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ABOVE-GROUND BIOMASS AND SOME WOOD PROPERTIES OF 30- YEARS- OLD *CHRYSOPHYLLUM OLIVIFORME* AND *TAMARINDUS INDICA* TREES GROWN IN ASWAN, EGYPT

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ABSTRACT

Aboveground-tree biomass and some wood properties (specific gravity, moisture content, extractive content, cellulose, hemicellulose, holocellulose and ash content) were measured in 30-year-old of two tree species: *Chrysophyllum oliviforme* L. and *Tamarindus indica* L., growing on infertile soils as single row at 5m spacing for each species in the Tropical Farm, Kom- Ombo, Aswan Botanical Garden. Biomass and wood properties of the two species were similar to those reported for other tropical tree plantations in the same region. *T. indica* had the highest accumulation of aboveground tree biomass, in term of stem fresh and dry weight, branches fresh weight, leaves fresh weight and total biomass. However, *C. oliviforme* had the highest average of specific gravity, cellulose, hemicellulose and holocellulose contents of wood, while *T. indica* had the highest wood moisture, extractive and ash contents. Moreover, regarding the effects of bole heights on wood constitutes, there were significant differences between height treatments on wood properties of the two species. Diameter at breast height (dbh) and 0.75 of the total height showed a high potential for producing a best wood constitutes due to its more even distribution in this heights compared to 0.25 or 0.50 of the total height .

Keyword: Aboveground biomass, wood properties, *Chrysophyllum oliviforme*, *Tamarindus indica.*

INTRODUCTION

Stainleaf tree (*Chrysophyllum oliviforme* L.) belongs to family Sapotaceae. It contributes to the aesthetics of the forests where it grows, helps protect the soil, and furnishes food and cover for wildlife. The wood, which has a specific gravity of 0.9 g/cm^2, is hard, heavy and strong. It is used for construction in Cuba (Little and Wadsworth, 1964).Moreover, Tamarind tree (*Tamarindus indica* L.) belongs to family Fabaceae, is an important woody perennial tree species that is found throughout the tropics for its beauty as an ornamental, adaptability to variable climatic and edaphic conditions and fruit production (El-Siddig *et al*., 1999). Tamarind timber consists of hard, dark red heartwood and softer yellowish sapwood. Due to its denseness and durability, tamarind heartwood can be used in making furniture, wood flooring, building purposes, furnishes and excellent charcoal for gunpowder (Morton, 1987).

Biomass is the term used to describe all biologically matter (Babu, 2008). However, estimating tree biomass (weight) based on parameters that are measured in the field is becoming a fundamental task in forestry. The intensity of forest utilization has increased in recent years because of whole-tree harvesting and the use of wood for energy. Branches, leaves, bark, small trees, and trees of poor form or vigor are now commonly included in the harvested product. Thus, biomass of either the whole tree or individual components is a useful stand parameter (Tritton and Hornbeck, 1982).

The biomass of the various compartments in the forest, e.g. foliage, branches, and stem wood, is general interest to researchers of different scientific backgrounds, working on different scales: 1) On regional scales, estimations of carbon storage in forests require information of total tree biomass (Kursten and Burschel, 1993). 2) Foresters, who concentrate on the stand level, are mainly interested in stem wood biomass to determine thinning intensity and harvest gain. However, in large trees, particularly if grown without major competition, the amount of branch biomass can be considerable and should not be neglected (Brown, 1976). 3) On a smaller scale, ecological studies are executed to maintain sustainable management not only for stem wood but also for nutrients. Balance and flow estimations, however, have to consider different tree fractions because the nutrient concentration varies with tissue type and each compartment has different turnover rates (Martin *et al.*, 1999).

Like humans, trees are delicate when young and typically grow vigorously when given proper nutrition and a suitable environment. As age progresses, vigor is maintained for a lengthy period but then begins to wane and this called growth curve (Haygreen and Bowyer, 1996).

