RESEARCH | Egyptian Journal of Agricultural Research | HORTICULTURE

Carbon content of some timber trees grown in El-Kassasin Horticulture Research Station

Mahmoud M.E. Abd El-Kader, Hesham A. Gharib and Salah A. Abd El-Megeed

Address:
Dept. of Timber Trees and Forestry, Horticulture Research Institute, Agricultural Research Center, Egypt
*Corresponding author: ***Hesham A. Gharib****, E mail:- hetshsalam@yahoo.com*

Received: 22-12-2020; **Accepted**: 20-04-2021 ; **Published:** 20-04-2021 10.21608/ejar.2021.54736.1063

ABSTRACT

The objective of this study determination total storage of carbon content weight for three tree species namely *Eucalyptus gomphocephala*, *Casuarina equisetifolia* and *Casuarina glauca* during 2019. On this concerning carbon content decreased in available merchantable portions which decreased carbon content as environment balance region and economic value. *E. gomphocephala* and *C. equisetifolia* have recorded total tree biomass values (378.49 and 327.95 kg/tree) respectively which were significantly higher when compared to C. *glauca* (148.95 kg/tree). On the other hand evaluating total weight of carbon content on merchantable fewer portions had stayed on the same area. *E. gomphocephala* and *C. equisetifolia* had significantly enhanced carbon content weight values on merchantable fewer portions (146.45 and 138.34 kg/tree) respectively compared to *C. glauca* (32.99 kg/tree) more fourfold increment approximately. The investigated study was carried out at the Experimental Farm of El-Kassasin Horticulture Research station, Horticulture Research Institute, Agriculture Research Center, Giza, Egypt.

Keywords: Climate change, *Casuarina,* carbon contents, timber trees

INTRODUCTION

Global warming and climate change are the most widespread and pressing global issues. They primarily result from increasing greenhouse gases levels due to anthropogenic activities like excessive use of fossil fuel, industrialization and land-use change. Deforestation contributes about 20% to global greenhouse gases emission (Sternm 2007). Carbon dioxide is the main component accounting for total anthropogenic greenhouse gases emissions (IPCC, 2014). At this time the importance of different activities to decrease CO_2 emissions is being realized in connection with global warming (IPCC, 2003). Concerning Kyoto protocol explicitly considered afforestation, reforestation and regeneration of forests for carbon sequestration accounting (IPCC, 2007). Trees accumulated carbon dioxide to biomass through photosynthesis (Liu and Li 2012). This function is beneficial to humans because it counteracts emissions of CO_2 greenhouse gas. Anthropogenic carbon emissions have caused a 40% increase in atmospheric CO_2 concentrations in the last century, a change that is known to cause global warming (IPCC, 2013). The untraditional technique of isolated CO_2 from the atmosphere in industrial factory area by using capture pipeline underground geological and transported to terminals or permanently storage (Fanchi *et al.,* 2016). It coasted 11000 U$/tC/250km (Akimoto et al., 2004). On the other hand, afforestation still appears to be a relatively low-cost approach to reducing CO_2 concentrations (Andrew, 1999).

The biotransformation of carbon dioxide is quantified as tree carbon storage, in kilograms, and overtime as carbon sequestration, in kilograms per year (Nowak and Crane, 2002). New Zealand has opted out of binding carbon targets of the Kyoto Protocol but is still obligated to report on climate change mitigation measures regularly (Ministry of the Environment, 2010). Thus, carbon storage data is of use in New Zealand for estimating carbon stocks to report under the Kyoto Protocol and for contributing to a better understanding of how trees offset carbon emissions.

E. gomphocephala (Fam: Myrtaceae) naturally occur in all Australian mainland states (Hall *et al.,* 1970). They have widely planted overseas in areas with a Mediterranean climate. However, *Eucalyptus* is believed to be introduced into Egypt in the 1800's via El-Lakany et al. (1980). They are highly adapted to the local environmental conditions and grow very fast. These species are traditionally planted as a windbreak, for shade and to supply wood for lumber. Ohlde *et al.* (2019) observed that eucalyptus varieties fast-growing trees and safe long-term biological fixation of carbon. Behera *et al.* (2020) concluded that plantation eucalyptus had significant carbon sequestration. Kumar *et al.* (2020) confirmed that eucalyptus-based plantation offers a low-cost strategy for carbon sequestration besides increasing farm income.

