

DIAGONAL GROWTH CURVE FOR (*ZIZIPHUS SPINA CHRISTI*) GROWING IN GOVERNORATE ANBAR

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ABSTRACT

The research was conducted with the aim of obtaining equations to estimate the diameter growth of different tree ages for the species (*Ziziphus spina-christi*) to determine the validity of the site for cultivating the species under study. Field data were collected from the site of the University of Anbar in Anbar Governorate, the city of Ramadi. The samples were randomly selected. Cross sections of the tree were taken. The data were collected by conducting the required field measurements, then the data were tabulated using the Excel program, and by using the method of linear and non-linear regression analysis in the Statgraphics2022 statistical program. Obtaining equations for diagonal growth, precision measures were used to compare between equations (coefficient of determination, standard error, and average absolute error). The equation was reached: $d = 0.409131 + 1.90377 * A - 0.384178 * P - 0.0443618 * T1$ for the diameter growth, where the value of the coefficient of determination was (95.98%), the standard error was (0.084), and the mean absolute error was (0.055).

Keywords : sidr, diameter curves, diameter growth, site quality, Stem analysis, trees species.

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الزبيدي والجبوري

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منحنى النمو القطري للنوع (*Ziziphus spina-christi*) النامي في محافظة الانبار

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المستخلص

تم اجراء البحث بهدف الحصول على معادلات لتخمين النمو القطري لمختلف اعمار الشجرة للنوع (*Ziziphus spina-christi*) لتحديد صلاحية الموقع لزراعة النوع قيد الدراسة. جمعت البيانات الحقلية من موقع جامعة الانبار في محافظة الانبار مدينة الرمادي، تم اختيار العينات عشوائياً، اخذت المقاطع العرضية للشجرة، تم جمع البيانات بأجراء القياسات الحقلية المطلوبة، ثم بوبت البيانات بأستخدام برنامج Excel، وبأستخدام طريقة تحليل الانحدار الخطي وغير الخطي في البرنامج الاحصائي Statgraphics 2022 تم الحصول على معادلات للنمو القطري، استخدامت مقاييس الدقة للمفاضلة بين المعادلات (معامل التحديد وللخطأ القياسي، ومتوسط الخطأ المطلق). تم التوصل الى المعادلة: $d = 0.409131 + 1.90377 * A - 0.384178 * P - 0.0443618 * T1$ للنمو القطري حيث كانت قيمة معامل التحديد (95%) والخطأ القياسي (0.084) ومتوسط الخطأ المطلق (0.055).

الكلمات المفتاحية: سدر، منحنى النمو القطري، جودة الموقع، تحليل الساق، اشجار الغابات.

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INTRODUCTION

Forest trees provide many goods and services that humans use in various areas of their lives. They are also one of the most important stores of carbon in the world, and one of the most important solutions offered followed to mitigate the effects of climate change; Because of the increase in gaseous and carbon emissions and pollution at the level of the planet, and afforestation in desert and desertified areas is an important environmental necessity for a safe and sustainable future, which requires the selection of tree species on scientific grounds and in accordance with the characteristics of the site (site class) (18) . The science of forest management and measurements enables researchers to evaluate sites according to the growth of tree and shrub species, which can be widely applied to the range of different species and genus of trees and their geographical distribution under the same conditions. Similar to the production estimate for forest land (21 and 5). The genus Sidr (*Ziziphus spina-christi*) is one of the most important drought-tolerant, evergreen, fast-growing, perennial thorny species. It was mentioned (4 times) in the Holy Qur'an, due to its economic benefits of food and medicine, as well as the environmental benefit of Sidr with wide medical uses (13), recently gained Sidr trees are of great interest to many because of their high ability to withstand drought conditions and the wide adaptation to different soils (17). Sidr trees have been used for medicinal and natural treatment purposes, and they are also used as disinfectants and other benefits that made them the focus of attention of scholars (6). Trees of the genus *Ziziphus* are distinguished by their great diversity in the different environmental systems in which they grow, such as arid, semi-arid, saline and desert environments, and they have a wide spread in throughout Iraq (30). The size ranges in height from (15 m) and Its stem is branched, Normally, the diameter at chest height (dbh) ranges from (15-26 cm), with a large crown with an area of up to 100 m (in ideal locations), and its root group is deep. The leaves are oval in shape and their length ranges between (2-4 cm) and the color of its flowers is yellowish green. In general, Sidr trees grow in hot and temperate regions, and Sidr grows

