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Effect of NPK- Fertilization on Growth, Chemical Composition and Wood Specific Gravity of Some Timber Trees Grown in Aswan Governorate, Egypt

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Abstract

The response of three timber tree species of Azadirachta indica, Khaya ivorensis and K. senegalensis (6-year- old) grown on loamy sand soil to different NPK- fertilization levels were studied during 2008 and 2009 seasons at the Tropical Farm, Kom- Ombo, Aswan, Egypt. Levels of N, P and K in the fertilizer mixtures were variables as N 30, 45 and 60; P 20, 35 and 50; and K 20, 30 and 40 g and influenced the growth parameters of the tree. Chemical analysis showed that the highest foliar concentrations of P and K were obtained by fertilizing with N 45- P 35- K 30 g/tree. These amounts were divided into three equal doses added at August, September and October during both seasons. Data obtained showed that the mixture of N 45- P 20- K 40 g/tree produced the longest and thickest stems. The maximum N content in leaves was obtained by applying N 60- P 20- K 20 g/ tree. Concerning the effect of NPK- fertilization on wood specific gravity of the three woody tree species, all fertilization levels resulted in significant increase in this parameter, while the mixture of N 45- P 20 – K 40 g/ tree was more effective in respect of wood specific gravity.

Introduction

Applications of fertilizer to the soil beneath trees and shrubs are sometimes needed to replenish essential mineral elements and promote healthy. However, trees require nutrients to live and thrive. When one or more of these nutrients are deficient in the soil, the tree will not reach its full landscape potential, be more susceptible to disease and insect problems, and have a shorter life than the well-fertilized one.

Basic plant nutrition involves the uptake of sixteen mineral elements essential to plant growth. The elements nitrogen (N), phosphorus (P) and potassium (K) are required in a greatest abundance. Research in woody plant nutrition has shown however that nitrogen is the element that yields the greatest growth response in trees and shrubs. For this reason, high nitrogen fertilizers with N-P-K ratios of 4-1-1, 3-1-1 or 3-1-2 are generally recommended for feeding established woody plants. These include fertilizers with analyses such as 8-2-2, 15-5-5, 24-8-16 and similar formulations. The analysis refers to % nitrogen, % phosphorus and % potassium in the fertilizer (Kujawski and Ryan, 2010).

In England, Mitchell and Chandler (1939) showed that there is a strong relationship between nitrogen supply and radial increment of several deciduous trees of the Northeast and estimated that only 15% of the soils supporting hardwood species had an optimum nitrogen status. However, Hoyle and Bjorkbom (1969) emphasized that not only N but also P and K in mineral soils in New Hampshire were deficient for growth of yellow birch.

Dickens *et al*. (2003) pointed out that many acres of southern pines potentially benefit from improved forest nutrition and result in sizeable investment returns. Proper fertilization should be considered as an integral part of a good forest management, and be based on the pine species grown, site and stand characteristics, target product goals, and market prices.

The impact of fertilization on wood quality in hardwoods has been less widely investigated than effects upon softwoods. However, increased specific gravity in trees from fertilized stands has been shown in tests involving red oak (Szopa *et al*. ,1977) and red oak and white ash (Mitchell, 1972).

On the other hand, a 60-year-old northern hardwood stand treated with NPK fertilizer observed that growth rate of sugar maple, paper birch, and yellow birch were increased over untreated trees by 128, 69, and 51%, respectively (Safford ,1973).

Samuelson *et al*.(2001) stated that Sweet gum trees under irrigation and fertigation had increased height, diameter, and production of foliage, stem, and branch mass. Fertigation increased annual increment in woody net primary productivity and projected leaf area index.

Nutrient concentration in soil solution has been of interest for many decades as indicators of soil fertility in agriculture (Hoagland *et al*., 1920) and forestry (Wang and Zabowski, 1998).

Khaya senegalensis (Desr.) A.Juss. is the most common species in the mahogany family (Meliaceae) in Egypt particularly in the South. It produced a valuable wood for carpentry, joinery, furniture, cabinet work, ship building and decorative veneer. It is suitable for construction, flooring, interior trim, vehicle bodies, railway sleepers and pulpwood (Arbonnier, 2004).

Khaya ivorensis A. Chev.; the wood (trade name: African mahogany) is highly valued for furniture, cabinet work, decorative boxes and cases, and veneer, and is also commonly used for window frames, paneling, doors and staircases. It is suitable for light construction, light flooring, ship building, vehicle bodies, handles, sporting goods, musical instruments and pulpwood (Phongphaew, 2003).

Azadirachta indica A. Juss., referred to neem tree, is a member of the Meliaceae family. This

tree can reach heights of 30m with a trunk girth of 2.5m and live for over two centuries. Parts of this tree have been used for medicine, shade, building materials, fuel, lubrication, and most of all as pesticides (Menn, 1990).

