (2.5, 3.5 and 5 ml) were dissolved in 1 liter of water and applied as a foliar spray to the plants according to the planned treatment. All other cultural and agronomical practices were maintained uniformly across all applications throughout the process.

Table 1: Treatment Details		
Treatment	Dose (mL/L of water)	Application DAP
T ₁	Water spray	-
T ₂	2.5	10 DAP
T ₃	3.5	10 DAP

T ₄	5.0	10 DAP
T ₅	2.5	30 DAP
T ₆	3.5	30 DAP
T ₇	5.0	30 DAP
T ₈	2.5	10 and 30 DAP
T ₉	3.5	10 and 30 DAP
T ₁₀	5.0	10 and 30 DAP

3. Results and discussion

3.1 Effect of humic acid on plant height

The foliar application of humic acid of different concentration and days to application significantly increased plant height. clearly through the experiment plants sprayed with 3.5 mL/L after 10 and 30 days (T₉) of planting showed tallest plant height (44.77 cm). The minimum effect showed in the plant height (36.90 cm) in spraying of humic acid @ 2.5mL/L after 10 days of planting (T₂), Which was statistically similar to no application of humic acid on plants (T₁) *i.e.*, 36.87 cm .The increase in the plant height could be as during the initial growing stage and budding stage that is 10 days and 30 days respectively when requirement of nutrition is high , humic acid made the plants absorb soil food more effectively increasing the ongoing metabolism in zinnia plants. There is a gradual increase in the water holding capacity making the soil more productive and fertile. Similar result found by Sani (2014) and Abourayya *et al.* (2020). Calcium is one of leading element to influence plant height. At higher concentration of available humic acid there occurs huge uptake of calcium from soil adding positive impact on mitotic activity at growing apical meristem, which consequently produce higher plant height (Ahmedian *et.al.*, 2011).

3.2 Effect of humic acid on leaf area

The maximum leaf area (33.67 cm²) among all the treatment was resulted from spraying plants with 3.5 mL/L in 10 and 30 days after planting (Table 2). Not so significant change was seen in the plans with zero treatment (lowest of all value shown in T₁ application *i.e.*, 20.90 cm²). There observed statistically similarity in leaf area of the treatment T₆ (3.5 mL/L at 30 days) T₅ (2.5 mL/L at 30 days). The increment in the leaf area in T₉ treatment was seen as humic acid is a decent wellspring of carbon, hydrogen, nitrogen, and oxygen which can be gotten from decayed natural material.

This indirectly results in healthy root growth. High root length makes nutrients absorption more efficient thus plants Having efficient photosynthetic activity, cell proliferation, and efficient nutrition absorption all resulted in the increment of leaf area. The increase in leaf area may attributes to presence of humic acid on soil for a longer period of time directly adding to the photo

synthetic activity of the plants. The maximum leaf area was caused by the presence of photosynthetic pigments with increased humic acid concentration, as well as the initiation of the production of carotenoids, which protect chlorophyll from oxidative damage, leading to an increase in the number of cells in leaves, the number of chloroplasts per cell, and gradually the leaf area. The current findings are in agreement with (Yildirim, 2007), who reported that the leaf area increased with increasing humic acid concentration.

3.3 Effect of humic acid on root length

Data concerning the root length of all the treatment applied clearly shows that the treatment T₉ that is 3.5 ml per liter in 10 and 30 days after planting is highest (16.00 cm). On a close look T₈ that is 2.5 mL/L in 10 and 30 days (value of 14.57 cm) and T₉ (16 cm) that is 3.5 mL/L in 10 and 30 days are similar statistically.

So, concentration of 2.5 and 3.5 mL/L in 10 and 30 days seems to be significantly effective in order to obtain high root length. This can be due to as during the initial days after transplanting of *Zinnia elegans* and its height growing period there is also high need to increase in the root length to support the plant. Improvement of soil properties by giving humic acid changes the design and element of plant root development there is an expansion in root size stretching or potentially more root hairs thickness with a bigger surface region. Despite of absence of any rooting hormone in humic acid it functions to stop rooting hormones already present in the soil to oxidize and break down. Thus, keeping IAA active for prolong period of time (Ichwan *et. al.*, 2017). This improves the plant ability to absorb more water and nutrients.