The moisture content of green wood varies considerably among species. However, the moisture content of green wood is important because of its direct relation to the weight of logs and green lumber. Therefore, it is of concern to those who design harvesting and transport equipment, purchase wood on a weight basis, or must ship or transport green wood. On the other hand, within any species there is considerable variation depending upon the location, age, and volume of the tree (Koch, 1972). The specific gravity of wood is single most important physical property. Most mechanical properties of wood are closely correlated to specific gravity and density. The strength of wood, as well as its stiffness, increases with specific gravity. The yield of pulp per unit volume is directly related to specific gravity. Moreover, the heat transmission of wood increases with specific gravity as well as the heat per unit volume produced in combustion (Haygreen and Bowyer, 1996). Wood ash is the inorganic and organic residue remaining after the combustion of wood or unbleached wood fiber. The physical and chemical properties of wood ash vary significantly depending on many factors. Hardwoods usually produce more ash than softwoods and the bark and leaves generally produce more ash than the inner woody parts of the tree (Misra *et al.,* 1993). Therefore, wood ash composition can be highly variable depending on geographical location and tree species. This makes testing the ash extremely important.

Chemical composition of the plant gives an idea of how feasible the plant is as raw material for papermaking. Extractives, cellulose and hemicellulose are the principal component of plant fibers used in pulping. They form the basic structural material of cell walls in all higher terrestrial plants being largely responsible for the strength of plant cells (Haygreen and Bowyer, 1996). Therefore, in this paper we present the results on aboveground biomass and some wood properties for 30- year- old of *Chrysophyllum oliviforme* and *Tamarindus indica* trees grown in Aswan, Southern Egypt.

MATERIALS AND METHODS

In 2011, biomass and some wood properties for 30- year- old of. *Chrysophyllum oliviforme* L. and *Tamarindus indica* L trees from plantations located in the Tropical Farm, Kom-Ombo, Aswan, were evaluated in the study. The soils of the study area were loamy sand. These were characterized as having soil pH 8.4, low organic matter (0.45%), and electrical conductivity 0.31 mmhos. There 10 trees for each species planted as a single row and the distance between trees was 5 m. For each species, 6 trees were selected and used to characterize mean height (m) and diameter at breast height (cm) and from these trees, 3 trees were randomly selected. They were harvested, measured, and sampled by the method of direct and destructive of estimation (Goeble, 1955). The total height for each tree was measured from the stump to the tree top. All branches up to 1.0 cm diameter, stem and leaves were weighted.

The sampled trees (a total 3 trees from each species) were harvested by harvesting machinery. The total height for each tree was measured from the stump to the tree top. All branches and leaves were weighted. In addition, three disks about 5 cm. in thickness at breast height, and 0.25, 0.50 and 0.75 of the total height were removed from each tree for specific gravity, moisture content, wood extractive, cellulose, hemicellulose and holocellulose content.

Specific gravity (g/cm^3), and moisture % of wood were estimated according to American to Society for Testing Materials (ASTMD, 1989).
Extractive % was determined according to ASTMD - 1107 - 56 (1989).

Cellulose was determined by treatment of extractive free sawdust meal according to (Nikitin, 1960).
Cellulose content = weight of cellulose / oven dry weight ×100
Hemicellulose content was determined according to Rozmarin and Simionescu (1973).
Hemicellulose % = Weight of Hemicellulose / Oven dry weight × 100
Holocellulose was calculated by addition of cellulose to hemicellulose.

Obtained data on the specific gravity, moisture content, extractive content, cellulose, hemicellulose, holocellulose and ash content as affected by height treatments were tabulated and statistically analyzed according to the method by Snedecor (1956), and L.S.D method by Little and Hills (1978). Data of above-ground biomass, chemical constitutes were pooled to compute the range, average and standard deviation of these characters.

RESULTS AND DISCUSSION

Biomass determination:

The average values of range and standard deviation of the diameter at breast height and total height for 30- year- old of *Chrysophyllum oliviforme* and *Tamarindus indica* trees are presented in Table (1). Data from the table pointed out that, the highest values of diameter and total height were resulted from *C. oliviforme* trees at the same age.

