ZANCO Journal of Pure and Applied Sciences
The official scientific journal of Salahaddin University-Erbil
https://zancojournals.su.edu.krd/index.php/JPAS

ISSN (print):2218-0230, **ISSN (online):** 2412-3986, **DOI:** **http://dx.doi.org/10.21271/zjpas**

RESEARCH PAPER

Effect of Chemical Fertilizer and Humic Acid on the Growth and Development of *Paulownia tomentosa* Seedlings.

[1]Nigar Abdulrahman Sabir,[2]Sherzad Omar Hamad

1&2 Department of Forestry, College of Agriculture Engineering Science, Salahaddin University- Erbil, Kurdistan Region, Iraq

A B S T R A C T:

Silvicultural treatments were applied in forest nursery to produce high quality and quantity seedlings. Fertilizer application is one of the most important treatments that were used to improve seedling morphological and physiological traits. The study investigated the influence of NPK fertilizer levels viz. 0, 0.5, 1, and 1.5 g pot^{-1}, Humic acid levels viz. 0, 5, 10 and 15 g pot^{-1} and their interactions on growth and physiological properties of *Paulownia tomentosa.* Morphological growth parameters (the increment in the stem height, stem diameter and leaf number) and physiological parameters (leaf area, chlorophyll content and protein percent, and N, P, K content) were measured. The results indicate that the highest values of stem height and stem diameter increment were (52.70 cm and 10.69mm) at (1.5g) of NPK fertilizers. The maximum values of both traits were (51.40 cm and 10.33mm) recorded at (15g) of Humic acid. The highest mean value of nitrogen (2.90 and 2.53 %) reported from application of (1.5 g NPK and15g Humic acid), respectively. Among physiological parameters chlorophyll content recorded the highest value which were (56.97 and 56.04) at (1.5g NPK and 10g Humic acid,) respectively. From interaction between (1g NPK x 15g Humic acid) recorded the highest value of potassium which was (3.74%). The results will help will improve nursery practices to produce healthy and a high quality of *P. tomentosa* seedlings to meet the plantation programs.

KEY WORDS: *Paulownia tomentosa* Seedlings, Seedling quality, Fast-growing species, Empress tree, Inorganic and Organic fertilizer
DOI: http://dx.doi.org/10.21271/ZJPAS.34.4.3
ZJPAS (2022) , 34(4);19-32 .

1. INTRODUCTION:

Paulwonia tomentosa (Empress tree), is a genus belonging to Paulowniaceae family, indigenous to China and East Asia including over 20 species (Barton *et al*., 2007). Paulownia is a hardwood tree which is documented with some names such as Kiri tree, Princess tree, Phoenix tree, Royal tree, Dragon tree, empress tree, and the tree of Adam. There are six species that are presently recognized (*P. tomentosa, P. fargesii, P. glabrata, P. elongate, P. fortune and P. taiwaniana*) (Alagawany *et al*., 2020). They are deciduous trees, fast growing species and hard wood trees and most commercially developed trees in the world for wood production, protect smaller tree species from strong wind, for the establishment of forests and farms (Bergmann, 2003).

* **Corresponding Author:**
Nigar Abdulrahman Sabr
E-mail: nigar.abdulrahman775@gmail.com
Article History:
Received: 17/04/2022
Accepted: 09/05/2022
Published: 15/08 /2022

The height of the Paulownia tree may exceed 15 m in 3 years, as age progress can reach 20 - 30 m, and its diameter can reach 2 m, which makes it an excellent source of timber. In the maturated tree, the leaf length could reach 15–30 cm and its width of 10–12 cm with weaved and smooth sides and has large leaves with width (15-40 cm) with heart form and arranged in reversely on the stem (Alagawany *et al*., 2020). Paulownia leaves are also a good source of carbohydrates and protein and it can be compared to legume family crops in terms of the nutritional value of the leaves. Therefore, it is used as feed for livestock, green fertilizer, or peat moss manufacturing (Al Taher *et al*., 2020). Paulownia's timber is popular in the world market used for furniture, musical instruments, decorative moldings, laminated structural beams shipping containers and plywood (EL Showk and EL Showk, 2003). Mahmood *et* *al*. (2017) reported that this tree is propagated through seed, stem and root cuttings.

Paulownia tree was exported to Kurdistan region – Iraq last decay. Nowadays, there are several Paulownia plantations in Erbil for timber production. Therefore, to increase and improve Paulownia plantation, a high-quality seedling of Paulownia should be produced in nursery. For this purpose, some Silvicultural treatments were applied in forest nursery to produce high quality and quantity seedlings. Fertilizer application is one of the most important treatments that was used to encourage seedling growth and development (Sherzad *et al*., 2015 and Hamad *et al*., 2020).

Seedlings quality can be enhanced by governing the type, amount, and timing of fertilization (Duryea and Landis, 2012). Nitrogen (N), phosphorus (P), and potassium (K) are three central macro-nutrients that are very important in the early development stage of seedlings (Pallardy,2008). The seedlings treat with adequate level of fertilizer usually have larger stems, and bigger root mass (Deng *et al*., 2019). Humic acid are black or dark brown materials which are partially or fully decomposed plant or animal wastes. Main composition of soil organic materials is humus, which are the most important reasons of using Humic acids for increasing soil fertility. It is also highly beneficial for both plant and soil; it maintains proper plant growth as well as it increases nutrient uptake, tolerance to drought and temperature extremes, activity of beneficial soil microorganisms, and availability of soil nutrients particularly in low organic matter (Eissa *et al*., 2007 and Ismail *et al*., 2007). The rates of fertilizing are established depending on the degree of provision of the arable layer with the corresponding elements of mineral nutrition, on the granulomeres composition of the soils, as well as on the breed and age of the seedlings (Pobedov e*t al*., 1986).