3.4 Effect of humic acid on branching of plants:

As shown in table 2 branching of *Zinnia elegans* is highest when sprayed with 3.5 mL/L of humic acid in 10 and 30 days (T₉) *i.e.*, 11.91. Treatment of 3.5 mL/L that is T₉ and treatment of 2.5 mL/L that is T₈ (10.77) in 10 and 30 days for both the concentration showed similar branching statistically. Plant with zero treatment (minimum value of 4.34) that is the one has minimum branching compared to all the plants sprayed with humic acid. More branches observed at both 10 and 30 growing days can be due to you make acid boost plant uptake utilization and transport of phosphorus and potassium while reducing damaging aluminum ions in the soil reducing soil acidity promoting the release of alkali hydrolysable nitrogen exchangeable calcium an exchangeable magnesium (Memon *et.al.*, 2014) As the plants get boost up with all macro and micro nutrients thus adding to its growth. One of significant role of humic acid is buffering. It buffers soil pH 5.5 to 7.5 level, maintaining perfect pH on soil makes the roots to observe nutrient more efficiently leaving a huge long-term positive impact implanted in soil (Shahmaleki *et.al.*, 2010).

3.5 Days taken to flower on applying Humic acid

The data from Table 3 signifies the plants sprayed with 3.5 ml per liter of humic acid in 10 and 30 days (39.71 cm) takes 1/4 of the day to bloom completely as compared with the plants

sprayed with 2.5 mL/L of humic acid in 10 days (52.56 cm). after transplanting. Days to bloom for plants sprayed with 2.5 mL/L of humic acid in 10 days showed to be comparatively same with plants sprayed with no treatment (T_1 -53.50 cm) As discussed earlier humate based application have significant role in increasing the vegetative growth in plants. Humate based application can also be a great substrate to be used for flowering, regulating flower period and adding high value to the ornamental quality of zinnia (Memon *et al.*, 2014). As application of humic acid increases the root length of the plant with structural increase in physical and chemical properties of soil thus making roots to absorb macro elements and trace elements to apical meristem and other shoot parts of zinnia more profusely. This can be the reason behind early blooming of flower on application of high concentrations of humic acid in growing period (Yildirim 2007).

3.6 Number of flowers per plant on applying Humic acid

Data regarding number of flowers per plant is shown in table 3 which indicates that the highest number of flowers per plant bloomed in those plants which has been sprayed with 3.5 mL/L and 2.5 mL/L in both 10 and 30 days after transplanting (*i.e.*, 14.23 and 13.59, respectively).Very a smaller number of flowers bloomed on plants with no treatment(T_1 -7.77) which means the spraying of higher concentration of humic acid in both 10 and 30 days after transplanting resulted in a greater number of flowers. It is because the high photosynthetic ability of zinnia plants with increase in leaf area, the increase in root absorption efficiency of soil nutrient and bypassing the element to whole shoot parts has a huge positive impact on blooming number of zinnias. The result is justified by (Tina *et. al.*, 2015) that applying humic acid in higher concentration increases flowering six times per plant in compare to the plants without any humic application in pot marigold.

3.7 Effect of humic acid on flower size:

Foliage spray of humic acid influences flowers size as shown in table 3. Plants sprayed with higher concentration of humic acid *i.e.*, 3.5 mL/L and 2.5 mL/L for 10 and 30 days (T_9 -11.62 cm and T_8 -10.42 cm, respectively) showed high rise in flower size **as compare** to the other treatments. The minimum flower size (5.15 cm) observed with plants without any humic acid applications. This can be due to presence of higher amount of different carbohydrates form in plants like soluble sugar, soluble protein gets increase because of humic acid applications. The fact is supported by **Gulzar *et.al* 2005**, due to the presence **of high** carbohydrate products like soluble sugar and soluble proteins makes the flower size bigger adding to its ornamental values . As humic acid application leads to higher amount of soluble sugar and protein on leaves, increases the process of photosynthesis on leaves ,which gradually influence the size of zinnia flower (**Hong-mei fan *et.al.*, 2015**)

3.8 Blooming period on applying Humic acid

Blooming period of ***Zinnia elegans*** shown in **Table 3**. T h e data signifies blooming period of ***Zinnia elegans*** is highest in plants sprayed with 3.5 mL/L and 2.5 mL/L of humic acid (36.40 and

37.13 days, respectively) in 10 and 30 days after transplanting. The lowest number of blooming days was noted in those plants with no spraying of humic acid (*i.e.*, 28.47 days) Ethylene which is also known as 'Ripening hormone gets reduced when plants are sprayed with Humate based fertilizer which may be the cause of high blooming period in zinnia. This result reported resemble with those reported by (Yazdani *et al.*, 2014), who noted effect of ethylene in plant is inversely proportional to the effect of humic acid. As on applying humic acid there is reduction in ethylene effect, thus increasing the blooming period of zinnia.

