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Original Research

The effect of the density of the forest and age on the amount of carbonic stock of *Pinus brutia* Ten.

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ABSTRACT:

This study was conducted on *Pinus brutia* Ten. in Zawita region northern Iraq, which located between latitude (36°43′-36°54′) and longitude (43°02′–44°00′) and altitude ranging (681-1014) m above the level sea. The search method of data collection depended on the ground inventory done in summer 2010, where all basic data of the study were collected, which represented the variable of tree and forest from 30 samples. The layered random stocktaking was used to this effect, and it was divided into two layers. Twenty samples taken form artificial plantation and ten samples from natural forests were distributed to the study region with dimensions (30x30). Then from each sample, the measures of diameter at the Breast Height (DBH) and the variables of the forest represented by the number of trees per unit area and average square diameter and prevailing average height of trees. By using the mathematical models, the size of the trunk and branches was estimated, and from the specific weight of *Pinus brutia* Ten. of about (0.4676) kg/m^3, the weight of trunk and branches of the study sample was calculated, also the weight of wet leaves was calculated from the study site for different diametrical categories of samples, by using multiple regression data field for trunk, branches, leaves and forest variables, were calculated using the following equations:

$WDS=-1314.2 + 67.564N + 413.13dq + 592.838\ Hm$

$WDB = 893.88 + 2.10712dq^2 + 1.0NHm^{1.2667}$

$WDL = 138.26 + 0.2958dq^2 + 0.64491\ NHm^{0.7456}$

Through these equations, we could estimate the molecular weight of the different dried tree elements represented by (trunk, branch, leaves), which represents the dry mass of the tree per unit area, and by combining these elements, we can obtain the total dry mass per unit area, and the change occurred in the forest in terms of tree number per unit area, the prevailing average height, or the average square diameter that leads to significant changes in the total dry weight above ground.

Keywords:

Forest density, *Pinus* sp, Carbon stock, Biomass production, Bioenergy.

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INTRODUCTION

Forests are a renewable natural resource that present many raw, service and environmental materials for the society. Thus, maintaining its balance in terms of production, renewal and performing its various duties continuously requires us to know the full circumstances in which trees grow. They need raw and environmental materials to grow and produce in an ideal manner, since the frosts cover vast areas of land on the surface of earth, estimated with about (26%) of its area (FAO, 1995)

The *Pinus brutia* Ten. is of economic importance in many areas, as it is used in the wood industries and afforestation in the poor and arid land in northern Iraq. The biomass of the forests is the different parts of tree above ground and underground per unit area. Moreover, they are used widely in estimating the samples of carbon or carbon dioxide absorbed by the atmosphere, as there is a wide range of uses of the tree biomass, as through which we could estimate the forest qualities and the change in from time to time along with its growth and production therein. Not mentioning the preparation of different environmental models, such as determining the changes in the biomass and as a result of applying different activities with the uses of forest lands. The determination of wet weight of the tree and plantation is a basic step in estimating the ability of forests in absorbing and storing carbon, and it is possible through deriving.

Mathematical model by which we determine the biomass based on volume only or the size of the sole tree, then converting it to a dry biomass through using conversion factors that depend mainly on the tree type. Therefore, this study seeks reaching to the estimation of *Pinus brutia* Ten. plantations productivity, in terms of biomass productivity of trunk, branches, leaves, biomass per unit area.

MATERIALS AND METHODS

The study area is a mountainous region with naturally occurring *Pinus brutia* Ten. plantations and also the area contains man-made plantations afforested within the years (1975 – 1980). In order to determine the samples number of study represented by the society of study site, two random samples were taken, one form each layer, and from each samples the diameter was measured at the breast level and total height for all trees of sample and by using the equation prepared by (Al-Zuhairi, 2006). The size per tree was estimated and the preliminary data was used in survey along some statistic measures to specify the number of samples representing this forest, and it was specified randomly with 30 samples, from which the following data was taken:

The diameter of sample trees at the breast level was measured by using diametrical tape and the total height of the sample trees was also measured. The equation that estimate the total tree size and the equation estimating the trunk size and the total size of tree for its

Table 1. Dried trunk weight (kg) of *Pinus brutia* Ten. plantations in terms of the average square diameter and prevailing average height at the density (877 tree/hectare)