Afterward, there is a worldwide interest in optimizing nutrient application (Sherzad *et al*., 2015; Fu *et al*., 2017) and Humic acid (Melendrez, 2020; Fagbenro and Agboola, 1993) for different species in the nursery to achieve healthy and high-quality seedlings. In contrast, and according to our knowledge there is no prior study on the morphological and physiological properties of *Paulwonia tomentosa* in responses to chemical fertilizer and Humic acid levels, and their interactions under the nursery growing condition. Even though *Paulownia tomentosa* is thought to be fast growing species, fertilizer application is essential for full growth and improved seedling quality. Accordingly, and based on our knowledge that there is no study tested yet the morphological and physiological properties of *Paulwonia tomentosa* in responses to chemical fertilizer, Humic acid levels and their interactions under the nursery growing condition. Consequently, the present study was directed to determine the effect of different NPK fertilizer and Humic acid rates, and their interactions on the growth and physiological traits of *Paulwonia tomentosa* potted seedlings.

2. Materials and Methods

Study location

The study was carried out from 1st June 2021 to 1st of November 2021 on potted (*Paulownia tomentosa*) seedlings grown under a shade net house in Girdarasha (Latitude: 360 06′ 48.9 ″ N, Longitude: 4401 00′ 45.5 ″ E, Altitude: 415 meters above sea level) field which belongs to College of Agricultural Engineering Sciences, Salahaddin University-Erbil.

The species under study

At the first, the *Paulownia tomentosa* seedlings were used in this study were supported and provided by Company of Hawargay Hawkary for Paulownia tree in Erbil on 1st June of 2021. The seedlings were transferred from small pots into bigger pots (26 cm in diameter and 28 cm in length) as each pot filled with 10 Kg of mixture soil. Before the experiment had been conducted, a representative number of soil samples were taken from the upper 50 cm of the used soil to produce Paulownia seedlings sent to soil laboratory at Directorate of Agriculture Research Center- Erbil to analysis its physical and chemical properties as shown in Table (1).

Table 1 Some physical and chemical properties of the used soil of the study*

Soil properties		Units	Hawrgay Hawkary Soil
Particle distribution Size	Sand	(g kg^{-1})	59
	Silt		18.4
	Clay		22.6
Soil texture			Sandy clay loam
Soil PH			7.65
EC		dSm^{-1}	0.4
Organic matter content		(g kg^{-1} soil)	0.66
Potassium			220
Total nitrogen		(mg g^{-1}soil)	0.11
Available Phosphorous		(µg g^{-1} soil)	7.5

***The soil properties tests were conducted at the Directorate of Agriculture Research Center/Erbil**.

The experimental design

A factorial experiment was used based on completely randomized design (CRD) with two factors. The first factor was four rates of NPK Fertilizer which were 0, 0.5, 1, and 1.5 g pot^{-1} (20:20:20) and the second factor was also four rates of Humic acid (HA) which were 0, 5, 10 and 15 g pot^{-1} applied as soil addition. NPK and Humic acid both of them was added every month till the end of experiment duration. Each treatment was replicated five times. So, that the total number has to be 4 (NPK)*4 (Humic)*5 (Replications)*1 (Seedling) = 80 seedlings.

R: Replication

NPK fertilizer	Humic acid
F1: Control	H1: Control
F2: 0.5 g	H2: 5 g
F3: 1 g	H3: 10 g
F4: 1.5 g	H4: 15 g

1m 1m

F1H3 R3	F3H1 R3	F3H1 R1	F2H2 R4	F1H2 R5
F3H2 R4	F2H2 R2	F2H4 R5	F3H3 R1	F4H3 R2
F1H3 R1	F1H1 R3	F3H2 R2	F4H4 R3	F2H3 R5
F4H2 R2	F1H2 R4	F3H3 R4	F4H3 R5	F4H2 R1
F4H1 R1	F1H1 R5	F1H1 R4	F4H2 R3	F4H4 R4
F3H1 R2	F3H3 R2	F1H4 R3	F3H4 R1	F2H4 R4
F2H4 R3	F1H4 R1	F1H1 R1	F1H4 R5	F3H4 R2
F4H4 R5	F4H1 R3	F2H1 R4	F4H1 R2	F3H2 R5
F1H2 R1	F1H3 R5	F4H3 R4	F3H1 R4	F4H2 R5
F2H2 R3	F2H3 R4	F3H2 R1	F2H1 R3	F3H4 R4
F2H1 R1	F2H2 R1	F1H2 R3	F4H3 R1	F3H4 R3
F1H4 R4	F4H4 R1	F4H2 R4	F2H4 R2	F4H3 R3
F2H1 R5	F3H1 R5	F2H1 R2	F1H4 R2	F2H3 R1
F4H1 R5	F2H3 R3	F2H2 R5	F3H4 R5	F1H2 R2
F3H2 R3	F2H3 R2	F3H3 R5	F1H3 R4	F2H4 R1
F3H3 R3	F1H3 R2	F4H4 R2	F1H1 R2	F4H1 R4

Figure 1: the seedlings distribution according to the adapted design

The studied parameters

Growth parameters

At the beginning of the study (July), growth parameters viz stem height (cm), stem diameter (mm) and leaf number for all seedlings were recorded. Before applying the treatments, the average of these parameters for 80 seedlings were (25.40cm, 6.82mm, and 10.37 respectively) recorded. The stem height was measured from the at the edge of the pots to the highest living apical shoot using a measuring tape in centimeter units. The stem diameter was measured at the edge of the pots by using a digital vernier caliper in millimeter units (Digimatic caliper Mitutoyo-Japan). Leaf number for each seedling was counted manually. Moreover, the aforementioned parameters re-measured at the end of the experiment (November) to find stem height increment (cm), stem diameter increment (mm) and leaf number increment.

To calculate leaf area (cm^2), three seedlings were randomly selected from each treatment, then the leaves of each seedling were collected, later on, the leaves were placed on a white paper and the picture was taken with the smart phone's camera. The pictures were moved to the laptop and analyzed through Image J software for leaf area measurements as described by (Ahmad *et al*., 2015).

Physiological properties

A- Chlorophyll Content %

The measurement of chlorophyll content was achieved for all plants under the study using a portable chlorophyll meter SPAD-502 (Minolta Co. Ltd. Japan). Moreover, the mean of three chlorophyll content readings was obtained from the three leaves in three positions (top, middle and bottom) per plant (Sherzad *et al*., 2015).