in all regions. Soil types and tolerate soil salinity, provided that the ground water level does not rise, and its cultivation is good in sandy or yellow lands, which indicates that Sidr trees are tolerant of drought (3). The importance of studying the phenomenon of desertification through its devastating effects. At a time when the world is looking to produce more food to keep pace with the growing demographic growth, desertification comes to threaten the pastures and areas of agricultural production, especially the dry and semi-arid areas where desertification is increasing. Iraq is among those countries that It has been affected by this phenomenon for several reasons, including climate change, low rates of rainfall and misuse of natural pastures due to overgrazing and urban sprawl at the expense of agricultural lands without taking into account regulations and laws, as well as unsustainable farming methods of irrigation operations, and the increasing decline in rates and levels (23, 29). The surface water running into Iraq's rivers has led to the exacerbation of this phenomenon and its extension to areas that were previously considered among the most fertile agricultural areas (22 , 24). Iraq is located in the of semi-tropical latitude in the range Northern Hemisphere (38.45° - 48.45°) east of Greenwich line and between latitudes (29.5° - 37.59) north of the equator. Iraq lies within the moderate northern region, a system similar Mediterranean where rainfall occurs almost in winter, autumn, spring and disappears in summer. The seasonal rainfall of Iraq in Climate Atlas illustrating, the lower rainfall in the south and southwest and increase towards to the north and north-east (15 , 23). Because of the importance of the Sidr tree in the environment of Iraq, specifically the central and western regions and similar sites in the climatic and environmental conditions because they are dry sites that suffer from desertification, this study came with the aim estimating the diameter growth of the different ages of the tree for the species (*Ziziphus spina-christi*) to determine the validity of the site for planting the specie under study.

MATERIALS AND METHODS

Location data: The site was chosen at the University of Anbar in the Ramadi

Government, which is located in the western part of Iraq, to collect data related to the study. The governorate is part of the western plateau and the desert of the island, which is an extension of the plateau of the Arabian Peninsula, and is subject to severe erosion due to the slope of its lands, which vary in heights and range from (250-300) m, near the course of the Euphrates River, while the height of the western plateau reaches more than (800) m above Sea level at Jabal Anza on the Jordanian border. The study site was visited in order to select a sample for data collection. A number of variables in the tree were initially measured.

The method of stem analysis was used for a sample of trees (14, 20 and 31).

Data collection

Soil samples were collected for each depth of the study bench, then they were kept in nylon bags, the depths were recorded on them, and then transferred to the laboratory. The samples were air dried, impurities were removed from them, then dismantled by grinding them with a wooden hammer and sifted through a sieve with holes diameter (2 mm) and kept in plastic containers for laboratory analysis. Table (1) shows some physical and chemical properties of the soil.

Table 1. laboratory, chemical and physical analyzes of profile soil in the study site

Horizon		A p	C1	C2
Adjective				
Depth cm		0-30	30-70	70-120
Volume	total sand 0.05.2 mm	714.2	955	972.5
distribution of	Total silt 0.05.0.002 mm	136.7	12.4	8.4
soil separations	Clay aggregate 0.002 less than	149	32.7	18.1
g/kg				
Tissue class		SL	S	S
Bulk Density Mgm.3		1.68	1.29	1.57
True Density Mgm.3		2.58	2.46	2.43
Porosity %		31.1	46.76	35.3
PH		7.07	7.24	7.31
EC DC Siemens M-1		19.71	6.08	3.29
Gypsum gm. Kg ⁻¹¹		43.18	345.41	453.24
CEC Centi Mall		7.03	3.27	2.96
Shipment kg ⁻¹				
Total carbonate gm. kg ⁻¹		494.61	419.79	519.06