S. No	Prevailing average height/m	Average square diameter/cm					
		14	17	20	23	26	29
1	5	10256.07	24013.41				
2	6	16836.7	30593.93	44351.16			
3	7	23417.23	37174.46	50931.68	50931.68		
4	8	29997.64	43754.98	57512.21	57512.21	85026.78	
5	9	36578.16	50335.39	64092.73	64092.73	91607.19	
6	10	43158.69	56915.92	70673.26	70673.26	98187.71	111944.6
7	11	49739.21	63496.44	77253.67	77253.67	104768.2	118525.9
8	12	56319.74	70076.96	83834.19	83834.19	111348.5	125105.9

Table 2. Dried branches weight (kg) in terms of average square diameter and prevailing height average at density (877 tree/hectare)

S. No	Prevailing average height/m	Average square diameter/cm					
		14	17	20	23	26	29
1	5	1374.402	3549.558				
2	6	3118.545	5293.701	7889.88			
3	7	4942.497	7117.653	9713.832	12731.03		
4	8	6837.489	9012.645	11608.94	14626.14	18064.25	
5	9	8796.972	10972.13	13568.42	16858.62	2002.73	
6	10	10815.62	12990.77	15586.95	18604.16	2242.38	25901.52
7	11	12888.88	15064.14	17660.32	20677.41	24115.64	27974.89
8	12	15012.19	17188.35	19784.53	22801.73	26239.96	30099.09

different elements, which were prepared beforehand (Al-Zuhairi, 2006), among which the estimation the trunk size and branch stands important (Pettersson, 1969). As for the weight of dried leaves, three trees were selected from each sample grown naturally and free from diseases and defect, and their crown was divided into three layers, and from each layer, a branch was selected randomly, then the leaves were removed from all branches and weighted at the field and placed in plastic bags, then a secondary sample was taken from each of them and dried by electric oven at 120°C until the weight is stable in proportion method according to the weight of the dried leaves for each tree.

RESULTS AND DISCUSSION

The tree trunks per unit area are important elements in the plantation, as it the trunks establish a percentage of 78% of the total production of tree elements abovegrounds. We noticed that the production is focused on the tree trunks, compared with the branches and leaves, consequently its estimation is of ultimate importance in evaluating the product per unit area. Moreover, we can estimate the breeding processes occurring in the forest along with the estimation of the annual growth and its average, because of its importance, we have prepared the equations of estimation, the weight of dried tree dependent on plantation and variables represented by the average square diameter and the prevailing average height of the plantation with the number of trees per unit area. The following equation were formulated on the basis Table 5.

$$WDS= -1314.2+67.564N+413.13dq+592.838Hm \quad (1)$$

$R^2adj= 0.9128$; S.E = 856.18; Bais = -0.011

where, WDS: Weight of dried trunk (kg); Dq: Average square diameter (cm); Hm: Prevailing height average of the forest; N: Number of trees per unit area (tree/hectare)

Also, we prepared the equations of the dry weight of branches in terms of plantation variables. By using the data of *Pinus brutia* Ten. plantations in Zawita

Table 3. The weight of dried leaves (kg) in terms of average square diameter and prevailing height average at density (877 tree/hectare)

S. No	Prevailing average height/m	Average square diameter/cm					
		14	17	20	23	26	29
1	5	979.575	1284.936				
2	6	1252.08	1557.33	1921.854			
3	7	1513.152	1818.402	2182.926	2606.502		
4	8	1765.011	2070.261	2434.674	2858.25	3340.878	
5	9	2008.656	2314.017	2678.541	3102.006	3584.634	
6	10	2245.752	2551.002	2615.526	3338.991	3821.73	4363.521
7	11	2476.743	2782.104	3146.517	3570.093	44052.721	4594.512
8	12	2702.517	3007.878	3372.291	3795.867	4278.495	4820.386

Table 4. Total dry weight (kg) in terms of average square diameter and prevailing height average at density (877 tree/hectare)

S. No	Prevailing average height/m	Average square diameter/cm					
		14	17	20	23	26	29
1	5	12610.05	28847.9				
2	6	21207.33	37444.96	54162.89			
3	7	29872.88	46110.52	62828.44	66269.21		
4	8	38600.14	54837.89	71555.82	74996.6	106431.9	
5	9	47383.79	63621.54	80339.69	83780.36	115215.6	
6	10	56220.06	72457.69	89175.74	92616.41	124051.8	142209.6
7	11	65104.83	81342.68	98060.51	101501.2	132936.6	151095.3
8	12	74035.45	90273.19	106991	110431.8	141867	160025.3

northern Iraq, with different methods of regression, we have reached a mathematical equation to estimate the weight of dried branches, as follows:

$$WDB=-893.88 + 2.1072dq^2 + 1.0\ NHm^{1.2667} \quad (2)$$

R2adj= 0.9514; S.E = 146.005; Bais = -0.0109

where, WDB: Weight of Dried Branches (kg).

