ISSN: 2538-2152; ECOPERSIA 2025;13(1): 37-48.

Tarbiat Modares University

Effect of Different Nutritional Treatments on the Growth of Datura *Stramonium* L.

ARTICLEINFO

Article Type
Original Research

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How to cite this article
Sheidai-Karkaj E, Jahantab E., Sasanifar S. Mofidi-Chelan M. Babazadeh S. Effect of Different Nutritional Treatments on the Growth of Datura *Stramonium* L. ECOPERSIA 2025;13(1): 37-48.

DOI:
10.22034/ECOPERSIA.13.1.37

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Article History
Received: November 26, 2024
Accepted: February 1, 2025
Published: February 28, 2025

ABSTRACT

Aims: *Datura stramonium L.* is a medicinal plant known for its alkaloid compounds. Limited research has explored the impact of fertilizers like solopotas and fulvic acid on its growth and structural traits. This study aimed to evaluate the effects of these fertilizers on the growth rate and biomass of *D. stramonium*.

Materials & Methods: Solopotas and fulvic acid were applied as foliar sprays at concentrations of 2%, 4%, 6%, and 8%, with five applications at 5-day intervals. Growth parameters such as plant height, leaf length, stem length, root length, leaf number, flower and fruit counts, and shoot weight were measured at maturity and compared with control plants treated with distilled water.

Findings: The fertilizer treatments significantly affected leaf traits, flower and fruit numbers, plant height, and shoot weight ($p<0.05$) but not root length. The 2% fulvic acid treatment resulted in the tallest plants (45.75 cm), compared to 31.25 cm in the control. The 4% fulvic acid treatment had the most leaves (39.5), while the control had the lowest (19). The 2% solopotas treatment produced the most extended leaves (14.15 cm), while the 8% solopotas had the shortest (8.17 cm). The 2% fulvic acid also resulted in the heaviest shoots (13.5 g), compared to 3.5 g in the control.

Conclusion: The application of 2% fulvic acid and 2% solopotas significantly improved the growth and biomass of *D. stramonium*, particularly in plant height, leaf number, and leaf length. These findings suggest that these fertilizers can enhance the commercial potential of *D. stramonium*.

Keywords: Solopotas and Fulvic Acid Fertilizer; Biomass; Medicinal Plant; Structural Traits.

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Introduction

In addition to their aesthetic value and productivity, many plants have medicinal properties. Identifying these plant species and understanding the impact of environmental and nutritional factors on the concentration of active compounds, their chemical composition, and plant growth is both important and beneficial. Nutritional substances sometimes effectively strengthen these plants' medicinal aspects [1]. The use of medicinal plants as a source of healing in local communities worldwide has a history of thousands of years. Today, the role of medicinal plants as a primary healthcare method for most communities is not hidden. Medicinal plants have vast potential in treating various diseases due to the presence of important therapeutic phytochemicals. Therefore, pharmaceutical sources are very important, so a significant share of all synthetic drugs comes from them. Iran has a special place in the world regarding geographical location, climate, and weather, and it is the habitat of many plant species, including medicinal plants. Climatic diversity in Iran has caused the existence of few medicinal plants in the world that do not have the same or similar species in Iran. Various researches have shown that it is possible to achieve high production due to suitable conditions for growing medicinal plant species [2, 3, 4, 5]. On the other hand, due to the growing economic importance of medicinal plants and also because most of the medicinal plants are native to developing countries, it is possible to provide part of the significant health and treatment needs of the society with proper use.

Datura stramonium, an annual plant known by common names such as thornapple, jimsonweed, and devil's trumpet, is a toxic flowering species in the Daturae tribe of the Solanaceae family. Its likely origin is in Central America and has been introduced in many world regions [6]. This plant is abundantly observed in the coastal areas of northern Iran from Astara to the east of Mazandaran [7]. *D. stramonium* is one of the most important medicinal plants [8, 9]. This plant has antibacterial, insecticidal, repellent, antioxidant, anti-inflammatory, analgesic and antipyretic, antispasmodic, anticancer, antifertility, sedative, antiasthmatic, invigorating and protective against organophosphate toxins [8, 9]. Also, this plant is used to treat diabetes, asthma, herpes, diarrhea, menstrual cramps, painful skin ulcers, stomach inflammation, headache, and muscle cramps [8, 9]. The important phytochemical compounds in *D. stramonium* are alkaloids, and a group of alkaloids called tropane alkaloids are mainly found in plants of the Solanaceae family, especially in the Datura genus [10].