Soil trophic, thermal and hydrological regimes significantly influence site productivity. The hydrological conditions of sites depend not only on the physical properties of the soil but also on the topographical location and ambient atmospheric conditions (10, 11 and 19), for forest management. The influence of site factors (slope, aspect, elevation, and topographic location) on the characteristics and productivity of forest areas cannot be ignored. Site productivity is largely determined by the physical and chemical properties of the soil. However, it is also affected by climatic factors such as precipitation and temperature, and length of growing season, soil physical and chemical properties are used in soil site methods to estimate site productivity (4,7,9,12, 25, 26 and 28). Better estimate site productivity/site quality (27). The study samples were randomly selected for the species (*Ziziphus spina-christi*) at the University of Anbar in Anbar Governorate. The method of stem analysis is

considered the main technique for data collection in this study, as the tree representing the community was cut down by following the method of stem analysis, and the following measurements were taken:

1. The diameter of the tree was measured at breast height and recorded to the nearest mm using a tape measure.
2. The total height of the tree was measured and recorded from ground surface to the top of tree using a tape measure.
3. The main stem of the tree was cut into many tree stems, the first was at a height of 0.30 m, the second was at the height of the breast and then at a height of one meter until it reached a diameter (4-6 cm) and often 7 cm.
4. A disc about (5 cm) thick was taken from each cut for log analysis (16, 20, and 31).

a) Laboratory work

- 1) One surface of each disc has been perfectly smoothed using sandpaper and an electric smoothing device (Figure 1).

- 2) Soaking the discs with water in order to show the annual rings before taking pictures.
- 3) Determine the age of the tree by calculating (the number of rings on the surface of the stump + the year of the nursery).
- 4) The radius was found for each cross section.
- 5) The cross-sections were photographed with a high-resolution camera Then collect the images into a file to calculate the number of annual episodes in each disc and to measure the width of the annual episodes.
- 6) The Auto Cad program was used to calculate and record the number of annual rings from the cambium inward, to determine the age
- 7) Using the same program, the distance was taken and recorded for all annual rings in cross-sections, starting from the center of each cross-section and along the average specified radius.

b) Stem analysis

From such section much data could be extracted as follows:

1. Starting from the center of each disc, the diameter of the second ring was considered as the diameter of the first tree, D_1 . The width of the first ring along the average radius was considered as half diameter increment. Multiplication of this value with 2 yields the diameter increment of that diameter, ΔD_0 . This data represents the diameter and diameter increment of the first tree

2. From these two measurements, the data about another tree was extracted, as follows:

$$D3 = D2 + \Delta D1$$

The diameter growth ($D2$) of this tree will be the twice of distance between the second and third annual ring along the average radius.

3. In the same way the data about the diameter and diameter increment was extracted from the same cross - section, which could be formulated as follows:

$D4 = D3 + \Delta D2$ The general formula for such concept could be summarized as follow:

$$D_{n+1} = D_n + \Delta D_{n-1}$$

Where D_{n+1} = the diameter of any tree in the cross - section, D_n and ΔD_{n-1} = diameter of a

tree and the diameter increment of the previous tree

4. The number of extracted trees depended on the available numbers of annual rings, on the cross- section, which in turn depended on the diameter of the cross - section (Figure 2).

summarizes the above mention procedure for constructing the dataset.