The genus *Casuarina* (Fam. Casuarinaceae) comprises nearly 50 species, which are found in the Southern Hemisphere from India and Malaya to the islands of the South Pacific Ocean, and find their greatest development in Australia where they occur both in the arid areas of the center and the higher rainfall coastal regions (Hall *et al.,* 1972). Casuarina wood is a hard, heavy, dark redwood known as she-oak, river-oak, or Australian pine Potgieter *et al.* (2013). The trees vary in size from small to large and their principal value is for shelter, conservation and rehabilitation, timber or fuel supply. A few species were introduced into Egypt last century where they are planted essentially as windbreaks and to supply wood for local industries. The trees proved to be superior to several other exotic and native species as they are adapted to local severe climatic and soil conditions. Plenty of them has been used as windbreaks in the northern regions of Egypt, where desert reclamation is underway. On this concern means of transport emissions, greenhouse gas is expected to increase from about 169 thousand tons of CO_2 in 2013 to about 764 thousand tons of CO_2 in 2018. Accordingly, estimates of total accumulated greenhouse gas reduction during this period (2013-2018) accounted for 2.8 million ton of CO_2 Table (1). This study aimed to evaluate the aboveground biomass carbon storage content on *E. gomphocephala, C. equisetifolia* and *C. glauca* at different merchantable and merchantable fewer portions levels under El- Kassasin Station environment.

Table (1): Transports production greenhouse gas from different Egypt regions (ton CO_2 /year) Hamed (2014)

Region \ Year	2013	2014	2015	2016	2017	2018	Total (2013-2018)
Greater Cairo Region	168667	197953	227239	256526	285812	315098	1451295
Alexandria	0	10712	21425	32137	42850	53562	160686
Other Governorates	0	79096	158193	237289	316385	395481	1186444
Total	168667	287762	406857	525952	645046	764141	2798425

MATERIALS AND METHODS

This study was carried out at the Experimental Farm of El-Kassasin station. Horticulture Research Institute, Agriculture, Research, Center, Giza, Egypt during 2019 spring. The objectives of this paper were to estimate the aboveground carbon storage from *E. gomphocephala, C. equisetifolia* and *C. glauca* over a growth period of 28 years at different merchantable and merchantable less portions. Meanwhile samples were selected from 28 years old trees of *Eucalyptus gomphocephala, Casuarina equisetifolia* and *Casuarina glauca.* Trees were planted at 6x6 m spacing.

Location study:
The present experiments were performed in Kassasin Station, Horticulture Research Institute Agriculture Research Center. Kassasin station located near El-Salhia rod. According to the google earth application, the coordinates of Kassasin Station were 30.53Nº and 31.96Eº.

Soil analysis
Physical and chemical characteristics for the soil under study were conducted according to Page et al. (1982) and Klute (1986). The results are shown in Table (2).

Table (2): Physical and chemical properties of the soil

Particle size distribution (%)				Textural class	Ca CO_3 (%)	*O.M. (%)
Coarse sand	Fin sand	Silt	Clay			
73.75	11.17	3.60	6.40	Sandy	4.60	0.48

pH	EC dS/ m	SP %	Ion concentration in "paste extract" (meq/L)								Available (mg/kg)		
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	$SO_4^{=}$	N	P	K
8.20	0.87	29.00	3.90	2.70	1.85	0.55	0.00	1.30	4.55	3.15	25.40	10.50	69.51

***O.M.= organic matter**

Recorded data:
During the 2019 spring season at the end of the experiment (28 years after planting), responses of eucalyptus and *Casuarina* sp. trees were evaluated as follows:

Sample trees:
Before tree cutting, the girth on breast height (DBH) was measured and converted to diameter. DBH is the stem diameter at 1.3 m above the ground level FAO **(**2004**)**. Trees grown in the plot sector under this study were DBH measured. Three trees were selected randomly from each species with a total of 9 trees and 45 samples (3 species × 3 replicate trees × 5 levels determination carbon storage among tree height).

Tree height:
Total tree height (from stump to the tree end) and merchantable tree height (from the stump up to 5 cm stem in diameter) were measured by a measuring tape (m/tree).

Above-ground biomass:
The selected trees were felled and the aboveground portion was processed into trunk wood, branches and leaves at the field. Total height was measured from stump height (30 cm from ground level) up to the trunk end. The stem at the top was cut at about 5 cm in diameter to measure the merchantable height, while the part of the stem smaller than 5 cm was considered as branches. Leaves that were removed from the branches by hand and branches less than 5 cm in diameter were combined and considered as foliage.

Tree volume measurements and equations:
The volume of each stem log was calculated using Samilian's formula investigated by de Gier **(**2003**).** The total stem volume was computed as the sum of the calculated stem logs volume.
$Vol. = \pi/8\ (D^2+ d^2) \times L.$ Where, Vol. = volume of the stem log, π = 3.14, L= length of log, D= diameter of the larger end of the stem log, and d= diameter of the smaller end of the stem log.