The growth and performance of plants are influenced by genetic and environmental factors, which are essential for expressing a plant's genetic traits. Plant growth will be disrupted or halted if either of these factors is lacking or deficient. Properly using agricultural methods and factors in medicinal plant production is essential to increase the number of effective substances [11]. In this regard, it seems necessary to investigate detailed scientific research to determine the effect of different fertilizers on the growth rate and performance of medicinal plants. In the following section, various research studies that have been done on different plants will be reviewed. In a study, Mohammadpour Vashvaei et al. (2021) evaluated the physiological, biochemical, and agronomic characteristics of *D. stramonium* under the residual effect of conventional and low-input cultivation systems. The results showed that the highest amount of plant height, number of branches per plant, number of leaves per plant, and dry weight of leaves belonged to the combined

[DOI: 10.22034/ECOPERSIA.13.1.37]

treatment of vermicompost and nanobiomic fertilizers [12]. In research, the researchers investigated the effect of different levels of nitrogen and density on the growth and performance of the *D. stramonium* plant. The results showed that the application of 180 kg. ha^{-1} of urea and the density of 6 plants per unit area can be essential in increasing the seed yield of the medicinal plant *D. stramonium* [13]. Investigating the effect of different levels of urea fertilizer on *D. stramonium* showed that the use of 240 kg. ha^{-1} of urea increases the biomass yield and grain yield [14]. In a study using 150 and 300 kg. ha^{-1} of nitrogen fertilizer on the *D. stramonium* plant, the results showed that the treatment of 300 kg. ha^{-1} increased the growth and the percentage of seed germination in the *D. stramonium* plant [15]. Hadinezhad et al. (2021) stated that using biological and combined fertilizers (biological and chemical) and providing the necessary materials to increase the growth of *Nigella sativa* L. is effective. It will lead to better efficiency [16]. Mardi et al. (2022) reported that the use of fertilizers such as supernitroplus has increased plant height, functional traits, and the number of leaves compared to control (no fertilizer use) in *Allium sativum* L. [17]. Ehsani et al. (2021) surveyed the effect of lignite and wheat straw biochar on vegetation growth for *Astragalus podolobus* Boiss. & Hohen found that with the addition of lignite to the soil, the maximum height, crown diameter, canopy cover, and volume of biomass were recorded for a 3.75% application rate after the fourth month and were 25.03cm, 23.52cm, 528.65cm^2, and 15581cm^3, respectively [18]. Najafzadeh Nobar and Safari Sinegani (2020) reported that the antioxidant activity of green bean biomass was improved in mine soil in comparison with rangeland and cropland soils (37.76% and 18.43%, respectively) [19]. Abbasi Khalaki et al. (2021) concluded that the maximum plant viability (80, 82.22%), height (59, 68.33cm), leaf area index (67.79, 84.93cm^2), basal diameter (13.33, 16.66cm), canopy cover (993.33, 1242.66cm^2), relative water content (70.46, 88.32%), photosynthesis rate (27.29, 28.49$\mu molco_2.cm^{-2}.s^{-1}$), chlorophyll (0.87, 0.72$mg.g^{-1}$), number of inflorescence (57.33, 56Nm^{-2}) and 1000-grain weight (33.30, 3.89$g.m^{-2}$) were in sainfoin (EM2%) and alfalfa (PSN1000mg lit^{-1}), respectively [20]. Gorji et al. (2023), in comparison of the impact of organic and inorganic fertilizers on phenol content and growth traits in cultivated and wild safflower**,** found that the leaf area, number of leaves, dry and fresh biomass weights significantly increased in the case of adding vermicompost to the soil [21]. Seilsepour and Moharami (2024) surveyed the impact of nitrogen adding and municipal solid waste compost on wheat yield in soil with high $caco_3$. The experiment's results demonstrated that the effect of MSW compost with N-fertilizer and their interaction on grain yield and biological function were significant [22].