B- Nitrogen percentage

The total nitrogen content was determined by the micro-Kjeldahl digestion method as described by (Bremmer and Mulvaney, 1982).

C- Protein percent %

Protein percent was determined according to the equation described by (Magomya *et al.*, 2014) and as follow:

Protein % = N% x 4.64

D - The Total Phosphorus Concentration:

Phosphorus was measured by the colorimetric method (V-1100 digital), as described by (Jones, 2001) using a spectrophotometer at 410 nm.

E- The Total Potassium Concentration:

The total potassium was measured by the flame photometric (BWB- Technologies), method (Jones, 2001).

Data Analysis:

Data of the studied parameters were analysed according to the Analysis of Variance (ANOVA) using SPSS Version 26. The significant differences between treatment means were compared by Duncan Multiple Rang Test at $p \leq 0.05$.

3. Results and Discussion

1- Effect of NPK fertilizers and Humic acid separately on the increment of stem height (cm), stem diameter (mm), and leaf number increment:

a. Stem height increment (cm)

Table 2 shows the significant effect of chemical fertilizer and Humic Acid on the growth properties of (*Paulownia tomentosa* Steud.) seedlings.

Both chemical fertilizers and Humic acid affected stem height increment significantly, the highest mean value (52.70 cm) was obtained from the application of (1.5 g) of NPK fertilizer while, the lowest value (42.70 cm) was recorded from the control treatment. This result was agree with Abdelkader *et al*. (2016) who carried out an experiment to study the effect of monthly treatments of NPK rates (0, 1.5, 3.0, 4.5 g $plant^{-1}$) on *Magnolia grandiflora* L. Their results indicated that application of 3 g pot^{-1} had significant effect on plant height.

In addition, there were not significant effect among 5, 10 and 15 g/ seedling Humic acid in terms of stem height increment. However, these three rates of Humic acid recorded significantly higher stem height increment compared with the control treatment. Moreover, the maximum stem height (51.40 cm) was noted by using 15 g/seedling Humic acid, and the lowest value (42.40 cm) was recorded from the control treatment. A similar result was reported by El-Khateeb *et al*. (2011) who indicated that stem height of *Acacia* seedlings improved by application of Humic acid at level (4 g/pot).

b. Stem diameter increment (mm)

As per the findings, the stem diameter increment was significantly affected by applying different amounts of NPK fertilizer and Humic acid (table 2). The maximum mean values (10.69 and 10.33 mm), were obtained from the application of 1.5 g/seedling NPK fertilizer and 15 g/seedling Humic acid respectively, while the minimum mean values (8.43 and 8.08 mm) were obtained from control treatment for both factors, respectively. These results supported by the conclusion that has been arrived by Hamad *et al*. (2020) whose concluded that, the maximum stem diameter (5.76 mm) of *Brachychiton populneus* seedlings, recorded from application of (3 g) of NPK fertilizer. In addition, these results were in tune with the previous findings of Ghani *et al*. (2018) who reported that application of (6 g) Humic acid recorded a significantly higher stem diameter which was (1.10 mm) in the (*Mangifera indica* L.).

Our experiment results revealed that increasing the rate of Humic acid will increase of growth because the role of Humic acid inmproving the soil fertility and increasing the availability of nutrient elements and consequently increased the growth (Abdel-Mawgoud *et al*., 2007).

c. Leaf number increment

The results in (table 2) indicated that there was not significant effect among 5, 10 and 15 g/ seedling Humic acid in terms of leaf number increment. However, these three rates of Humic acid recorded significantly higher leaf number increment compared with the control treatment. Moreover, the highest mean value (9.50 leaves plant^{-1}) was obtained from the application of (1g) NPK fertilizer. On the other hand, the lowest mean value (6.50 leaves plant^{-1}) was recorded from the control treatment. This result agreement with Sultan, (2020) who demonstrated that the highest values of number of leaves was (19.67) from used (10:8:6 g /transplant) of NPK fertilizers.

This study clearly indicated that the availability of nutrients (NPK) had a significant impact on growth Paulownia seedlings productivity because phosphorus is involved in energy metabolism and photosynthesis during growth (Yan *et al*., 2021), and potassium plays an important role in carbohydrate and protein metabolism (Hassanein *et al*., 2021), indicating that a reasonable proportion of nutrition (NPK) factors directly promote the absorption and assimilation of plant, there by affecting their growth and development (Bertin *et al*., 2009).

Whilst, leaf number increment was not-significant when different levels of Humic acid applied.

Table 2 Influence of NPK fertilizer and Humic acid separately on the increment of stem height (cm), stem diameter (mm), and leaf number

Factors	Treatments	Stem height increment (cm)	Stem diameter increment (mm)	Leaf number increment
NPK fertilizer	Control	42.70^c	8.43^c	6.50^b
	NPK (0.5 g)	47.70^b	9.37^b	9.00^a
	NPK (1 g)	51.55^a	9.54^b	9.50^a
	NPK (1.5 g)	52.70^a	10.69^a	9.20^a
	P-Value	*0.000*	*0.000*	*0.004*
Humic acid (HA)	Control	42.40^b	8.08^c	8.20^a
	HA (5 g)	50.00^a	9.77^b	8.85^a
	HA (10 g)	50.85^a	9.85^b	8.70^a
	0HA (15 g)	51.40^a	10.33^a	8.45^a
	P-Value	*0.000*	*0.000*	*0.888*

Values with different letters within a column for each factor indicates significantly differences at 5% of probability according to Duncan's multiple range test.

2. The interaction effect of NPK fertilizer and Humic acid on the increment of stem height, stem diameter, and leaf number

The interaction between NPK fertilizer and Humic acid on stem height increment, stem diameter increment and leaf number increment were shown in table (3). The highest value of stem height increment (55.00 cm) reported from the interaction between (1g NPK x 15 g Humic acid), and the lowest value (23.40 cm) was recorded from control treatment. The maximum mean value of stem diameter increment was (11.30 mm) from the interaction between (1.5 g NPK x 15 g Humic acid), while the minimum value was (4.17 mm) in control treatment.