Green and dry weight determination:

The trunk was divided into logs, the base ground log up to the (DBH), while the distance between breast height (BH) and the merchantable tree height (up to 4 cm) in diameter) was divided into four sections. Green weights were recorded using a digital scale (0.1 kg) in the field for a trunk, branches and leaves (Kg/ tree). From each portion of the trunk, a disk with 50 cm length was cut and leaves samples were collected. All the samples were oven-dried until they reach a constant weight, where leaves were dried at 70 Cº while trunk and branches samples at 105 Cº Kettering et al. **(**2001**)**. The ratio of dry/green biomass weight of each component samples was calculated and used to determine the dry biomass weight of each tree component. The green and dry weight for each component to the total above-ground weight were calculated.

Basal area:

The basal area at 130 cm above ground level (DBH) was calculated (m^2/tree). Wooden samples: Two disks of 50 centimetres length were cut, one was taken at DBH (diameter at breast height) and the other disk at 50% of tree height up DBH, and they were dried at 105 Cº even to constant weight.

Carbon determination:

The green samples of different parts of wood and leaves of each sample were weighed (2 mg), and oven-dried 75 Cº until constant weights and then reweighed. All samples were finely powdered utilizing an electric grinder separately. The carbon content was determined in Regional Center for Food and Feed Lab., Agric, Res. Cent., using an elemental analyzer Perkin-Elmer 2400 Series II CHNS/O Elemental Analyzer AOAC **(**2012**).** See Table 3.

Table (3): Storage carbon content on different timber trees biomass portion kgC/kg biomass

Organic carbon %	*E. gomphocephala*	*C. equisetifolia*	*C. glauca*
Level (1)	0.59 ± 0.00	0.53 ± 0.00	0.54 ± 0.00
Level (2)	0.56 ± 0.00	0.52 ± 0.00	0.51 ± 0.00
Level (3)	0.53 ± 0.00	0.49 ± 0.00	0.49 ± 0.00
Level (4)	0.54 ± 0.00	0.54 ± 0.00	0.49 ± 0.00
Level (5)	0.47 ± 0.00	0.48 ± 0.00	0.50 ± 0.00

Level (1) = carbon storage content at DBH. Level (2) = carbon storage content at 50% trunk height.
Level (3) = carbon storage content at end of trunk height. Level (4) = carbon storage content on branch up 5cm diameter.
Level (5) = carbon storage content on foliage.

Statistical design and analysis:

The design was a completely randomized block (RCBD) with three replicates for each species. Each tree contained five-carbon storage determination levels among tree portions. The least significant differences (LSD) were used for testing the differences among the means of each parameter (Snedecor and Cochran, 1974)

RESULTS

Biomass parameter:

The total height of three species was non significantly different from each other, whereas the merchantable height was found significantly different **Table (4).** Diameter at breast height (DBH) for *C. equisetifolia* had a recorded mean value 0.39 m which were significantly higher compare to *E. gomphocephala* and C. *glauca*. On other hand, *E. gomphocephala* had the highest significant basal area mean value of 0.059 m^2. The merchantable stem volume of *E. gomphocephala* had a significantly higher mean value of 1.18 m^3 while C. *equisetifolia* and *C. glauca* had 0.98 and 0.409 m^3, respectively. For the total stem volume, *E. gomphocephala* had the highest significant mean value of 1.36 m^3 while *C. galuca* had the lowest significant value of 0.472 m^3.

Table (4): Mean values of biomass parameters of *E. gomphocephala*, *C. equisetifolia* and *C. glauca* grown in El- Kassasin Station.

Species	**Total height (m)**	**Merchantable Height (m)**	**diameter at breast height (m)**	**Basal area (m^2)**	**Merchantable Volume (m^3/tree)**	**Total Volume (m^3/tree)**
E. gomphocephala	23.00±0.76 a	20.00 ±0.50 b	0.38 ±0.01 b	0.06±0.00a	1.18 ±0.02 a	1.36 ±0.02 a
C. equisetifolia	22.50±3.06 a	21.00 ±0.30 a	0.39 ±0.00 a	0.05±0.00b	0.98 ±0.02 b	1.05 ±0.23 b
C. glauca	22.80±1.26 a	19.80 ±0.38 c	0.26 ±0.01 c	0.02±0.00 c	0.41 ±0.03 c	0.47 ±0.09 c
LSD 0.05%	**N.S.**	**0.12**	**0.00**	**0.00**	**0.02**	**0.13**

***Numbers followed the mean are the standard deviation of the mean

Green and dry weight:

Data presented in **Table (5)** showed the green and dry weight of trunk, branches, foliage for three tree species. *C. glauca* has higher significant mean values compared to *E. gomphocephala* and *C. equisetifolia* branches per tree. The green weight values for branches were 70, 30 and 50 kg/tree and the dry weight were 50, 22 and 35 kg/tree for *E. gomphocephala, C. equisetifolia* and *C. glauca,* respectively. Significant increases in foliage green and dry weight (45 and 22 kg/tree) respectively were measured for *E. gomphocephala* compared to *C. equisetifolia* and *C. glauca.* Total trunk weight of *C.*

glauca had the lowest significant decrease on green and dry weight compared to other tree species. The merchantable trunk dry weight values for *C. equisetifolia* were 266 kg/tree. The higher merchantable trunk weight would be considered of more economic value for the wood market.