Considering the high value and importance of the medicinal plant *D. stramonium* and on the other hand, since there has been no report on the effect of solopotas and fulvic fertilizers on the structural characteristics and biomass of the *D. stramonium* plant, it seems necessary to investigate the impact of these treatments on the medicinal plant *D. stramonium*. Therefore, considering the importance of *D. stramonium* as a medicinal plant and its widespread use in the pharmaceutical industry, the present research was conducted to survey the effects of different treatments on the structural traits and biomass of *D. stramonium*. The most important purpose and context of this research is to support the necessities for plant domestication. Since most medicinal plants, such as *Datura stramonium* L., are

[DOI: 10.22034/ECOPERSIA.13.1.37]

suitable for producing drug products, several efforts are needed to domesticate them. On the other hand, the vast area of dry farming lands is abandoned, and then it is required to be restored. This species is one of the candidate species for cropping in this area.

Materials & Methods

In the present study, the seeds of the *D. stramonium* plant were collected from the region of Nazlu in Urmia, West Azerbaijan Province, and the dried seeds of this plant were removed and used. Because of controlling the effects of environmental factors on germination and growth, the pots were filled by the soil of the *D. stramonium* species habitat in the Nazlu region. The soil texture was loamy-clay. Its pH was about 7.1, and EC was 0.23 months.cm^{-1}. The research started on January 1, 2021, and the seeds were first placed in the cultivation trays and watered every other day. After the plants reached 10-12 cm in height, they were transferred to larger pots, and the same watering routine was resumed. After the primary growth of the plants, the treatment was started. In this way, two types of fertilizer, solopotas, and fulvic acid, were used. Fulvic acid is used as a humic substance resulting from the decomposition of the remains of living organisms, without harmful environmental effects, in the production of agricultural and garden crops. Fulvic acid is a powerful organic electrolyte that regulates and energizes cells [23]. By entering the plant tissue, fulvic acid brings macro elements with it from the surface part of the plant to the plant tissue [24]. Also, potassium sulfate fertilizer or solopotas with 51% potassium and 17.5% sulfur is the best source of potassium, and due to its sulfur base, it can be easily used in salty soils and has the least leaching. This substance is obtained from the combination of potassium oxide K_2O 51% and sulfur 46% SO_3 and is very widely used; this fertilizer is one of the most harmless chemical and inorganic fertilizers. Potassium plays a role in transporting carbohydrates and other micronutrients in the stem and leaves. On the other hand, strengthening the plant and stem makes it more resistant to cold, heat, pests, and diseases. Solopotas is entirely soluble in water and allows foliar spraying without creating deposits in the nozzles. Solopotas fertilizer increases the nutritional value of products by positively affecting the production of starch, sugar, and vitamins [25]. The treatment was done by spraying solutions with different doses of fertilizers on the plant's leaves, buds, and flowers without falling on the soil's surface. A total of 27 pots of plants were available, and three replications were considered for each percentage of fertilizer. Thus, three pots were used as control plants: three for 2%, 4%, 6%, and 6%, and solopotas for 8%. The same procedure was repeated for fulvic acid. The pots were placed in the greenhouse of Urmia University with the same temperature and humidity conditions, and the treatment was done five times with an interval of 5 or 6 days (Figure 1). Irrigation was carried out every other day to prevent its level from decreasing to less than the field capacity (FC) during the experiment. After 35 days, the height and size of the plants were measured before separating the organs in question. This way, the length from the soil surface to the highest part of the plant was recorded as the height. The number of the smallest to the largest leaves was counted and recorded as the number of leaves. In the same way, the number of fruits, flowers, buds, and the length and width of two leaves from each pot were also noted, and the crown of the plant, the length of its large and small crowns were also reported, and after removing the plants from the pot, the length of the root was also recorded.