The interaction between 1.5 g NPK x control Humic acid recorded the highest value of leaf number increment which was (11.80 leaves plant^{-1}), while the lowest leaf number increment (2.60 leaves plant^{-1}) was observed in control treatment.

These results concurred with those reported by Hagag *et al*. (2011), where they investigated that there were interaction effect of different levels of NPK fertilizer and Humic acid on the growth of olive seedlings as they reported that the maximum values of plant height was (204cm) at (0 NPK + 4 cm^3 Humic substance/plant/month), stem diameter was (2.5mm) at (0g NPK + 6 cm^3 Humic substance/plant/month), and leave number per plant was (152 leaf $plant^{-1}$) at (0 NPK + 4 cm^3 Humic substance/plant/month) were recorded. Results of the growth parameters in table 2 and table 3 revealed that the stem height increment, stem diameter increment and leaf number increment of the seedlings treated with both NPK fertilizer and Humic acid all together were better than those treated with NPK fertilizer and Humic acid separately.

Table 3 Stem height increment, stem diameter increment, and leaf number increment as affected by the interaction between NPK fertilizer and Humic acid

Treatments	Stem height increment	Stem diameter increment	Leaf number increment
NPK-0+HA-0	**23.40^{d}**	**4.17^{f}**	**2.60^{c}**
NPK-0+HA-5	**48.80^{abc}**	**9.20^{de}**	**8.60^{ab}**
NPK-0+HA-10	**48.60^{abc}**	**9.79^{cde}**	**6.80^{b}**
NPK-0+HA-15	**50.00^{abc}**	**10.56^{abc}**	**8.00^{ab}**
NPK-0.5+HA-0	**47.80^{bc}**	**9.32^{de}**	**9.60^{ab}**
NPK-0.5+HA-5	**47.40^{bc}**	**9.69^{cde}**	**10.20^{ab}**
NPK-0.5+HA-10	**48.60^{abc}**	**9.03^{de}**	**8.40^{ab}**
NPK-0.5+HA-15	**47.00^{c}**	**9.45^{cde}**	**7.80^{ab}**
NPK-1+HA-0	**48.60^{abc}**	**8.75^{e}**	**8.80^{ab}**
NPK-1+HA-5	**50.40^{abc}**	**9.73^{cde}**	**8.80^{ab}**
NPK-1+HA-10	**52.20^{abc}**	**9.65^{cde}**	**11.00^{ab}**
NPK-1+HA-15	**55.00^{ab}**	**10.02^{bcd}**	**9.40^{ab}**
NPK-1.5+HA-0	**49.80^{abc}**	**10.08^{bcd}**	**11.80^{a}**
NPK-1.5+HA-5	**53.40^{abc}**	**10.46^{abc}**	**7.80^{ab}**
NPK-1.5+HA-10	**54.00^{ab}**	**10.91^{ab}**	**8.60^{ab}**
NPK-1.5+HA-15	**53.60^{abc}**	**11.30^{a}**	**8.60^{ab}**

Values with different letters within a column indicates significantly differences at 5% of probability according to Duncan's multiple range test.

3. Effect of NPK fertilizers and Humic acid separately on leaf area, chlorophyll content and protein percent:

a. Leaf area (cm^2)

The leaf area (cm^2) was affected significantly by the application of different levels of NPK fertilizer. Table (4) showed that the maximum and minimum mean values of leaf area (2393.66 and 1302.00 cm^2) were attained from the application of NPK fertilizer at level 1.5g and Control, respectively. This result agrees with that obtained by AbdelKader *et al.* (2016) after they carried out a study to determine the effect of different NPK rates (0, 1.5, 3.0, 4.5 g $plant^{-1}$) monthly on some physiological attributes of *Magnolia grandiflora* L. seedling, they found that the highest mean value of leaf area, (325 cm^2) was recorded from the seedlings that treated with 1.5g plant^{-1} of NPK fertilizers. A significant effect of different levels of NPK fertilizer on the leaf area. It showed maximum leaf area in paulownia seedlings that were treated with NPK 1.5 g as compared to control and all other treatments because fertilization increase the photosynthetic efficiency, prolong the duration of photosynthesis, and enlarge the leaf area index. Application of fertilizers often increases the rate of photosynthesis by improving the efficiency of essential physiological processes. The essential physiological processes include stomatal conductance, leaf area, capacity for photosynthetic electron transport, and activity of carboxylation; and other enzymes (Pallardy, 2008).

Even though the leaf area was not affected significantly by Humic acid, it was increased with application of Humic acid compared with untreated seedlings.

b. Chlorophyll content

As per the findings, a substantial difference was found among different levels of NPK fertilizer which significantly affected on chlorophyll content (table 4). The highest mean value was recorded for chlorophyll content which was (56.97) from (1.5g NPK/seedling) and the lowest value (49.03) from control treatment. This result in agreement with Mohamed *et al*. (2014) Selecting the best N, P and K levels for the newly introduced Wonderful pomegranate trees grown under Minia region. They found that, increasing levels of N from 100 to 400 g/ tree was accompanied with enhancing N in the chlorophylls a & b and total chlorophylls. A remarkable promotion was observed on chlorophylls a & b and total chlorophylls with increasing both P & K levels from 50 to 100 g / tree. Chlorophyll content increased at all treatments of NPK fertilizer compared to the control (Table 4). The increase in total chlorophyll content in the leaves was probably generated by the level of NPK fertilization. The application of NPK fertilizer especially nitrogen element directly leads to increasing chlorophyll content of the seedlings because nitrogen is one of the basic element to make chlorophyll molecular (Pallardy, 2008). According to Ciecko *et al*. (2004) the greater amount of NPK fertilizers is accompanied by the higher total chlorophyll content in plant material. According to Nalborczyk *et al*. (1994), nitrogen fertilization affects chlorophyll content in plants. Research by Skwaryło-Bednarz and Krzepiłko, (2009) shows that the level of chlorophyll in plants increases rapidly following application of organic fertilizer.