Diameter

$$D2 = \text{diameter of the second tree} = D1 + \Delta D_0$$

$$D3 = \text{diameter of the third tree} = D2 + \Delta D1$$

$$D4 = \text{diameter of the fourth tree} = D3 + \Delta D2$$

$$D_{n+1} = \text{diameter of the } n^{\text{th}} \text{ tree} = D_n + \Delta D_{n-1}$$

5. This data was subjected to a mathematical and statistical analysis, whereby Excel was used to tabulate it and Statgraphics 2022 to analyze the data and predict the diameter growth with predictive equations, and test the performance of the equations to choose the most appropriate one to estimate the growth of the diameter, we conclude from this that tree analysis to predict trees along the main stem with time, Information about diameter, diameter increase, height increase and age can be extracted using a simple calculation. The difference between the number of rings at the trunk and the disc cut at any other height represents the number of years it takes for the tree to grow from the trunk to the height at which the disc was taken (Table 2). This technique has many benefits: 1. There is no need to cut down many trees to obtain information for such a study. This in turn has many other benefits such as (a) being less expensive. (b) It needs less time to be consumed to get the required data from the field, and (c) It needs less effort, but needs more office work. 2. Using a small number of trees to develop a large number of trees has other benefits. All information extracted from a single tree has the same geographic characteristics, and the same site throughput. (3) Same soil, this means the only variables remaining are the diameter of each developed tree and the increase in annual diameter. This point is the most important and useful for this concept.

Table 2. Diameter data and diameter growth for each year in university of Anbar

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14
diameter/cm	1.42	3.03	4.73	6.48	8.28	10.1	11.96	13.84	15.75	17.67	19.61	21.57	23.54	25.53
Growth diameter/ cm	0	1.66	1.72	1.77	1.81	1.84	1.86	1.89	1.91	1.93	1.95	1.96	1.98	1.99



Figure 1. shows the cross-sections of the tree after the process of polishing and smoothing

Statistical metrics
The following accuracy measures were used:
1- Coefficient of Determination . (R^2)
2- Standard Error (S.E)
3- Mean absolute error (M.A.E)

RESULTS AND DISCUSSION

Tree Diameter: Through the pictures of the cross-sections of the tree taken from the disk, we can measure the diameter at the different age stages that the tree has gone through using the Auto Cad system. The arithmetic average of the diameter, then reading the standard ruler next to the cross section and converting the

ruler to its drawing scale, then multiplying this factor by the average value to extract the first outer diameter, then we start reading the second, third, fourth and fifth diameter and so on until you reach the center of the first cross section, taking into account taking Two or three measurements of diameter in the presence false rings, for example, the tree was (13) years old. From our reading of the first cross-section taken from the stump, we note the average diameters in the annual rings, (Table 3) illustrates this.

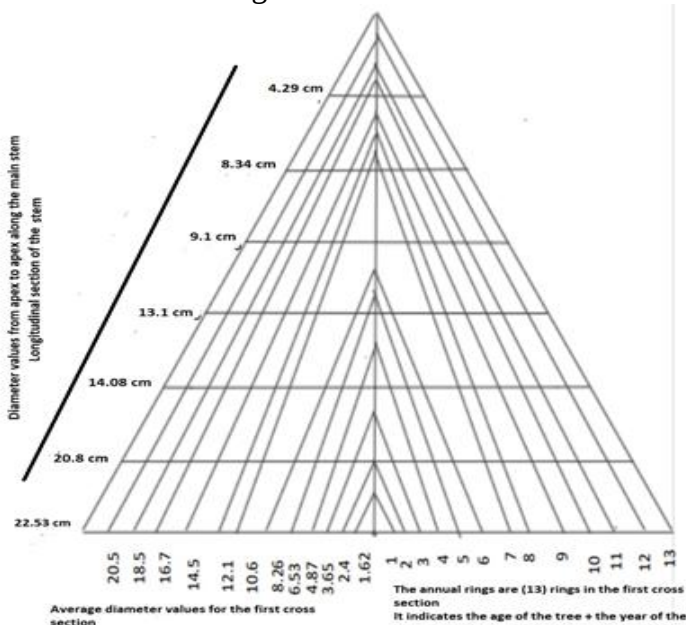


Figure 2. cross and longitudinal section of the tree

Table 3. shows the average diameters of the cross-section at the stump for the different ages of the tree