[DOI: 10.22034/ECOPERSIA.13.1.37]

Figure 1) *D. stramonium* plant in the research greenhouse.

The parameters considered during the measurement are flower, leaf, stem, root weight in grams, small crown length, considerable crown length, leaf width, leaf length, number of flowers and fruits, number of leaves, root length, and plant height. The measurements were accurately taken using a tape measure.

Analysis Method

In the current study, nine treatments, including solopotas solution spray at four concentration levels of 2, 4, 6, and 8% and fulvic acid solution spray at four concentration levels of 2, 4, 6, and 8%, and a control treatment with distilled water, spray, were used. Thus, different liquid solutions were prepared and sprayed onto the plant organs after the plant had grown. Three replications (pots) were considered for each treatment, and other traits were measured except leaf length and width in all three pots.

It is important to note that four repetitions were considered for both leaf length and width. Firstly, the normality test was conducted by Kolmogorov–Smirnov test. In the case of non-normal distribution, a log (10) transformation was used to make them normal. Eight of the 10 traits were normal, and two traits, including flower number and small canopy length, were abnormal. However, a one-way analysis of variance (ANOVA) was used to analyze the normal and transformed data of traits, and Tukey's test was applied for mean comparisons. Additionally, principal component analysis (PCA) was conducted to identify traits with high variability and sensitivity to different nutritional treatments. The Principal component analysis method has been used in various sciences to determine important parameters in differentiating various phenomena from each other, the results of which include eigenvalues, % of the variance of each variable, factor loading, and broken stick eigenvalue (BSE) [26]. All statistical analyses were performed using SPSS software.

Findings

Results of Analysis of Variance

The analysis of variance showed that the effect of different treatments on the characteristics of leaf length, leaf width, number of flowers and fruits, considerable canopy length, small canopy length, plant height, and shoot weight is significant (Table 1). The results showed that the effect of the treatments on the traits of root length and root weight was insignificant.

The mean comparison revealed that

[DOI: 10.22034/ECOPERSIA.13.1.37]

Table 1) The results of analysis of the variance for various traits for *D. stramonium.*

Traits/d.f	Source of Variation	Error	Total
d.f.	8	27	35
	Mean Squares		
Leal Length	15.01**	2.74	
Leaf Width	8.25**	1.36	
Traits/d.f	8	18	26
	Mean Squares		
Plant Height	68.26*	22.52	
Root Length	17.40ns	10.44	
Number of Leaves	143.71ns	64.56	
Number of Flowers	150.58**	9.88	
Length of Large Canopy	150.15**	43.08	
Length of Small Canopy	76.83**	12.69	
Weight of Roots	0.32ns	0.13	
Weight of Aerial Parts	31.35*	11.71	
Number of Flowers-Log(10)	0.17**	0.03	
Length of Small Canopy Log(10)	0.03**	0.004	

*: Significant at the 0.05 level; **: Significant at the 0.01 level; ns: Not Significant.

the highest plant height (45.75 cm) was observed with the 2% fulvic acid treatment, while the lowest height (31.25 cm) was found in the distilled water treatment. The most significant root length (0.21 cm) was recorded with the 4% fulvic acid treatment, while the lowest (12.75 cm) was associated with the distilled water treatment. For the number of leaves, the highest count (39.50 leaves) was observed in the 4% fulvic acid treatment, while the lowest (19.0 leaves) occurred with the distilled water treatment (Table 2). Regarding the number of flowers, the highest average [28] was observed in the 2% fulvic acid treatment, while the lowest (4.5) was found in the 4% solopotas treatment. The distilled water, fulvic acid 8 %, and solopotas 2 % were intermediate levels. In terms of canopy size, the largest (44.5 cm) and smallest (28.5 cm) canopy lengths were recorded with the 8% fulvic acid treatment, while the smallest (22.5 cm) and largest (15.5 cm) were found with the distilled water treatment (Table 3). For root and shoot weight, the highest values were observed with the 8% solopotas treatment (root weight: 2.65 gr, shoot weight: 13.5 gr), and the lowest values were associated with the distilled water treatment (root weight: 1.65 gr, shoot weight: 3.5 gr). The highest leaf length (14.15 cm) was found with the 2% solopotas treatment, while the lowest (8.17 cm) occurred with the 8% solopotas treatment. For leaf width, the highest (8.67 cm) and lowest (5.07 cm) values were recorded with the 8% fulvic acid and distilled water treatments, respectively (Table 2).