Table (1) : Average, range and standard deviation (S.D) of (dbh) diameter at breast height (cm.) and total height (m.) for the 30- year- old of *Chrysophyllum oliviforme* and *Tamarindus indica* trees grown in Aswan.

Species	Property	Range	Average	S.D
C. oliviforme	**dbh**	25.5 – 43.0	35.6	± 5.6
	Stem length	11.13 – 18.25	15.21	± 6.4
T. indica	**dbh**	28.7 – 40.1	34.5	± 5.1
	Stem length	13.19 – 13.56	13.38	± 0.26

Average, range and standard deviation (S.D) of stem fresh weight, branches fresh weight and leaves fresh weight for the 30- year- old of *Chrysophyllum oliviforme* and *Tamarindus indica* trees are tabulated in Table (2). The fresh weight of stem ranged from 463.84 to 618.88 kg/tree and the average was 554.83 ± 114.48 kg/ tree for *C. oliviforme* trees planted as a single row at 5 m spacing. While it ranged from 862.62 to. 925.00 kg/ tree with an average of 893.81 ± 44.11 kg/ tree for that of *T. indica* grown at the same condition. Also, the range and average of branches and leaves fresh weight of *T. indica* trees was pronounced from that of *C. oliviforme* trees. In general, the characters of biomass fresh weight of 30- year- old *T. indica* planted in single- row at 5 m spacing were higher than the biomass ranges of *C. oliviforme*.

Table (2) : Average, range and standard deviation (S.D) of stem fresh weight, branches fresh weight and leaves fresh weight for the 30- year- old of *Chrysophyllum oliviforme* and *Tamarindus indica* trees grown in Aswan.

Species	Property	Range	Average	S.D
C. oliviforme	Stem F.W. (kg)	463.84 – 618.88	554.83	± 114.48
	Branches F.W. at 5 cm. D. (kg)	81.92 – 116.50	101.95	± 17.93
	Branches F.W. at 1 cm.D.(kg)	70.45 – 103.42	86.39	± 16.51
	Leaves F.W. (kg)	219.67 – 293.35	249.31	± 38.89
T. indica	Stem F.W. (kg)	862.62 – 925.00	893.81	± 44.11
	Branches F.W. at 5 cm. D. (kg)	158.59 – 206.16	182.38	± 33.64
	Branches F.W. at 1 cm. D. (kg)	196.92 – 250.18	223.55	± 37.66
	Leaves F.W. (kg)	216.12 – 314.53	265.33	± 69.59

F.W = fresh weight **D. = diameter**

The Average, range and standard deviation (S.D) of total biomass, stem dry weight and leaves dry weight for the 30- year- old of *Chrysophyllum oliviforme* and *Tamarindus indica* trees are presented in Table (3). Average, range and standard deviation values of total biomass and stem dry weight for 30-year- old *T. indica* planted in a single row at 5 m spacing was higher than that of *C. oliviforme* trees grown in the same condition. On the other hand, the range, average standard deviation for leaves dry weight of *T. indica* are lower than those of *C. oliviforme* trees planted as a single row which recorded 110.83- 161.30, 136.07 and 125.53- 167.63, 142.46 kg/ tree, respectively.

Table (3) :Average, range and standard deviation (S.D) of total biomass, stemdry weight and leaves dry weight for the 30- year- old of *Chrysophyllum oliviforme* and *Tamarindus indica* trees grown in Aswan.

Species	Property	Range	Average	S.D
C. oliviforme	Total biomass (kg)	851.12 – 1123.08	992.48	± 136.30
	Stem dry weight,(kg)	298.87 – 400.05	359.80	± 53.67
	Leaves dry weight (kg)	125.53 – 167.63	142.46	± 22.22
T. indica	Total biomass (kg)	1487.51 – 1642.61	1565.06	± 109.67
	Stem dry weight,(kg)	559.05 – 589.17	574.11	± 21.30
	Leaves dry weight (kg)	110.83 – 161.30	136.07	± 35.69

Generally, total above- ground biomass for *T. indica* was superior from those of *C. oliviforme* trees planted at the same conditions. These results were in accordance with Bradstok (1981) and Nwoboshi (1985) who stated that, the relative distribution of the tree biomass differs depending on the tree species, tree age, tree size, stand density and site quality. However, differences between the two species could be attributed to the inherent potential of individual trees to produce higher or lower biomass than their neighbors and the ages of both tree part and the tree itself have been noted to have an effect upon the duration of seasonal growth activity (Eamas and MacDaniels, 1947; Taylor, 1973; Taylor and Wooten, 1973; Panshin and Dezeeuw, 1980).