On the other hand, the maximum and minimum values of chlorophyll content were (56.04 and 52.18) found from application Humic acid at levels 10 g and control respectively. This result is in line with the conclusion made by Mayi *et al*. (2014) who reported that Humic acid positively influenced chlorophyll content. The highest value (72.51) recorded in the olive transplants when spray with (40 mg L^{-1}) and the lowest value (68.71) was recorded in untreated olive transplants. Humic acid can caused an enhancement in the synthesis of the chlorophyll and/or delayed chlorophyll degradation in the two different types of leaves, primary and lateral shoot leaves (Nardi *et al*., 2002).

c. Protein percent

Application of NPK fertilizers significantly affected on protein percent. The highest mean value was recorded for protein percent which was (13.47) from (1.5g) and the lowest value (8.58) from (Control), respectively. Protein percent increased at all treatments of NPK fertilizer compared to the control (Table 4). It showed maximum protein percent in paulownia seedlings that were treated with NPK 1.5 g as compared to control and all other treatments. This may be due to the most important roles of nitrogen, phosphorus and potassium in promotion of several physiological and biochemical processes including photosynthesis and biosynthesis of various organic compounds such as nucleic acids, proteins, vitamins, hormones, chlorophyll molecules and carbohydrates which are considered very essential components for high plant growth and development (El-Saady and Omar, 2018). Nitrogen is also an essential component on the plant protein. Moreover, nitrogen is also a building factor of protein and nucleic acid that will support the plant productivity as a source for forages. It also supports the soil microorganisms that eventually will benefit the soil itself. (Umami *et al*., 2019).

On one hand, the maximum and minimum values of protein percent which (11.77 and 9.90) recorded from application of Humic acid at level (15 and 5) g, respectively. The result is confirmed that Humic acid has various biochemical effects on plants, such as enhancing protein synthesis (Saadati and Baghi, 2014).

.

Table 4 Influence of NPK fertilizer and Humic acid on the Leaf area (cm^2), chlorophyll content and protein percent

Factors	Treatments	Leaf area (cm^2)	Chlorophyll content (SPAD)	Protein percent
NPK fertilizer	Control	1302.00^c	49.03^b	8.58^d
	NPK (0.5 g)	1855.33^b	55.88^a	10.45^c
	NPK (1 g)	1886.00^b	56.72^a	11.15^b
	NPK (1.5 g)	2393.66^a	56.97^a	13.47^a
	P-Value	*0.000*	*0.000*	*0.000*
Humic acid (HA)	Control	1668.66^a	52.18^b	10.76^c
	HA (5 g)	2010.66^a	54.69^{ab}	9.90^d
	HA (10 g)	1940.33^a	56.04^a	11.22^b
	HA (15 g)	1817.33^a	55.69^a	11.77^a
	P-Value	*0.377*	*0.035*	*0.000*

4. The interaction between NPK fertilizers and Humic acid effected on the chlorophyll content, protein percent and leaf area:

Table (5) displayed that the interaction between the two factors (NPK fertilizers and Humic acid) were also found to be significant on the chlorophyll content. Chlorophyll content in Paulownia leaves was enhanced with application of NPK and Humic acid separately or together compared with once that did not treat with any amount of NPK and / or Humic acid. The highest mean value was (58.92) and the lowest value (34.10) reported from the interaction (1 g NPK x 0g Humic acid) and (control x control), respectively. The increase in the concentrations of chlorophyll in the leaves, as well as the increase in the leaf area of the seedlings that it increases the efficiency of the photosynthesis process.

Furthermore, table (5) also revealed that protein percent was significantly affected by combination treatments of NPK fertilizer and Humic acid, where the combination treatment of (1.5g NPK x 15 g Humic acid) and (Control x Control) recorded the highest value of protein percent (15.59 %), while the lowest value of protein percent was (8.17 %) achieved from the seedlings that were not treated by any amount of NPK and Humic acid. Previous studies showed the similar results for instance, an experiment was conducted by Imam and Al-Obaidi, (2020) to study the effect of chemical fertilization (NPK), with three concentrations which are (0, 125, 250 mg NPK L^{-1}) and Humic acid (HA) in three concentrations (0, 10, 20 mg L^{-1}) on (*Vitis vinifera*). Their results showed that application treatment of (250 mg NPK L^{-1} + 20 mg HA L^{-1}) had a positive significant effect on the protein percent in the leaves which is (8.575), as compared to the control treatment (0.612).

The interactions between the two factors NPK fertilizer and Humic acid were found to be non-significant on the leaf area that is why its data was not inserted in table (5).

Table 5 Chlorophyll content and protein percent as affected by the interaction between NPK fertilizer and Humic acid

Treatments	Chlorophyll content	Protein percent
NPK-0+HA-0	34.10^b	8.17^l

NPK-0+HA-5	**54.22^{a}**	**8.44^{k}**
NPK-0+HA-10	**53.14^{a}**	**8.96^{i}**
NPK-0+HA-15	**54.66^{a}**	**8.77^{j}**
NPK-0.5+HA-0	**57.68^{a}**	**10.58^{g}**
NPK-0.5+HA-5	**54.82^{a}**	**8.49^{k}**
NPK-0.5+HA-10	**56.00^{a}**	**11.65^{e}**
NPK-0.5+HA-15	**55.04^{a}**	**11.09^{f}**
NPK-1+HA-0	**58.92^{a}**	**12.16^{d}**
NPK-1+HA-5	**54.04^{a}**	**9.23^{h}**
NPK-1+HA-10	**57.08^{a}**	**11.60^{e}**
NPK-1+HA-15	**56.86^{a}**	**11.65^{e}**
NPK-1.5+HA-0	**58.04^{a}**	**12.16^{d}**
NPK-1.5+HA-5	**55.70^{a}**	**13.46^{b}**
NPK-1.5+HA-10	**57.94^{a}**	**12.71^{c}**
NPK-1.5+HA-15	**56.20^{a}**	**15.59^{a}**

Values with different letters within a column indicates significantly differences at 5% of probability according to Duncan's multiple range test.