Table 2) Comparison of the means effect of different treatments on the normal traits of *D. stramonium* plant.

Treatment	Plant Height (cm)	Root Length (cm)	Number of Leaves	Length of Large Canopy (cm)	Weight of Roots (gr)	Weight of Aerial Parts (gr)	Leaf Length (cm)	Leaf Width (cm)
Distilled Water	**31.25** ±1.75^{b}	**12.75** ±3.25^{a}	**19.0** ±6.0^{a}	**22. 5** ±2. 5^{b}	**1.65** ±0.1^{a}	**3.5** ±0.1^{b}	**9.25** ±0.9^{bc}	**5.07** ±1.4^{d}
Fulvic Acid 2 %	**45.75** ±1.75^{a}	**16.5** ±.5^{a}	**33.0** ±2.0^{a}	**41. 5** ±3. 5^{a}	**2.3** ±.1^{a}	**8.5** ±3.3^{ab}	**11.37** ±1^{bc}	**5.62** ±1.0^{bcd}
Fulvic Acid 4 %	**39.50** ±.50^{ab}	**21.0** ±2^{a}	**39.50** ±15.5^{a}	**29.5** ±.50^{ab}	**1.75** ±0.7^{a}	**7.1** ±.4^{ab}	**10.8** ±1 ^{abc}	**6.3** ±1.2^{abcd}
Fulvic Acid 6 %	**36.50** ±.50^{ab}	**19.0** ±1^{a}	**22.5** ±2.5^{a}	**31.50** ±7.5^{ab}	**2.15** ±0.1^{a}	**11.05** ±3.5^{ab}	**11.6**±1^{abc}	**8.05** ±1.15^{abc}
Fulvic Acid 8 %	**39.25** ±2.7^{ab}	**19.0** ±0^{a}	**30.50** ±9.5^{a}	**44.5** ±7.5^{a}	**2.2** ±0. 1^{a}	**10.6** ±0.1^{ab}	**12.9** ±0.8^{ab}	**8.67** ±0.2^{a}
Solopotas 2 %	**45.00** ±7^{a}	**18.75** ±2.75^{a}	**36.0** ±6.0^{a}	**39.5** ±10.5^{ab}	**2. 5** ±0. 4^{a}	**14.15** ±6.65^{a}	**14.0** ±3.2^{a}	**8.4** ±1.65^{ab}
Solopotas 4 %	**35.5** ±2.5^{ab}	**17.25** ±5.75^{a}	**27.00** ±7.0^{a}	**29.5** ±0.5^{ab}	**2.1** ±0.2^{a}	**9.4** ±1.9^{ab}	**8.75** ±1.19^{c}	**5.4** ±1.3^{cd}
Solopotas 6 %	**38.5** ±3.5^{ab}	**18.75** ±1.25^{a}	**38.0** ±3.0^{a}	**35.0** ±5.0^{ab}	**2.4** ±0.1^{a}	**11.0** ±0.5^{ab}	**9.65** ±1.0^{bc}	**5.65** ±1.06^{bcd}
Solopotas8 %	**34.00** ±11^{ab}	**20.0** ±6^{a}	**29.5** ±10.5^{a}	**29.0** ±11^{ab}	**2.65** ±0.6^{a}	**13.3** ±5.8^{a}	**8.17** ±0.9^{c}	**5.5** ±0.4^{cd}

Table 3) Comparison of the means effect of different treatments on the abnormal traits of *the D. stramonium* plant.