Wood properties:

The range and average of specific gravity, moisture %, extractive % and cellulose % of wood for 30- year- old of *C. oliviforme* and *T. indica* trees is shown in Table (4). It is obvious from the table that, the highest value of specific gravity and cellulose % was produced with *C. oliviforme* wood. However, *T. indica* wood gave the greatest amount of moisture and extractive percentages . On the other hand, average, range and standard deviation of wood hemicellulose, holocellulose % and ash % for the 30- year-old of *C. oliviforme* and *T. indica* trees grown is shown in Table (5). In this table, the highest values of hemicellulose (28.59%) and holocellulose (73.19%) were recorded with *C. oliviforme* wood, while *T. indica* wood produced ash (3.23%) more than that of *C. oliviforme* wood (2.98%) at the same condition.

The effect of different heights for *C. oliviforme* and *T. indica* wood on specific gravity, moisture %, extractive % and cellulose % is presented in Table (6). It is obvious from the table that, significantly differences were detected between the tested characters due to the different heights. For *C. oliviforme*, extractive content and specific gravity were significantly increases for diameter at breast height, while the moisture contents were significantly increases due to the height of 0.75 of the total height. For the same tree, the highest values of moisture content (61.80%) and cellulose content (45.51%)

were produced from 0.75 of the total height, while the best specific gravity (0.82) and extractive content (3.64%) from diameter at breast height compared to the other heights. For *T. indica*, significantly increases were detected in extractive content and moisture content by using the height of 0.75 of the total height . Also, the specific gravity and cellulose content were significantly increases for diameter at breast height compared to the other heights used. In this respect, the highest values of specific gravity (0.80) and cellulose content (37.66%) were detected with diameter at breast height, while the 0.75 of the total height was the most effective for wood extractive and moisture contents.

The effects of different heights for *C. oliviforme* and *T. indica* wood on hemicellulose, holocellulose and ash % are presented in Table (7). It is clearly noticed that, significantly differences were detected between the tested characters due to the different heights. For *C. oliviforme*, there were significantly increases of hemicellulose and ash content due to the height of diameter at breast height, while the height of 0.75 of the total height resulted in significantly increases in holocellulose content compared to the other heights. In this respect, the highest values of hemicellulose (28.86%) and ash contents (3.47%) were produced from dbh height, while the best amount of holocellulose (73.63%) from the 0.75 of the total height compared to the other heights. For *T. indica*, diameter at breast height increased the values of the tested characters in this table and the increment was significant compared to the other height treatments.

Table (4) : Average, range and standard deviation (S.D) of wood specific gravity, moisture % , extractive % and cellulose % for the 30- year- old of *Chrysophyllumoliviforme* and *Tamarindus indica* trees grown in Aswan.

Species	Property	Range	Average	S.D
C. oliviforme	Specific gravity	0.73 – 0.85	0.79	± 0.05
	Moisture % at fresh condition	45.08 – 62.15	53.29	± 6.00
	Extractive %	2.27 – 3.71	3.17	± 0.52
	Cellulose %	43.S61 - 45.67	44.60	± 0.72
T. indica	Specific gravity	0.70 – 0.82	0.76	± 0.04
	Moisture % at fresh condition	50.53 – 61.38	55.13	± 3.73
	Extractive %	3.48 - 5.75	4.42	± 0.68
	Cellulose %	35.21 – 37.74	36.65	± 0.86

Table (5) : Average, range and standard deviation (S.D) of wood hemicelluloses, holocellulose % and ash % for the 30- year- old of *Chrysophyllum oliviforme* and *Tamarindus indica* trees grown in Aswan.