5. Effect of NPK fertilizers and Humic acid separately on nitrogen (N), phosphorus (P) and potassium (K) uptake

Table (6), illustrates the effect of NPK fertilizer and Humic acid on NPK content in the leaves. The application of different fertilizers significantly increased the NPK content of Paulownia seedling. The highest and lowest values of nitrogen (2.90 and 1.85 %), were recorded when (1.5 g and control NPK) had been added respectively. The maximum and minimum values of phosphorus were 1.17 and 0.32 % when 0.5 and 1.5 g of NPK fertilizer had been applied. Moreover, the greatest and smallest values of potassium were 2.58 and 2.08 % from application of 1 and 1.5 g NPK respectively. These results explain that NPK fertilizer application to a certain level caused a significant decrease in the phosphorus and potassium content of Paulownia leaves. In contrast, nitrogen uptake raised significantly with increasing NPK fertilizer application.

Gill *et al*. (2014) study the influence of different levels of NPK fertilizers on leaf NPK content in pomegranate cv. Kandhari under sub-tropical conditions. Graded doses of nitrogen (0-300g/plant), phosphorus (0-150g/plant) and potassium (0- 300g/plant) fertilizers were applied through soil, in addition to a basal dose of FYM (Farmyard Manure). Control plants were fed FYM only. Leaf N, P and K content increased with application of the respective nutrient.

Table (6) also demonstrated that application of different Humic acid amounts had significant influence on nitrogen, phosphorus and potassium uptakes. The highest and lowest values of nitrogen (2.53 and 2.13 %), were recorded from the seedlings that treated with 15 and 5g of Humic acid respectively. The maximum and minimum values of phosphorus were (1.43 and 0.46%) when the 10 and 5 g of Humic acid had been applied, respectively. Moreover, the highest (3.21 %) and lowest (0.92 %) values of potassium obtained from the seedlings that treated with (15 and 0g), of Humic acid respectively. These results revealed that application a suitable amount of Humic acid is a key factor to uptake nutrients. The results also confirmed the prior studies that reported the significant role of Humic acid in soil stability, fertility and nutrient availability (Sharif *et al*.,2002 and El Ibrahim *et al*.,2016). Paksoy *et al*. (2010) have found out that Humic substances played a major role in plant nutrient uptake and growth parameters in seedlings. In addition, results in table 4 concluded that Humic acid, which is a relatively stable product of organic matter decomposition (El Ibrahim *et al*.,2016), can be used as alternative to use chemical fertilizer in order to raise nutrient content in Paulownia leaves.

Table 6 Influence of NPK fertilizer and Humic acid on the NPK content

Factors	Treatments	N (%)	P (%)	K (%)
NPK fertilizer	Control	**1.85^{d}**	**0.66^{c}**	**2.16^{b}**
	NPK (0.5g)	**2.25^{c}**	**1.17^{a}**	**2.11^{c}**
	NPK (1 g)	**2.40^{b}**	**1.06^{b}**	**2.58^{a}**
	NPK (1.5g)	**2.90^{a}**	**0.32^{d}**	**2.08^{c}**
	P-Value	***0.000***	***0.000***	***0.000***
Humic acid (HA)	Control	**2.32^{c}**	**0.77^{b}**	**0.92^{d}**
	HA (5 g)	**2.13^{d}**	**0.46^{d}**	**2.07^{c}**
	HA (10 g)	**2.42^{b}**	**1.43^{a}**	**2.73^{b}**
	HA (15 g)	**2.53^{a}**	**0.55^{c}**	**3.21^{a}**
	P-Value	***0.000***	***0.000***	***0.000***

6. The interaction between NPK fertilizer and Humic acid effected on the nitrogen (N), phosphorus (P) and potassium (K) up take

A significant difference was observed in the nitrogen, phosphorus, and potassium due to the interaction between NPK fertilizer and Humic acid. The nitrogen varied from as high as (3.36 %) under the treatment combination of (1.5g NPK x 15g Humic acid) to as low as (1.76 %) under the treatment combination of (Control x Control or 0 g NPK x 0 HA).

The interaction treatments of (0.5 g NPK x 10 g HA) and (0 g NPK x 0 HA) were recorded the highest and lowest phosphorus values which were (1.97 and 0.15 %), respectively. However, the highest mean value of potassium (3.74 %) were observed from interaction treatments of (1g NPK x 15g Humic acid) and the lowest value (0.70 %) from the interaction between (1.5g NPK x 0g Humic acid), respectively. Generally, the results of nutrient content in Paulownia leaves illustrated that nitrogen and potassium gradually increased with increasing concentration of NPK fertilizer and Humic acid. In contrast, phosphorus decreased when over concentration of NPK fertilizer and Humic acid were applied.

Table 7 Nitrogen, phosphorus, and potassium content (%) in paulownia leaves as affected by the interaction between NPK fertilizer and Humic acid

Treatments	N (%)	P (%)	K (%)
NPK-0+HA-0	**1.76^{l}**	**0.15^{m}**	**0.92^{k}**
NPK-0+HA-5	**1.82^{k}**	**0.69^{g}**	**1.91^{i}**
NPK-0+HA-10	**1.93^{i}**	**1.46^{d}**	**2.86^{e}**
NPK-0+HA-15	**1.89^{j}**	**0.34^{j}**	**2.98^{d}**
NPK-0.5+HA-0	**2.28^{g}**	**0.97^{f}**	**0.72^{l}**
NPK-0.5+HA-5	**1.83^{k}**	**0.47^{h}**	**2.06^{h}**
NPK-0.5+HA-10	**2.51^{e}**	**1.97^{a}**	**2.03^{h}**
NPK-0.5+HA-15	**2.39^{f}**	**1.29^{e}**	**3.63^{b}**

NPK-1+HA-0	**2.62[d]**	**1.71[c]**	**1.36[j]**
NPK-1+HA-5	**1.99[h]**	**0.27[k]**	**2.36[g]**
NPK-1+HA-10	**2.50[e]**	**1.93[b]**	**2.87[e]**
NPK-1+HA-15	**2.51[e]**	**0.36[j]**	**3.74[a]**
NPK-1.5+HA-0	**2.62[d]**	**0.26[kl]**	**0.70[l]**
NPK-1.5+HA-5	**2.90[b]**	**0.41[i]**	**1.95[i]**
NPK-1.5+HA-10	**2.74[c]**	**0.39[i]**	**3.17[c]**
NPK-1.5+HA-15	**3.36[a]**	**0.24[l]**	**2.51[f]**

4. Conclusion

As a conclusion of this study, the application of NPK fertilizer and Humic acid caused a significant increase in the most important studied characteristics such as morphological and physiological properties of *Paulownia tomentosa* seedlings. The production of *Paulownia tomentosa* seedlings can be improved by adding the adequate levels of NPK fertilizer and/or Humic acid. Even though the NPK fertilizers were superior Humic acid in the most morphological and physiological properties, Humic acid can be used as replacement of chemical fertilizer.