Treatment	Number of Flowers	Number of Flower Log(10)	Length of Small Canopy (cm)	Length of small canopy log(10)
Distilled Water	**10.0**±3.0^{b}	**0.98 ab**	**15.5**±3.5^{b}	**1.82b**
Fulvic Acid 2 %	**28.0**±5.0^{a}	**1.44a**	**23.5**±5.5^{ab}	**1.36ab**
Fulvic Acid 4 %	**8.0**±4.0^{b}	**0.86b**	**20.5**±0.5^{ab}	**1.31ab**
Fulvic Acid 6 %	**5.50**±.50^{b}	**0.73b**	**19. 0**±1. 0^{ab}	**1.27ab**
Fulvic Acid 8 %	**8. 5**±2.5 ^{b}	**0.91ab**	**28. 5**±7.5 ^{a}	**1.44a**
Solopotas 2 %	**10.00**±1.0^{b}	**0.99ab**	**28.0**±2.0^{a}	**1.44a**
Solopotas 4 %	**4.5**±2.5^{b}	**0.6 b**	**16.5**±0.5^{b}	**1.21b**
Solopotas 6 %	**6.5**±0.5^{b}	**0.81b**	**19.0**±1.0^{ab}	**1.27ab**
Solopotas 8 %	**7.00**±5^{b}	**0.74 b**	**15.0**±3.0^{b}	**1.17b**

[DOI: 10.22034/ECOPERSIA.13.1.37]

Principal Component Analysis (PCA) Results

To identify the most important and sensitive traits under the change caused by different treatments and specify the relevant treatment, principal component analysis was used, and the results are presented below (Table 4 and Figure 2). By observing the contribution of each of the components in justifying the traits (Table 3), it can be stated that the traits of considerable crown length, small crown length, plant height, leaf length, leaf width, shoot weight, root length, number of leaves, Root weight and the number of flowers and fruits have the most changes due to different treatments. The results of the principal components analysis showed that 50.9% of the variation in the traits of the *D. stramonium* species was made by the first axis (plant height, length of large canopy, length of small canopy, leaf length, and leaf width) and second axis was made by number of flowers with 20.68 % of the data variance (Table 4).

Table 4) results of analyzing the main components of traits and different treatments.

		Axis (Eigenvector)	
	Parameter	**1**	**2**
	Eigenvalue	5.09	2.06
	% Of Variance	50.9	20.68
	Cum.% of Variance	50.9	71.59
	Broken-stick Eigenvalue	2.92	1.92
Factor Load	Plant Height	**-0.859**	-0.321
	Root Length	-0.540	0.661
	Number of Leaves	0.621	0.1723
	Number of Flowers	0.272	**-0.713**
	Length of Large Canopy	**0.910**	-0.191
	Length of Small Canopy	**-0.900**	-0.327
	Weight of Roots	0.572	0.523
	Weight of Aerial Parts	-0.662	0.660
	Leaf Length	**0.808**	-0.364
	Leaf Width	**0.736**	0.044

Note: Bold parameters are chosen to weigh more in the separation of treatments.

The principal component analysis method was used to extract the most important and sensitive plant traits of *D. stramonium* under different treatments. In this type of analysis, parameters are determined and selected that provide and justify the most information from the available data [27]. To determine the extracted factors and the number of principal components, a large set of indicators such as eigenvalues, scree plots, and percentage of factor load variance are used [27]. This study selected components and factors with a specific value higher than the broken stick eigenvalue and a factor loading of more than 0.5 [28].

By examining the two-plot diagram related to the distribution of treatments in the space of traits, it is clear that almost all plant traits have higher values when solopotas and fulvic acid are used compared to pure water spray. However, in more detail, solopotas spray at a low concentration of about 2% increases leaf width, large crown diameter, and height values. In addition, fulvic acid spray with a concentration of two percent increases the number of flowers and leaf length and causes a relative decrease in root and stem length. To improve this plant's growth efficiency, spraying small amounts of these foods will improve its performance.