Table (5). Green and dry weight of trunk, branches, foliage and total above-ground biomass of *E. gomphocephala*, *C. equisetifolia* and *C. glauca* grown in El- Kassasin Station

Species	Branches Number	Green weight (Kg / tree)			
		Total trunk	Merchantable trunk	Branches up 5 cm	Foliage
E. gomphocephala	12.00±0.58 b	1458.00 ±49.01b	1341.00±16.86b	70.00 ±1.26 a	45.00 ±3.28 a
C. equisetifolia	10.00±1.03 b	1629.00 ±88.79a	1570.00±14.23a	30.00 ±1.53 c	40.00 ±1.26 c
C. glauca	60.00±6.03 a	561.00±50.69c	520.00±11.02 c	50.00 ±1.53 b	42.00 ±1.25 b
LSD 0.05%	**3.06**	**56.56**	**12.24**	**1.25**	**1.86**
		Dry weight (kg / tree)			
		Total trunk	**Merchantable trunk**	**Branches up 5 cm**	**Foliage**
E. gomphocephala		884.00 ±3.51 a	767.00±2.65 b	50.00±1.53 a	22.00 ±1.73 a
C. equisetifolia		871.00 ±3.61 b	812.00±3.05 a	22.00±1.24 c	15.00 ±0.50 c
C. glauca		307.00 ±2.52 c	266.00±7.51 c	35.00±2.03 b	18.00 ±1.26 b
LSD 0.05%		**12.84**	**4.24**	**1.35**	**1.09**

*Numbers followed the mean are the standard deviation of the mean

Carbon determination content:

Table 6 showed the carbon content weight of different merchantable portions of all three species. Carbon content percentage increases from down to up across the trunk height. The first log biomass (under the DBH, level 1) of *E. gomphocephala* contained carbon weight values of **29.58** kg/tree significantly higher than *C. glauca* (12.54 kg/tree). The carbon content weight contained in the merchantable biomass stem of the three species (Level 2), also takes the same trend as prescribed previously, where *E. gomphocephala* and *C. equisetifolia* had recorded mean values of 321.91 and 288.49 kg/tree respectively, while the carbon content was 119.35 kg/tree for *C. glauca.* The carbon content weight values for branches up to 5cm in diameter (level 4) were 27, 11.8 and 17.15 for the same species in the same order respectively, where *E. gomphocephala* had the significantly higher value of 27.0 kg/tree.

Table (6): Carbon content weight (kg) on different merchantable portions of *E. gomphocephala*, C. *equisetifolia* and *C. glauca* grown in El- Kassasin Station

Species	Level (1)			Level (2)			Level (4)		
	DBHW	C	CW	UPDBHW	C	CW	BW	C	CW
E. gomphocephala	49.85 ±2.97a	0.59 ±0.00 a	29.56 ±1.13a	575.25 ±2.95a	0.56 ±0.00 a	321.57 ±15.22a	50.00 ±2.52a	0.54 ±0.00a	27.00 ±1.80a
C. equisetifolia	51.94 ±2.56a	0.53 ±0.00c	27.63 ±0.86b	559.30 ±1.01b	0.52 ±0.00b	288.59 ±8.29b	22.00 ±1.50c	0.54 ±0.00b	11.81 ±1.15c
C. glauca	23.21 ±1.80b	0.54 ±0.0b	12.46 ±1.55c	232.10 ±3.67c	0.51 ±0.00c	119.29 ±4.02c	35.00 ±2.57b	0.49 ±0.00c	17.15 ±2.08b
LSD 0.05%	**2.15**	**0.0020**	**1.05**	**2.39**	**0.00**	**8.86**	**1.94**	**0.00**	**1.49**

*Values followed by the same letters within each column are not significantly different at $p > 0.05$ according to Duncan's multiple range test. **DBHW=** diameter breast height weight, **C%=** carbon percentage, **CW=** carbon weight, **UPDBHW=** up diameter breast height weight, **BW=** branches up 5cm diameter weigh

Data in Table (7) showed carbon content weight on the merchantable-less value portions. Level (3) clear that *E. gomphocephala* and *C. equisetifolia* had carbon weight of 136.21 and 129.69 kg/tree respectively which were significantly higher when compared to *C. glauca*. On other hand, the combined carbon weight values of foliage and small branches (level 5) were 10.24, 8.65 and 7.56 kg/tree *E. gomphocephala, C. equisetifolia* and *C. glauca*; respectively. Table (8) summarized the total carbon content weight stored in the studied tree species (either as merchantable or stable carbon). The calculated values of total weight of carbon content on the merchantable portions (available for transport) were 378.49, 327.45 and 184.95 kg/tree, while the stable carbon (merchantable-less) and stayed on forest site were 146.45, 138.34 and 32.99 kg/tree *E. gomphocephala, C equisetifolia* and *C. glauca* respectively.