In view of the importance of leaves as one of the tree elements through which the processes of photosynthesis was performed in the plant, which is the basis for growth process in all trees. Thus, the estimation of this important element of tree by using mathematical equations was considered substantial in estimating the forest products, one of which are leaves. Through using field data, a mathematical equation was prepared to estimate the dried leaves weight, as follows:

$$WDL = 138.26 + 0.2958dq^2 + 0.64491NHm^{0.7456} \quad (3)$$

R2adj=0.9620; S.E = 19.72; Bias = 0.0134

where, WDL: Weight of Dried Branches (kg).

The statistical tests represented by the corrected coefficient of determination, standard error and deviation were performed, and all of which indicated the accuracy of these equations and their fitness to be used. Thus, they were used in the preparation of Tables (1, 2 and 3). Biomass estimates based on allometric equation assume that biomass of hectare reflect the sum of each tree-level biomass (Kanninen *et al*., 2003; Valentine *et al*., 1984). Noting the Table 1, we find that relationship is direct between the stem weight and the average diameter and dominant height increasing of variable of equation, and this is in agreement with what was indicated by (Thomas *et al.*, 1999). As through the tables, we can estimate the dried stem weight of different trees spread in the pine forest in Zawita and since the branches form an important part of biomass, we have prepared the equation of weight of dried branches in terms of forest variables and by using equation 2, Table 2 was prepared.

Noting Table 2 for the relationship between the weight of dried branches as dependent variable and average square diameter and prevailing height average as

Table 5. Total removed carbon dioxide of tree elements (kg) in terms of average square diameter and prevailing height average at density (877 tree/hectare)

S. No	Prevailing average height/m	Average square diameter/cm					
		14	17	20	23	26	29
1	5	23076.39	52791.66				
2	6	38809.4	68524.28	99118.1			
3	7	54667.37	84382.24	114976	121272.7		
4	8	70638.26	100353.3	130947.2	137243.8	194770.4	
5	9	86712.33	116427.4	147021.6	153318.1	210844.5	
6	10	102882.7	132597.6	163191.6	169488	227014.8	260243.6
7	11	119141.8	148857.1	179450.7	185747.1	243273.9	276504.4
8	12	135484.9	165199.9	195793.6	202090.2	259616.5	292846.3

independent variables at density 877 tree/hectare. We found that there is a direct increase in the dependent variable along with an increase in both independent variables, which indicated the development and growth of forests and still in their early stages of age before reaching to the end of the life cycle. The weight factor is one of the significant factors in expressing the biomass because is less variant from the size, and this factor is used to estimate the weight of dried leaves, as it expresses the quantity logic and accurate manner (Hoffman and Usoltsev, 2002) and equation 3 was used in preparing Table 3 regarding the estimation of the weight of dried leaves.

Noting Table 3, we find that there is an increase in the weight of the dried leaves at the increase of average square diameter and prevailing height average, as the increase in the weight of dried leaves agrees with the increase in average square diameter and prevailing height average, which is indicated by Peper *et al.* (2001). Therefore we rely on Table 3 in estimating the weight of dried leaves in terms of forest variables, and by adding the weights of the dried trunk, branches and leaves of trees, we get the total dry weight per unit area in terms of the prevailing height average and average square diameter, as shown in Table 4.

In order to convert the total dry weight of *Pinus brutia* Ten. trees in Zawita to an organic material, it is multiplied by (0.5) according to IPCC (1996). Wood contains four basic materials, such as cellulose, hemi cellulose, alkene with percentages 50%, 20% and 25% respectively and the rest are resin materials and oils (Moll and Moll, 1998). Brown (1997) explained that the amount of carbon is 50% of the biomass above ground as indicated by Costa (1996) that the plant tissues vary in the amount of their carbonic storage.