Discussion

The growth and performance of plants can be influenced by genetic factors and environmental factors that play the leading role in the occurrence of genetic traits of each plant so that in the absence or deficiency of one of them, the growth of plants will be disturbed and stopped. Proper use of agricultural methods and factors in the production of medicinal plants is important to increase the amount of effective substance. In this regard, the present research was conducted to investigate the effect of different treatments on the structural

[DOI: 10.22034/ECOPERSIA.13.1.37]

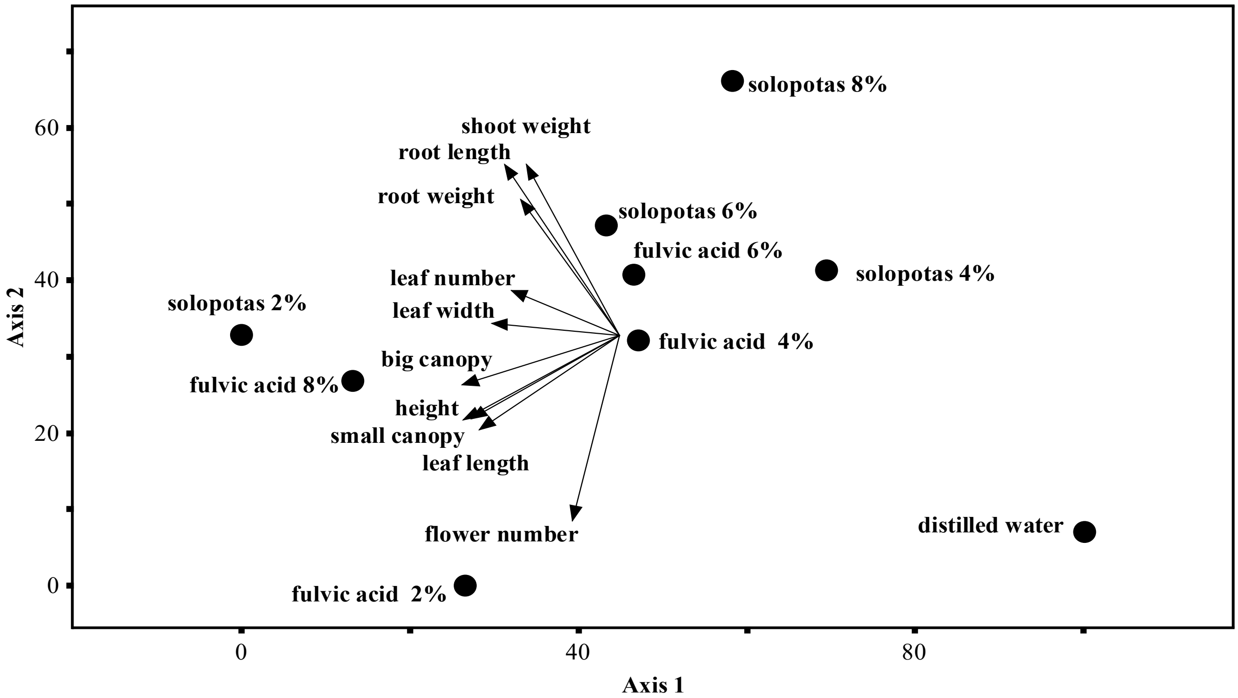

Figure 2) Two-plot space of the changes in *D. stramonium* species traits about different treatments using principal component analysis (50.9% and 20.68 % of the data variance are explained by the first and second axes, respectively).

traits and biomass of the medicinal plant *D. stramonium*. The results showed that the effect of different treatments on the characteristics of leaf length, leaf width, number of flowers and fruits, considerable canopy length, small canopy length, plant height, and aerial weight are significant. The comparison of the means showed that the highest height and number of flowers and fruits was related to 2% fulvic treatment, and the lowest amount was related to distilled water treatment. The results of this research are consistent with the results of Arvin (2019) [29], Makkizadeh et al. (2011) [30], Mollashahi et al. (2013) [31] and Hossain et al. (2010) [32]. They reported that when the plant is affected by different concentrations of complete fertilizers, its height traits increase significantly. Potassium has been reported to increase vegetative growth, size, and height in plants by activating enzymes that are effective in growth and increase the division of meristem cells and the turgorescence of meristem cells [33]. This mechanism likely explains the superior performance observed with fulvic acid and potassium treatments in this study. During their research on fennel, they stated that Azotobacter inoculation caused a significant increase in the height, side branch, and seed yield of the plant compared to the control [34]. The highest and lowest root length and number of leaves were related to the treatment of 4% fulvic and distilled water, respectively. In research, Arvin (2019) stated that the simultaneous consumption of nutrients nitrogen, phosphorus, and potassium caused an increase in the number of leaves and branches in savory plants compared to the control sample [29]. Researchers also reported that the foliar application of potassium fertilizer increased mung bean area and number of leaves and side branches [35]. In the study of