Table (7): Determination of carbon content weight (kg) on different merchantable fewer value portions from *E. gomphocephala*, *C. equisetifolia* and *C. glauca* grown in El- Kassasin Station

Species	Level (3)			Level (5)		
	EW	**C**	**CW**	**FW**	**C**	**CW**
E. gomphocephala	259.00 ±1.85 a	0.53 ±0.00 a	136.21 ±8.51 a	22.00 ±2.65 a	0.47 ±0.00 b	10.24 a±1.64 a
C. equisetifolia	259.80 ±1.52 a	0.49 c±0.00 c	129.69 ±5.35 b	18.00 ±3.03 b	0.48 ±0.00 b	8.65 ±1.40 b
C. glauca	51.69 ±2.25 b	0.49 ±0.00 b	25.43 ±2.52 c	15.00 ±1.73 c	0.50 ±0.00 a	7.56 ±1.01 c
LSD 0.05%	**1.64**	**0.00**	**5.16**	**2.17**	**0.00**	**1.19**

*Numbers followed the mean are the standard deviation of the mean

EW= end of trunk weight merchantable less, C**%**= carbon percentage, **CW**= carbon weight, **FW**= foliage weight

Table (8): Total carbon content weight (kg/tree) on merchantable portions available transported and merchantable fewer portions from E. *gomphocephala*, C. *equisetifolia* and *C. glauca* grown in El- Kassasin Station

Species	Merchantable carbon available transport (kg/tree)	Stable carbon (merchantable less) (kg/tree)
E. gomphocephala	378.49 ±1.80	146.45 ±2.29 a
C. equisetifolia	327.95 ±2.02 b	138.34 ±2.16 b
C. glauca	148.95 ±1.23 c	32.99 ±2.13 c
LSD 0.05%	**1.48**	**1.89**

*Numbers followed the mean are the standard deviation of the mean

DISCUSSION

Carbon is the main component accounting for total anthropogenic greenhouse gases emissions. At this time the importance of different activities to increase C emissions is being realized in connection with global warming. Concerning explicitly considered afforestation, reforestation and regeneration of forests for carbon sequestration. On this concern means of transport emissions, greenhouse gas is expected to increase from about 169 thousand tons of CO_2 in 2013 to about 764 thousand tons of CO_2 in Egypt during 2018. The target of this investigation was to evaluate the aboveground biomass carbon storage content on *E. gomphocephala*, *C. equisetifolia* and *C. glauca* at different merchantable and merchantable less portions levels under El- Kassasin station environment.

The results were in agreement with earlier researchers including (EL-Lakany *et al.,* 1980; Baker *et al.,* 2002; Saint-André *et al.,* 2005; Pambudi, 2011) they mention that eucalypt stand tended to fast volume rate. Rockwood et al. (1983) reported that *C. equisetifolia* and *C. glauca* reached up to 32 and 19 m, respectively in height. Diameter at breast height (41-23.5cm) respectively. On this concern, EL-Lakany (1981) described that *C. equisetifolia* had higher growth performance than *C. glauca* under Egyptian condition. Meanwhile Zhong (1996) reported significant variables in height, diameter, volume and crown spread between Casuarina sp. in Southern China. Trees of *C. glauca* had the lowest merchantable volume value of 0.21 m^3/tree compared to other casuarina species mentioned in the study (El-Juhany *et al.,* 2002).

These data agreeable with the results of (El-Lakany 1981; John and Racette, 1989; Ngom *et al.,* 2016) they found that *C. equisetifolia* followed by *C. glauca* in biomass content. (Marcar, 1996) reported also that *C. equisetifolia* biomass production was better than *C. glauca*. Chonglu *et al.* (2010) stated that the volume of wood production and adaptability of clones were significantly superior in *C. equisetifolia* followed by *C. glauca* under abiotic stress in different areas of China.