Species	Property	Range	Average	S.D
C. oliviforme	Hemicelluloses %	28.05 - 29.05	28.59	± 0.33
	Holocellulose %	72.59 - 73.77	73.19	± 0.41
	Ash %	2.01 -3.71	2.98	± 0.50
T. indica	Hemicelluloses %	26.52 - 27.82	27.05	± 0.43
	Holocellulose %	61.94 - 65.43	63.70	± 1.23
	Ash %	2.01 - 4.24	3.23	± 0.64

Table(6): Wood specific gravity, moisture %, extractive % and cellulose % for diameter at breast height (dbh), 0.25, 0.50 and 0.75 of total height of*Chrysophyllum oliviforme* and *Tamarindus indica* trees.

Species	Property	Total heights				L.S.D
		d.b.h.	0.25	0.50	0.75	
C. oliviforme	Specific gravity	0.82	0.82	0.79	0.73	5% :0.01 1% :0.02
	Moisture % at fresh condition	46.50	50.39	54.47	61.80	5% :2.21 1% :3.22
	Extractive %	3.64	3.42	3.26	2.37	5% :0.29 1% :0.42
	Cellulose %	44.02	44.31	44.54	45.51	5% :0.54 1% :0.78
T. indica	Specific gravity	0.80	0.77	0.75	0.71	5% :0.01 1% :0.02
	Moisture % at fresh condition	51.72	52.80	55.21	60.81	5% :0.55 1% :0.80
	Extractive %	3.62	4.09	4.76	5.22	5% :0.56 1% :0.81
	Cellulose %	37.66	37.13	36.26	35.56	5% :0.25 1% :0.37

Table (7): Wood hemicellulose %, holocellulose % and ash contents % for diameterat breast height (dbh), 0.25, 0.50 and 0.75 of total height of *Chrysophyllum oliviforme* and *Tamarindus indica* trees.

Species	Property	Heights				L.S.D
		d.b.h.	0.25	0.50	0.75	
C. oliviforme	Hemicelluloses %	28.86	28.75	28.64	28.13	5% :0.27 1% :0.40
	Holocellulose %	72.88	73.06	73.19	73.63	5% :0.32 1% :0.46
	Ash %	3.47	3.17	2.38	2.40	5% :0.46 1% :0.68
T. indica	Hemicellulose %	27.54	27.20	26.87	26.60	5% :0.30 1% :0.44
	Holocellulose %	65.19	64.33	63.12	62.16	5% :0.47 1% :0.68
	Ash %	3.96	3.45	2.93	2.56	5% :0.32 1% :0.47

The moisture content of green wood is important because of its direct relation to the weight of logs and green lumber. Therefore, it is of concern to those who design harvesting and transport equipment, purchase wood on a weight basis, or must ship or transport green wood. However, the moisture content of green wood varies considerably among species and within any species there is considerable variation depending upon the location, age, and volume of the tree (Koch, 1972). On the other hand, the specific gravity of wood is single most important physical property. Density and specific gravity can be calculated at any moisture content desired. Density decreases as moisture content decreases, but below the fiber saturation point the specific gravity of a sample increases as the moisture content decreases. Moreover, wood density varies greatly within any species because of a number of factors. These include location in a tree, location within the range of the species, site condition (soil, water, and slope), and genetic source (Shepard, 1990 and Shepard and Shottafer, 1992). Wood is composed principally of carbon, hydrogen, and oxygen. In addition, wood contains inorganic compounds that remain after high- temperature combustion in the presence of abundant oxygen; such residues are known as ash (Kollmann and Cote, 1968). Cellulose, perhaps the most important component of wood, constitutes slightly less than one- half the weight of hardwoods and softwoods. Moreover, amount of cellulose, hemicellulose and holocellulose varies widely among species and between the hardwood and softwood groups (Okamura, 1991).

CONCLUSIONS

On the basis of the present results the following conclusions can be drawn:

1- Total biomass produced from *T. indica* had a higher value than those of *C. oliviforme* (1565.06 and 992.48 kg/tree, respectively) planted at the age of 30 year.