[DOI: 10.22034/ECOPERSIA.13.1.37]

Alizad et al. (2019), they reported that the combined application of vermicompost with Azospirillium has increased the number of leaves in garlic plants [36].

Regarding the traits of considerable canopy length and small canopy length, respectively, in both traits, the highest amount related to fulvic acid treatment was 8%, and the lowest amount was related to a distilled water treatment. The highest amount of root weight and shoot weight traits were related to 8% solopotas treatment, and the lowest amount was related to distilled water treatment. In this regard, the results of Abd Allah et al. (2015) studies showed that salicylic acid foliar application increased the fresh and dry weight of the aerial part of quinoa [37]. Additionally, Mosavi Fazl et al. (2015) [38] showed that potassium fertilizers enhance dry weight in fodder sorghum, while Habib et al. (2011) [39] noted significant increases in wet and dry weights in potato plants following potassium nitrate application. These findings collectively emphasize the crucial role of potassium in biomass accumulation across diverse plant species, including *D. stramonium*. Also, Rahimi and Salahizade (2015) stated that applying potassium sulfate fertilizer in bean plants increased the fresh weight of the stem [40]. These results highlight how targeted nutrient application optimizes canopy structure, which is critical for enhancing light capture and growth. Also, Habib et al. (2011) reported that spraying and foliar application of potassium nitrate significantly increased plant length and dry and wet weight in potatoes [39]. The highest amount of leaf length is related to 2% solopotas treatment, and the lowest amount is 8% about solopotas treatment. Regarding leaf width, this trait's highest and lowest levels were related to 8% fulvic treatment and distilled water. Therefore, according to the results, using the fertilizers mentioned above has improved the structural characteristics and biomass of the *D. stramonium* plant. The results of the present research are consistent with the results of the studies of Mohammadpour Vashvaei et al. (2021) [12] and Mardi et al. (2022) [17]. The results of the survey by Mohammadpour Vashvaei et al. (2021) showed that the highest plant height, the number of branches per plant, the number of leaves per plant, and the dry weight of the leaves of the *D. stramonium* plant belonged to the combination treatment of vermicompost and nanobiomic fertilizers [12]. Mardi et al. (2022) reported that the use of fertilizers such as supernitroplus has increased plant height, functional traits, and the number of leaves compared to control (no fertilizer use) in garlic (*Allium sativum* L.) [17]. Different fertilizers can increase the plant's ability to absorb organic and inorganic substances from the soil solution and increase plant growth [41].

Conclusion

Based on the findings of this study, the application of the aforementioned fertilizers of solopotas 2% and fulvic acid 2% significantly improved the structural characteristics, such as the canopy cover of the *D. stramonium* plant. Shoot and root biomass will increase with the addition of solopotas 6%. However, since the effects on bioactive compounds were not assessed, an increase in biomass cannot be directly linked to a rise in the concentration of effective substances. Further studies are needed to evaluate the impact of these fertilizers on the production of bioactive compounds. It is recommended that future research focus on investigating how different fertilizers affect the concentration of bioactive compounds in *D. stramonium*, in addition to their impact on plant biomass. This will help clarify whether improvements in plant growth translate into higher yields of medicinally valuable substances.

Acknowledgments
The authors would like to thank Urmia University for providing the facilities for this research.

Authors' Contributions
All authors contributed to the manuscript and read and approved its final version.

Funding/Support
Personal funding has been spent to conduct this research.

Ethical Permission
None declared by authors.

Conflict of Interests
The authors declare no conflict of interest.

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