Previous results related to the carbon content at different timber tree were in agreement with many factors, including species, climate, growth rate, foliage area, site quality and tree vitality affected on C content. (Yang and Hazenberg, 1991). On this concerning C concentration of wood varies depending on the species, stem anatomical parts, growth, site conditions and stand characteristics (Elias and Potvin, 2003). Previous studies release trunk C content variation (Barahona, 2005) showed significant differences in cellulose content at different heights, without a unique trend. Agreeable (Bert and Danjon 2006; Campbell *et al.,* 1990) reported that vertical C content variations. The recording data observed that biomass and carbon content enhanced with increment standage (Litton *et al.,* 2004; Peichl and Arain 2006; Noh *et al.,* 2010; Li *et al.,* 2011). Data noted that carbon potency content of eucalypt trunk tended to increase with increasing trunk age. (Baker *et al.,* 2002; Saint-André *et al.,* 2005; Pambudi 2011).

CONCLUSION

Results of this study revealed that the stems of *E. gomphocephala* trees when they reach the age of 28 years, they would have an estimated wood volume of about 1.36 m^3/tree and an estimated biomass about 884 kg/tree. This biomass may store a total carbon of about 524.94 kg/tree, where 378.49 kg/tree would be considered as benefit carbon available to transport and the other amount of 146.45 kg/tree carbon would be considered as an organic matter.

The *C. equisetifolia* timber trees aged 28 years would give about 1.05 m^3 wood volume, and 871 kg/tree of biomass which may contain about 466.29 kg/tree of stored carbon, which could be divided into stored carbon of about 327.95 kg/tree as merchantable available for transport and the other 138.34 kg/tree as organic matter.

The *C. glauca* had cultivated after 28 years recorded 0.47 m^3/tree wood volume and 307 kg/tree of biomass which may isolation 148.95 kg/tree carbon from atmosphere and storage as merchantable available for transport addition to 32.99 kg/tree organic matter**.**

REFERENCES

Akimoto, K., Kotsubo, H., Asami, T., Li, X., Uno, M., Tomoda, T., & Ohsumi, T. (2004). Evaluation of carbon dioxide sequestration in Japan with a mathematical model. *Energy*, 29(9–10), 1537–1549. https://doi.org/10.1016/j.energy.2004.03.058.

Andrew. (1999). An Econometric Analysis of the Costs of Sequestering Carbon in Forests American. *Agricultural Economics*, 81, 812–82.

AOAC 18th (2012). Perkin Elmer CHN analysis Manual. 152-153.

Baker T., Morris, J., Duncan M., Ningnan Z., Zengjiang Y., Zhihong H., & Guowei C. (2002). Tree and stand growth and biomass relationships for *Eucalyptus urophylla* and *E. 12ABL* on the Lei Zhou Peninsula, Guangdong Province, China. *New Forest* 41, 95-112.

Barahona G. L. (2005): Chemical variation on E. globules wood composition under sand soil. Department de la Ingenerate de la Madera, Austral University of Chile, Valdivia, Chile, MSc. thesis.

Behera L. K., Lala I. P., Ray M. R., Nayak A.A., Meht A. & Patel S.M. (2020). Carbon sequestration potential of eucalyptus sp. *e-planet Journal* 18, (1)79-84.

Bert D. & Danjon F. (2006). Carbon concentration variations in the roots, stem and crown of mature *Pinus pinaster* (Ait.). *Forest Ecology and Management* (222), 279–295

Campbell A. G., Kim W. J. & Koch P. (1990). Chemical variation in lodge pole pine with sapwood/heartwood, stem height, and variety. *Wood Fiber Science* 22, 22–30

Chonglu Z., Yong Z., Yu C., Qingbin J., Zhen C., Junfeng L., Khongsak P., Claudine F. & Didier B. (2010). Casuarina research and applications in China Symbiosis 50, 107–114.

de Gier, A. (2003). A new approach to woody biomass assessment in woodlands and shrub lands. In: P. Roy (Ed), Geoinformatics for Tropical Ecosystems, India 161-198

Elias M. & Potvin C. (2003). Assessing inter-and intra-specific variation in trunk carbon concentration for 32 geotropically tree species. *Canadian Journal and Forestry* 33, 1039–1045.

El-Juhany L. I., Ibrahim A. & El-Wakeel A. (2002). Evaluation of above-ground biomass and stem volume of three casuarina species grown in the central region of Saudi Arabia. *Emirates Journal of Food and Agriculture* 17(1): 10.9755/ejfa.v14i1.4980.

El-Lakany M. H. (1981). A review of breeding drought-resistant casuarina for shelterbelt establishment in arid regions with special reference to Egypt. *Forest Ecology and Management 6,* 129-137.

El-Lakany M., El-Osta L. M. & Badran O. A. (1980). Evaluation of newly introduced Eucalyptus camaldulensis provinces in Egypt. *Alexandria Journal of Agricultural Sciences 28* (3), 309-319.