4 Conclusion

The phenotypical effect of present examination demonstrates that humate based foliar application to *Zinnia elegans* of high concentration (2.5-and 3.5 mL/L) during growing days (*i.e.*, 10 and 30 days) highly influence different vegetative and flowering parameters in plants. The humic acid application also caused a long-term positive impact on soil. Amongst all the applications treatment T₈ (2.5 mL/L in 10 and 30 days) and T₉ (3.5 mL/L in 10 and 30 days) proven to be superior. Hence, concluding that presence of humic acid can enhance the process of nutrient absorption from soil, tracing the elements to shoot parts specifically to apical meristem, influence process of photosynthesis due to increase in chlorophyll and prompting the ornamental values of *Zinnia elegans* from all aspect.

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Table 2: Effect of humic acid in vegetative parameters in *Zinnia elegans*

Treatment	Vegetative parameters			
	Plant height (cm)	Leaf area (cm ²)	Root length (cm)	Branching
T ₁	36.9 ^f	20.9 ^d	10.97 ^d	4.34 ^e
T ₂	36.87 ^f	21.87 ^{cd}	11.9 ^{cd}	5.36 ^{de}
T ₃	37.83 ^{ef}	23 ^{cd}	11.9 ^{cd}	5.36 ^{de}
T ₄	38.83 ^{def}	23.5 ^c	12.83 ^{bcd}	6.48 ^d
T ₅	39.77 ^{cde}	28.03 ^b	13.87 ^{abc}	8.56 ^c

T ₆	41.7 ^{bc}	28.73 ^b	13.67 ^{bc}	9.63 ^{bc}
T ₇	38.97 ^{def}	23.73 ^c	12.93 ^{bcd}	6.46 ^d
T ₈	42.53 ^b	29.03 ^b	14.57 ^{ab}	10.77 ^{ab}
T ₉	44.77 ^a	33.67 ^a	16 ^a	11.91 ^a
T ₁₀	40.83 ^{bcd}	28.47 ^b	13.9 ^{abc}	9 ^{bc}
Sem±	0.68	0.66	0.67	0.59
CD at 5%	2.02	1.94	1.98	1.76

In a column means followed by same letters are not significantly different at P=0.05. **CD** at 5%

Table 3: Effect of humic acid and time of application in flowering parameters in *Zinnia elegans*

Treatment	Flowering parameters			
	Days taken to flower	Number of flowers	Flower size (cm)	Blooming Period (days)
T1	53.5 ^a	7.74 ^e	5.15 ^f	28.44 ^e
T2	52.56 ^a	7.99 ^e	5.14 ^f	29.43 ^e
T3	50.87 ^b	10.96 ^d	6.24 ^{ef}	29.37 ^e
T4	49.91 ^{bc}	12.3 ^{bc}	6.21 ^{ef}	31.34 ^d
T5	46.44 ^d	11.81 ^{cd}	8.29 ^{cd}	34.55 ^c
T6	39.37 ^f	12.81 ^{abc}	9.35 ^{bc}	34.88 ^{bc}
T7	48.53 ^c	10.8 ^d	7.29 ^{de}	31.37 ^d

T8	39.96 ^f	13.31 ^{ab}	10.42 ^{ab}	37.05 ^a
T9	39.17 ^f	13.82 ^a	11.62 ^a	36.29 ^{ab}
T10	42.02 ^e	12.8 ^{abc}	8.57 ^c	34.55 ^c
Sem±	0.48	0.38	0.40	0.52
CD at 5%	1.43	1.12	1.20	1.54

In a column means followed by same letters are not significantly different at P=0.05 CD at

5%

UNDER PEER REVIEW