5. References

Saadati, J. and Baghi, M., (2014). Evaluation of the effect of various amounts of Humic acid on yield, yield components and protein of chickpea cultivars (Cicer arietinum L.). *Int. J. Adv. Biol. Biom. Res*, *2*(7), pp.2306-2313.

Jones, J.B., (2001. *Laboratory guide for conducting soil tests and plant analysis* (No. BOOK). CRC press.

Abdelkader, H.H., El–Boraie, E.A.H., Hamza, A.M. & Badawya, M.F.R., (2016). Effect of mineral fertilization with some growth regulators on growth of *magnolia grandiflora* L. seedling. I. Effect on vegetative growth. *Journal of plant production*, Mansoura University, 7(4), pp.401-407.

Abdel-Mawgoud, A.M.R., El-Greadly, N.H.M., Helmy, Y.I. and Singer, S.M., (2007). Responses of tomato plants to different rates of humic-based fertilizer and NPK fertilization. *Journal of Applied Sciences Research*, *3*(2), pp.169-174.

Ahmad, S., Ali, H., Ur Rehman, A., Khan, R.J.Z., Ahmad, W., Fatima, Z., Abbas, G., Irfan, M., Ali, H., Khan, M.A. & Hasanuzzaman, M., (2015). Measuring leaf area of winter cereals by different techniques: A comparison. *Pakistan Journal of Life and Social Sciences*, *13*(2), pp.117-125.

Al Taher, Z.A.A., Hassan, F.A. & Hassan, A.R.O., (2020). Effect of nitrogen fertilizer, ascorbic acid, the number of additions, and their interactions on the physical traits of paulownia plant (*Paulownia tomentose* L.). *Euphrates journal of agriculture science*, *12*(1).

Alagawany, M., Farag, M.R., Sahfi, M.E., Elnesr, S.S., Alqaisi, O., El-Kassas, S., Al-Wajeeh, A.S., Taha, A.E. & Abd E-Hack, M.E., (2020). Phytochemical characteristics of paulownia trees wastes and its use as unconventional feedstuff in animal feed. *Animal biotechnology*, pp.1-8.

Barton Il, Nicholas Id and Ecroyd Ce (2007). Paulownia. *The Forest Research Bulletin. 231:* 5-68.

Bergmann, B.A., (2003). Five years of paulownia field trials in north carolina. *New forests*, *25*(3), pp.185-199.

Bertin, C., Senesac, A.F., Rossi, F.S., DiTommaso, A. and Weston, L.A., (2009). Evaluation of selected fine-leaf fescue cultivars for their turfgrass quality and weed suppressive ability in field settings. *HortTechnology*, *19*(3), pp.660-668.

Bremmer, L. & Mulvaney, C. (1982). Total nitrogen. En: Methods of soil analysis. Chemical and microbiological properties (Agronomy 9)

Ciećko, Z., Kalembasa, S., Wyszkowski, M. and Rolka, E., (2004). Effect of soil contamination by cadmium on potassium uptake by plants. *Polish Journal of Environmental Studies*, *13*(3), pp.333-337.

Deng, S., Shi, K., Ma, J., Zhang, L., Ma, L. And Jia, Z., (2019). Effects of Fertilization Ratios and Frequencies On the Growth and Nutrient Uptake of *Magnolia Wufengensis* (Magnoliaceae). *Forests*, *10*(1), P.65.

Duryea, M.L. & Landis, T.D. Eds., (2012). *Forest nursery manual: production of bareroot seedlings* (vol. 11). Springer science & business media.

Eissa, H.A., Hussein, A.S. & Mostafa, B.E., (2007). Rheological properties and quality evaluation on Egyptian balady bread and biscuits supplemented with flours of un germinated and germinated legume seeds or mushroom. *Polish journal of food and nutrition sciences*, *57*(4), pp.487-496.

El Ibrahim, H., Gh El-Fadaly, H. & Am El-Naggar, A., (2016). Study on the response of statice plants (*limonium sinuatum*, L.) to humic acid application. *Alexandria science exchange journal*, *37*(july-september), pp.515-528.

El-Khateeb, M.A., El-Leithy, A.S. & Aljemaa, B.A., (2011). Effect of mycorrhizal fungi inoculation and humic acid on vegetative growth and chemical composition of *acacia saligna* labill. Seedlings under different irrigation intervals. *journal of horticultural science & ornamental plants*, *3*(3), pp.283-289.

El-Saady, W. A., & Omar, G. F. (2018). Effect of some Inorganic NPK Fertilization Treatments on Cauliflower. *Journal of Plant Production*, *9*(12), 1215-1222.

El-Showk, S. & El-Showk, N., (2003). The paulownia tree. *An alternative for sustainable forestry, crop development, morocco,* pp.1-8.

Fagbenro, J.A. & Agboola, A.A., (1993). Effect of different levels of humic acid on the growth and nutrient uptake of teak seedlings. *Journal of plant nutrition*, *16*(8), pp.1465-1483.

Fu, R., Feldman, D., Margolis, R., Woodhouse, M. and Ardani, K., (2017). *US solar photovoltaic system cost benchmark: Q1 2017* (No. NREL/TP-6A20-68925). EERE Publication and Product Library, Washington, DC (United States).

Ghani, F., Khan, M.R., Bostan, N., Nabi, G., Muhammad, H., Ali, A., Amin, J. & Rabi, F., (2018). Effect of humic acid and seed size on germination of mango (*Mangifera indica* L.) seed. *Pure and applied biology (pab)*, *7*(1), pp.315-320.