Fanchi J. R. & Fanchi C. J. (2016). Energy in the 21st Century. World Scientific Publishing Co Inc. 350. ISBN 978-981-314-480-4.

FAO (1981). Eucalyptus for planting. FAO Forestry Series 11. Rome

FAO (2004). National Forest Inventory: Field manual template, Rome. (Online) http://www.fao.org/ docrep/ 008/ ae 578e/ ae 578e 00.

Hall N., Johnston R. D. & Chippendale J. M. (1970). For trees of Australia. Australian Government Publishing service Canberra, Australia. 100-101.

Hall N., Boden R., Christian C. S., Condo N. R. Dale F., Hart A., Leigh J., Marshall J., Mcarthur A., Russell V. & Turnbull J. (1972). The use of trees and shrubs in the dry country of Australia. Australian Government Publishing Service: Canberra.

Hamed K. (2014). Policy reforms that were implemented to Promote Energy Efficiency in the Transportation Sector. United Nation Economic and Social Commission for Western Asia ESCWA. Promoting energy efficiency investments for climate change mitigation and sustainable development, Egypt case of study, http://dx.doi.org/10.1007/s11056-010-9213-0. 1-37.

IPCC (2003). Good practice guidance for land use, Land use change and Forestry. Institute for Global Environmental Strategies, Kanagawa, Japan.

IPCC (2013). Climate Change. The Physical Science Basis. (Assessment Report No. AR5). World Meteorological Organization and United Nations Environment Program.

IPCC Climate Change (2007). Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

IPCC Climate change (2014). Synthesis report. Contribution of working groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change Intergovernmental Panel on Climate Change, Geneva, Switzerland.

John G. T. & Suzanne R. (1989). Specificity among the Casuarinaceae. *Plant and Soil* (118), 1-2, Selected papers from the 7th International Conference on Frankia and Actionrhizal. Plants, 157-164. https://www.jstor.org/stable/42938230

Ketterings, Q.M., Coe R., Noordwijk M.V., Ambagan Y. & Palm C.A. (2001). Reducing uncertainty in the case of allometric biomass equations for predicting above-ground tree biomass in mixed secondary forests. *Forest Ecology and Management, 146* (1-3), 199-209.

Klute A. (1986). Methods of Soil Analysis part I. physical and mineralogical method (2nd Ed.) Amer. Soc. Agron. Monograph No. 9. Madison-Wisconsin. USA.

Kumar, P., Mishra, A. K., Chaudhari, S. K., Sharma, D. K., Rai, A. K., Singh, K., ... & Singh, R. (2020). Carbon sequestration and soil carbon build-up under eucalyptus plantation in semi-arid regions of North-West India. *Journal of Sustainable Forestry*, 1-13.

Li, X., Yi, M. J., Son, Y., Park, P. S., Lee, K. H., Son, Y. M., ... & Jeong, M. J. (2011). Biomass and carbon storage in an age-sequence of Korean pine (*Pinus koraiensis*) plantation forests in central Korea. *Journal of Plant Biology*, *54*(1), 33-42.

Litton, C. M., Ryan, M. G., & Knight, D. H. (2004). Effects of tree density and stand age on carbon allocation patterns in postfire lodgepole pine. *Ecological Applications*, *14*(2), 460-475.

Liu C. & Li X. (2012). Carbon storage and sequestration by urban forests in Shenyang, China. *Urban Forestry and Urban Greening* (11), 121-128.

Marcar N. E. (1996). Casuarinas for salt-affected land. Canberra. CSIRO Forestry and Forest Products. http://hdl.handle.net/102.100.100/229123?index=1. mass equations across the deferent stages of stand

Ministry of the Environment (2010). The Kyoto Protocol. Retrieved 04/15, 2013, from http://www.mfe.govt.nz/issues/climate/internation al/kyoto-protocol.html.

Ngom, M., Gray, K., Diagne, N., Oshone, R., Fardoux, J., Gherbi, H., ... & Champion, A. (2016). Symbiotic performance of diverse Frankia strains on salt-stressed *Casuarina glauca* and *Casuarina equisetifolia* plants. *Frontiers in Plant Science*, *7*, 1331.

Noh, N. J., Son, Y., Lee, S. K., Seo, K. W., Heo, S. J., Yi, M. J., ... & Lee, K. H. (2010). Carbon and nitrogen storage in an age-sequence of Pinus densiflora stands in Korea. *Science China Life Sciences*, *53*(7), 822-830.

Nowak D. J. & Crane D. E. (2002). Carbon storage and sequestration by urban trees in the USA. *Environmental Pollution* 116(3), 381-389.

Ohlde, G. W., Stadtlander, T., & Becker, K. (2019). Biomass Production and Carbon Sequestration by Cultivation of Trees under Hyperarid Conditions using Desalinated Seawater (Sewage Water). *Journal of Agriculture Food and Development*, *5*, 33-42.