Age / year	13	12	11	10	9	8	7	6	5	4	3	2	1
Average diameter / cm	22.53	20.52	18.57	16.78	14.57	12.17	10.69	8.26	6.53	4.87	3.65	2.41	1.62

And by reading the successive sections of a single tree, starting from the stump to the last section of the tree, as we read the diameters in each section, as we mentioned using the Auto Cad program, and extract the diameters of these sections and their different ages, as in the (table 3, Figure 3).

$$di = 1.42411 * A^{1.0938}$$

$$R^2 = 88 \% \quad S.E = 0.42874$$

$$M.A.E = 0.32279$$

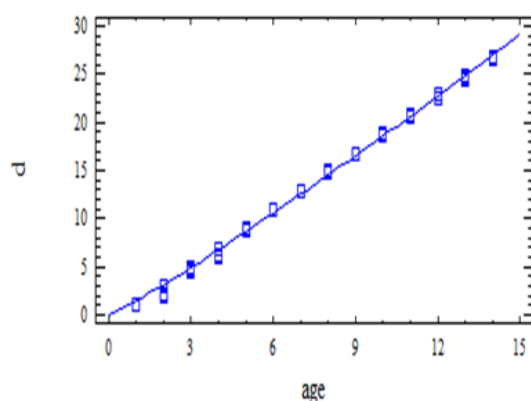


Figure 3. shows the cross-sectional area of the different ages of the species (*Ziziphus spina-chirsti*)

The following equation shows growth indicators based on climate elements and tree age only (Figure 4).

$$di = 0.40913 + 1.90377 * A - 0.38417 * P - 0.04436 * T1$$

whereas :

di = tree diameter A = age (year)

p = total annual rainfall

T1 = average annual maximum temperature

$$SE = 0.08480 \quad R^2 = 95\%$$

$$M.A.E = 0.05573$$

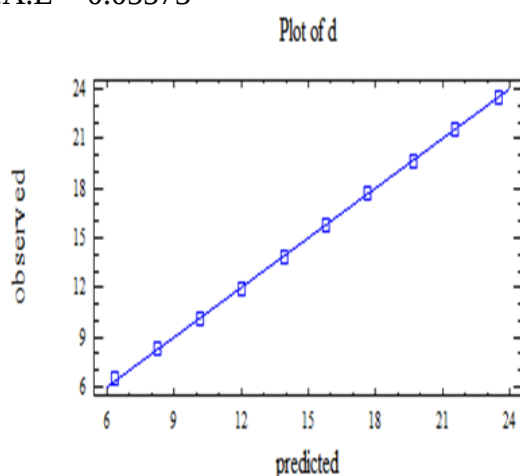


Figure 4. shows the growth curve in diameter for the (*Ziziphus spina-chirsti*) tree, depending on the climate elements and the age of the tree

Growth in diameter and growth in height for trees depends directly on soil characteristics in a given location, as well as the influence of climatic factors, which together form environmental growth requirements, and soil characteristics (soil texture, porosity, PH, EC, CEC, gypsum, carbonate) are of great importance to determine future and previous growth tree, in order to determine the environmental requirements and compare them with tree species of the same family or similar ones in areas of spread, growth and environmental requirements. (21 and 27). From the above results, it can be concluded the following:

1- The study was able to find mathematical models for estimating the changes in the tree growth of the cross-sections through the age of the tree (*Ziziphus spina-chirsti*) in the Anbar site using the variables of age, climate and soil
2- The method of linear and non-linear regression was used in preparing several models and a comparison was made between them using statistical measures (R^2 , S.E, M.A.E) (8).

3- The cross-sections equation was obtained to estimate the change in growth in the area of the cross-sections during the different age stages of the tree, as age was used as an independent variable and the diameter at chest height dbh as a dependent variable as the diameter over chest height gives close indications of accuracy for the growth in diameter.

4- using the stem analysis method to estimate the future growth and previous growth of (*Ziziphus spina-chirsti*) trees in Anbar site is recommended using it in other sites also recommended.

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