Through the process of photosynthesis, trees convert carbon dioxide and water into sugar and oxygen molecules, and the overall equation of this process can be expressed as follows:

$$6CO_2+6H_2O \xrightarrow{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$$

Some of this sugar is stored, while the most is used by the tree for other purposes, such as energy and metabolism, and many sugars are linked together to form cellulose that makes the tree composition, and when we look to this sugar, we found that it consists of high percentage of carbon. It is assumed that 72/180 (40%) of the sugar molecules mass formed in the trees by photosynthesis contains carbon, taking into account that other types of molecules found in the tree (proteins, fats, etc.) also contain carbon; therefore, many studies indicated that 50% of the dry mass of the tree are carbon, in other words, 100 kg of dry tree weight contains 50% of the carbon stock, i.e. one kilogram of dried tree stores 0.5 kg of carbon and removes more than a kilogram of carbon dioxide from the air because each molecule of carbon dioxide contains two atoms of oxygen. Referring to the previous equation, we find that each molecule of carbon dioxide has a weight of 12+2(16) = 44 and that 12 of which belongs to carbon, therefore, for each atom of carbon stock in the tree, (44 units of molecular weight) of carbon dioxide were removed from the atmosphere, which means that each kilogram of dried tree corresponds to:

(1kg of dried tree) x (0.5 kg of carbon/1 kg of dried tree) x (44/12) = 1.83 kg of carbon dioxide.

This also explains that a single weight unit of carbon stock in the forest environmental system results from removing (12/44) = 3.67 weight unit of carbon dioxide (Richard, 1992). This large amount gives the right idea to use trees in removing carbon dioxide from the air, however, the equation works conversely when the tree is burnt or allowed to decay completely. The carbon in the tree returns to the air as carbon dioxide. Through multiplication of the values available in Table 4 by 1.83, we get the amount of carbon dioxide removed from the air per hectare for the *Pinus brutia* Ten. Forests grown in Zawita northern Iraq.

CONCLUSION

In conclusion, we have established three allometric equation for estimating the weight of *Pinus brutia* Ten. naturally in Zawita, and this equations can be used to determine carbon storage for species.

REFERENCES

Al-Zuhairi MHO. 2006. Estimation of four methods for volume prediction of brutia pine grown in plantation in Dohuk. M. Sc. Thesis, 132 p.

Brown S. 1997. Estimating biomass and biomass change of tropical forests. A Primer. A Forest Resources Assessment publication, FAO Forestry Paper No 134. Rome, Italy.

Costa PM. 1996. Tropical forestry practices for carbon sequestration: A review and case study from Southeast Asia. *AMBIO A Journal of the Human Environment,* 25 (4): 279-278.

FAO 1995. Global forest resources assessments. WWW. FAO.org.

Hoffmann CW and Usoltsev VA. 2002. Tree-crown biomass estimation in forest species of the Ural and of Kazakhstan. *Forest Ecology and Management*, 158(1-3): 59-69.

Omar R. Masera, Garza-aligaris JF, Kanninen M, Karjalainen T, Liski J, Nabuurs GJ, Pussinen A, BHJ de Jong, Mohren GMJ. 2003. Modeling carbon sequestration in afforestation agroforestry and forest management projects: the CO2FIX V.2 approach. *Ecological Modelling*, 164(2–3): 177–199.

Moll E and Moll G. 1998. Struik pocket guide-common trees of Southern Africa. Struik Publishers (Pty), Cornelis Struik House, Cape Town-South Africa. ISBN-10: 1868255069; ISBN-13: 978-1868255061.

Peper PJ, Mcpherson EG and Sylvia MM. 2001. Predictive equations for dimensions and leaf area of coastal Southern California street trees. *Journal of Arboriculture,* 27(4): 169-180.

Pettersson S. 1969. Introduction to meterology, 3rd. ed. Mc. Graw Hill book company. New York, 333 p.

[IPCC] Intergovernmental Panel on Climate Change. 1996. Revised 1996 IPCC guidelines for national greenhouse gas inventories. Vol. 1. Reporting instructions. [cited]. Available from: https://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html.

Richard AB. 1992. Carbon storage and accumulation in United States Forest Ecosystems. General Technical Report W0-59. United States Department of Agriculture Forest Service, Northeastern Forest Experiment Station, Radnor, PA, August 1992, 51 p.

Thomas BL, Hueschmann M and Murphy PA. 1999. An individual-tree growth and yield prediction system for even-aged natural short leaf pine forests. *Southern Journal of Applied Forestry*, 23(4): 203-211.

Valentine HT, Trition LM and Furnival GM. 1984. Sub sampling trees for biomass, volume, or mineral content. *Forest Science*, 30(3): 673-681.