Page, A. L., Miller R. H. & Keeny D. R. (1982). Methods of Soil Analysis part II. Chemical and microbiological properties (2ndEd.) Amer. Soc. Agron. Monograph No. 9. Madison-Wisconsin, USA.

Pambudi G. P. (2011). Estimation of biomass some age grade mangrove plant on acreage PT. Bina Ovivipari Semesta, Kabupaten Kubu Raya, Kalimanatan Barat. http://repository.ipb.ac.id.

Peichl, M., & Arain, M. A. (2006). Above-and belowground ecosystem biomass and carbon pools in an age-sequence of temperate pine plantation forests. *Agricultural and Forest Meteorology*, *140*(1-4), 51-63.

Potgieter L., Richardson D. & Wilson J. (2013). Casuarina biogeography and ecology of an important tree genus in a changing world. *Biological Invasions, 16*(3), 609-633.

Rockwood D. L., Huffman J. B. J. B. & Conde L. F. (l983). Potential of Casuarina spp. for biomass production in Florida. IUFRO Fast Growing Trees Symp. *Silvicultura 8*(30), 376-377.

Saint-André, L., M'Bou, A. T., Mabiala, A., Mouvondy, W., Jourdan, C., Roupsard, O., Deleporte, P., Hamel, O., & Nouvellon, Y. (2005). Age-related equations for above- and below-ground biomass of a Eucalyptus hybrid in Congo. *Forest Ecology and Management, 205(*1–3), 199–214.

Snedecor G. & Cochran W. (1974). Statistical Methods. Sixth Edition. Iowa State University Press. Ames. Iowa. USA.

Stern, N. (2007). The Economics of climate change. The stern review, Cambridge University Press, Cambridge, United Kingdom.

Yang, K. C., & Hazenberg, G. (1991). Sapwood and heartwood width relationship to tree age in *Pinus banksiana*. *Canadian Journal of Forest Research*, *21*(4), 521-525.

Zhong B. (1996). Registered higher height, diameter and growth performance in *C. equisetifolia* and *C. gluaca* when compared to *C. cunninghamiana* and *C. cristata*. Publishing Co., New York, USA.

المحتوى الكربوني لبعض الأشجار الخشبية المزروعة في محطة بحوث القصاصين بمعهد بحوث البساتين

محمود محمد السيد عبد القادر و هشام عبد السلام غريب و صلاح عبد العال عبد المجيد

قسم بحوث الأشجار الخشبية والغابات معهد بحوث البساتين مركز البحوث الزراعية

بريد المؤلف المراسل hetshsalam@yahoo.com

الملخص العربى

الهدف من هذه الدراسة هو تحديد المخزون الكلي لوزن محتوى الكربون لثلاثة أنواع من الأشجار وهي: *Eucalyptus gomphocephala* و *Casuarina equisetifolia* و *Casuarina glauca* خلال عام 2019. فيما يتعلق بهذا ، انخفض محتوى الكربون في الأجزاء التجارية المتاحة مما أدى إلى انخفاض محتوى الكربون كمنطقة توازن بيئي وقيمة اقتصادية. سجل كل من *E. gomphocephala* و *C. equisetifolia* قيم الكتلة الحيوية الكلية للأشجار (378.49 و 327.95 كجم / شجرة) على التوالي والتي كانت أعلى بشكل معنوي بالمقارنة مع C. glauca (148.95 كجم / شجرة). من ناحية أخرى ، فإن تقييم الوزن الإجمالي لمحتوى الكربون على أجزاء أقل قابلة للتسويق بقي في نفس المنطقة. عززت *E. gomphocephala* و C. equisetifolia بشكل ملحوظ قيم وزن محتوى الكربون على أجزاء أقل من التجارة (146.45 و 138.34 كجم / شجرة) على التوالي مقارنة بـ *C. glauca* (32.99 كجم / شجرة) زيادة أربعة أضعاف تقريبًا. أوضحت النتائج ان كافور والكازورينا صنف C. *equisetifolia* أكثر كفاءة بتخزين الكربون من الكازوينا صنف *C. glauca* وعلي هذا توصى الدراسة بالإكثار من زراعة أشجار الكافور جيموسفيلا والكازورينا اكويستوفوليا للتخلص من الكربون وتقليل الضرر الناتج منه. أجريت الدراسة في المزرعة التجريبية بمحطة أبحاث البساتين بالقصاصين ، معهد بحوث البستنة ، مركز البحوث الزراعية ، الجيزة ، مصر.

الكلمات المفتاحية: الاشجار الخشبية ، اشجار الكازورينا ، اشجار الكافور ، الاحتباس الحراري