Gill, P.P.S., Kumar, M., Singh, N.P. & Dhillon, W.S., (2014). Studies on macronutrient fertilization in pomegranate under sub-tropical plains. *Journal of Horticultural Sciences*, *8*(2), pp.172-175.

Hagag, L.F., Shahin, M.F.M. & El-Migeed, M.M.M., (2011). Effect of NPK and humic substance applications on vegetative growth of egazy olive seedlings. *American-eurasian journal of agricultural & environmental sciences*, *11*(6), pp.807-811.

Hamad, S.O., Ali, N.S. & Karim, S.A., (2020). Effects of light and fertilizer amounts on seedling growth of *brachychiton populneus* (schott & endl.). *Basrah journal of agricultural sciences*, *33*(2), pp.158-171.

Hassanein, R.A., Hussein, O.S., Abdelkader, A.F., Farag, I.A., Hassan, Y.E. and Ibrahim, M., (2021). Metabolic activities and molecular investigations of the ameliorative impact of some growth biostimulators on chilling-stressed coriander (*Coriandrum sativum* L.) plant. *BioMed Central plant biology*, *21*(1), pp.1-23

Imam, N.M.A.A. & Al-Obaidi, H.S.F., (2020). Effect of adding the chemical fertilizer NPK and humic acid on the growth and mineral percentage for seedlings of three grape cultivars (*Vitis vinifera* L.). *Euphrates Journal of Agriculture Science,12* (2), pp 473-486.

Ismail, A.I., Sohn, W., Tellez, M., Amaya, A., Sen, A., Hasson, H. & Pitts, N.B., (2007). The international caries detection and assessment system (icdas): an integrated system for measuring dental caries. *Community dentistry and oral epidemiology*, *35*(3), pp.170-178.

Magomya, A.M., Kubmarawa, D., Ndahi, J.A. and Yebpella, G.G., (2014). Determination of plant proteins via the kjeldahl method and amino acid analysis: A comparative study. *International journal of scientific & technology research*, *3*(4), pp.68-72.

Mahmood, K.A., Ali, O.O. and Rahman, N.M.A., (2017). Effect of cutting type and Seradix 3 on rooting percentage and some characteristics of produced Paulownia's sapling *Paulownia tomentosa* L. *Tikrit Journal for Agricultural Sciences, 17*(3).

Mayi, A.A., Ibrahim, Z.R. & Abdurrahman, A.S., (2014). Effect of foliar spray of humic acid, ascorbic acid, cultivars and their interactions on growth of olive (*Olea european* L.) transplants cvs. Khithairy and sorany. *Iosr journal of agriculture and veterinary science*, *7*(4), pp.18-30.

Melendrez, M.M., (2020). Humic acid: The science of humus and how it benefits soil. *Eco Farming Daily. [Online] Available from: https://www. ecofarmingdaily. com/build-soil/humus/humic-acid*.

Mohamed, M.A., Ibrahiem, H.I. and Omar, M.O., (2014). Selecting the best N, P and K levels for the newly introduced Wounderful pomegranate trees grown under Minia region. *World Rural Observations*, *6*(4), pp.23-29.

Nalborczyk, E., Wróblewska, E., Marcinkowska, E. and Roszewski, R., (1994). Amaranthus-prospect cultivation and utilization. *Wydzial. Szko³a G³ówna Gospodarstwa Wiejskiego (Warsaw Agricultural University)., Warszawa*.

Nardi, S., Pizzeghello, D., Muscolo, A. and Vianello, A., (2002). Physiological effects of humic substances on higher plants. *Soil Biology and Biochemistry*, *34*(11), pp.1527-1536.

Paksoy, M., Türkmen, Ö. and Dursun, A., (2010). Effects of potassium and humic acid on emergence, growth and nutrient contents of okra (*Abelmoschus esculentus* L.) seedling under saline soil conditions. *African Journal of Biotechnology*, *9*(33).

Pallardy, S. G. (2008). Physiology of Woody Plants. (Third Edition). Academic Press. 464 Pp. Https://Www.Elsevier.Com/Books/Physiology-Ofwoody-Plants/Pallardy/978-0-12-088765-1.

Pobedov, S.V., Bulavyk, I.M., Lebedev, E.A., Shymansky, P.S., Volchkov, V.E. and Prokshin, D.N., (1986). Handbook of fertilizers in forestry. *Moskow: Agropromizdat (in Russian)*.

Sharif, M., Khattak, R.A. & Sarir, M.S., (2002). Effect of Different Levels of Lignitic Coal Derived Humic Acid On Growth of Maize Plants. *Communications in Soil Science and Plant Analysis*, *33*(19-20), Pp.3567-3580.

Sherzad, O.H., Mohd Zaki, H., Hazandy, A.H., Mohamad Azani, A. & Noordin, W.D., (2015). Growth and Physiological Responses of *Shorea Materialis* Ridl. Seedlings to Various Light Regimes and Fertilizer Levels Under Nursery Condition. *The Malaysian Forester*, *78*, Pp.133-150.

Skwaryło-Bednarz, B. and Krzepiłko, A., (2009). Effect of various doses of NPK fertilizers on chlorophyll content in the leaves of two varieties of amaranth (*Amaranthus cruentus* l.). *Ecological Chemistry and Engineering. A*, *16*(10), pp.1373-1378.

Sultan, H.M.N.M.I., (2020). Effect of fertilization on fig transplants (Doctoral dissertation, Benha University).

Umami, N., Abdiyansah, A. and Agus, A., (2019). November. Effects of different doses of NPK fertilization on growth and productivity of Cichorium intybus. *In Institute of Physics Publishing Conference Series: Earth and Environmental Science* (Vol. 387, No. 1, p. 012097). Institute of Physics Publishing.

Westerman, M.A., (1990). Coordination of maternal directives with preschoolers' behavior in compliance-problem and healthy dyads. *Developmental psychology*, *26*(4), p.621.

Yan, L., Sunoj, V.J., Short, A.W., Lambers, H., Elsheery, N.I., Kajita, T., Wee, A.K. and Cao, K.F., (2021). Correlations between allocation to foliar phosphorus fractions and maintenance of photosynthetic integrity in six mangrove populations as affected by chilling. *New Phytologist*, *232*(6), pp.2267-2282.