2- From the wood constitutes, it can be noted that *T. indica* wood contained higher moisture content (55.13%), extractive content (4.42%) and ash content (3.23%) than those of *C. oliviforme*. Meanwhile, the highest values of specific gravity (0.79), cellulose content (44.60%), hemicellulose content (28.59%) and holocellulose content (73.19%) were detected with *C. oliviforme* wood.

3- In the two species wood, there were significant differences between height treatments in the specific gravity, moisture content, extractive, cellulose, hemicellulose, holocellulose and ash contents. Generally, wood at diameter at breast height (dbh) and at 0.75 of the total height had a higher constitutes than those of 0.25 or 0.50 of the total height.

4- Based on the biomass and chemical characteristics it is possible to say that wood from *T. indica* and *C. oliviforme* can be used as raw material for the different purposes in Egypt as pulping.

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الكتلة الحيوية فوق سطح التربة وبعض خصائص الخشب لأشجار الكريزوفيللم والتمر الهندى النامية بأسوان- مصر

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أجريت هذه الدراسة بالمزرعة الاستوائية بكوم أمبو- أسوان والتابعة للحديقة النباتية بأسوان خلال عام 2011 بغرض دراسة مقارنة لأشجار الكريزوفيللم والتمر الهندى عمر 30 سنة من حيث انتاج الكتلة الحيوية، الثقل النوعي للخشب، محتوى الخشب من الرطوبة، محتوى الخشب من المستخلصات، المحتوى من السيليلوز، الهيميسيليولوز، الهولوسيليولوز، و محتوى خشب الساق من الرماد. وقد تمت الدراسة على أشجار منزرعة فى صفوف طولية، صف طولى لكل نوع شجرى وبكل صف 10 أشجار ، والمسافة بين الأشجار داخل الصف 5 م. وقد تم قياس القطر عند مستوى الصدر لعدد 6 أشجار من كل نوع، ثم اختيار 3 أشجار عشوائيا لتمثل الصف تم قطعها لتقدير الطول الكلى للشجرة، وزن الأفرع فى الحالة الخضراء، وزن الساق، ووزن الأوراق. بالاضافة الى تقدير بعض خواص الخشب سالفة الذكر.

وكان أهم النتائج ما يلى :

*زادت مكونات الكتلة الحيوية فوق سطح التربة فى حالة أشجار التمر الهندى عمر 30 سنة مقارنة بأشجار الكريزوفيللم عند نفس العمر.

*زادت قيم محتوى الرطوبة، محتوى المستخلصات، ومحتوى الرماد بالخشب لأشجار التمر الهندى مقارنة بأشجار الكريزوفيللم.

* زادت قيم الثقل النوعى ، محتوى السيليولوز، الهيميسليولوز، والهولوسيليولوز للخشب فى حالة أشجار الكريزوفيللم عنه فى حالة أشجار التمر الهندى.

*اختلفت القيم الخاصة بمكونات الخشب لنوعى الأشجار موضع الدراسة اختلافا معنويا عند أخذ عينات خشبية على ارتفاعات مختلفة.

*زاد محتوى خشب ساق التمر الهندى والكريزوفيللم من الرطوبة، الثقل النوعى، المستخلصات، السيليولوز، الهيميسيليولوز، الهولوسيليولوز، و الرماد عند أخذ العينات الخشبية عند ارتفاع مستوى الصدر وعلى ارتفاع 0.75متر مقارنة بباقى الارتفاعات .

*و عليه فانه من خلال هذه الدراسة يتضح أن أشجار التمر الهندى والكريزوفيللم تعد من صالدات الأخشاب الهامة فى مصر والتى يجب أن تلقى اهتماما أكبر فى زراعتها على نطاق واسع فى انشاء الغابات الصناعية و مصدات الرياح وبرامج التشجير خاصة وأنها يمكن أن تجود فى الأراضى الفقيرة و الجافة خاصة فى جنوب الوادى كما يمكن أن يعلق عليها الأمال فى زيادة الثروة الخشبية بمصر.

قام بتحكيم البحث

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