Recently reclaimed soils are low in organic matter, N, P, K and micronutrients particularly in the tested area according to the previous studies of Sayed (2001). Keeping all this in view, the present study was conducted with the following objectives: (1) would this relatively fast growing stand respond to different rates of NPK fertilization, (2) would there be an increase in N, P, and K content in leaves of the tested trees with fertilization, (3) is the specific gravity of wood affected by using these treatments and what is the proper combination of NPK- fertilizer that produced more woody yield?.

Materials and Methods

Plant material:

This invistigation was conducted at the Tropical Farm, Kom-Ombo, Aswan (Southern Egypt) during 2008 and 2009 seasons to study the effect of NPK fertilization on growth, nutrient levels and the specific gravity of wood (as the most important of physical properties) of 6-year-old *Khaya senegalensis*, *K. ivorensis*, and *Azadirachta indica* trees at a spacing of 3.5 by 3.5 m. The soils of these plantations are newly reclaimed (loamy sand), their chemical properties are presented in Table (1).

Methods*:*

The major nutrient fertilization combinations available were the following: N0P0K0(control or no fertilizer)**,** N30P20K20, N30P20K40, N30P35K40, N30P50K20, N30P50K30, N30P50K40, N45P35K30, N45P20K40, N45P35K40, N45P50K20, N45P50K30, N45P50K40, N60P50K40, N60P20K20, N60P35K20, N60P35K30 and N60P50K20 g fertilizer per tree. These amounts were applied at the first week of August, September and October during both seasons and given as ammonium nitrate (33%N), calcium superphosphate (15.5%P2O5) and potassium sulphate (50%K2O).

A split plot design with three replicates was done, one tree of the tested trees for each replicate. The main plots were assigned to the woody trees of *K.senegalensis, K. ivorensis* and *A. indica* and fertilization treatments as sub- plots.

Table (1): Some chemical properties of the soil before NPK-fertilizer application.

Character	Value
EC.ms/s	0.24
pH	8.5
$CaCo_3$ %	4.79
Ca^{++} Meq/L	1.26
Mg^{++} Meq/L	0.43
Na^{+} Meq/L	0.36
K^{+} Meq/L	0.11
CO^{2-}_3 Meq/L	---
HCO_3^- Meq/L	1.36
Cl^- Meq/L	0.26
SO_4^{2-} Meq/L	0.34
N%	0.17
P mg/kg	1.70
K mg/kg	76.13
O.M.%	0.33

Collected data:

The following parameters were obtained for *K.senegalensis, K. ivorensis* and *A. indica* trees*:* mean annual of height growth (m), mean annual of diameter growth (cm) and number of main branches. Nitrogen content in leaves of the tested trees was estimated by using semi-micro-kjeldahl method. Phosphorus and potassium contents in leaves of the trees were determined.

Specific gravity (SG) determination:

A -Wood samples preparation:

Wood samples were randomly obtained from tree stems at diameter at breast height (dbh) that is, 130 cm from the ground in such a way that the samples obtained represent all the wood types (sapwood, transition wood and heartwood) by taking samples from different position radically across the bole at this position and thoroughly mixing them together to ensure randomization. Samples were adequately coded for easy identification and taken to the laboratory for SG determination.

B - Measured of SG:

SG was measured for five (5) samples from each of the eighteen (18) trees per species of predetermined weight using the water displacement method at mean ambient temperature of 25 ˚C after oven dry the wood samples. A volume of 200 ml was used in a 250 ml beaker which made it possible to measure the wood SG directly without bark.

All means were compared using LSD at 5 % level according to Gomez and Gomez (1984).

Soil analysis:

Samples were collected from the surface soil (0-20cm) under trees and was analyzed after the two seasons of NPK fertilization using Walkely and Back's method (Jackson 1973), the soil pH was detected in 1:1 soil-water suspension using pH meter, electrical conductivity (E.C.) in 1:1 soil-water extracts using electrical conductivity meter was estimate.

Results

I-Response of the tested meliaceous trees to NPK-fertilization:

a- Mean of annual height growth of trees (m):

Significant increases were observed of mean annual height growth of trees due to applying different fertilization treatments. The tallest tree resulted from using N45P20K40 level in both seasons while, the shortest tree was observed in the control treatment (Table 2). Concerning the general effect of the tested trees on the mean annual height growth of trees regardless of fertilization treatments, it is obvious that the differences between trees were significant. The tallest stem length was *K. senegalensis* and the shortest one was *A. indica.* The interaction between NPK-fertilizer rates and tree species was significant only in the second season. Meanwhile, the tallest trees were obtained from *K. ivorensis* which fertilized by N45P20K40.

b -Mean of annual diameter growth of trees (cm):

Mean of annual diameter growth of trees was significantly affected by all different NPK-fertilization treatments as shown in Table (3). However, the highest value (2.99 cm) of annual diameter growth of stem was resulted from N45P20K40 level, whereas the lowest value (1.25 cm) in the mean of seasons was obtained from unfertilized treatment. In addition, the highest value (3.31 cm) of this character in the mean of two seasons was obtained from *K. ivorensis* trees. Concerning the interaction between treatments and tree species, fertilizing of *K. senegalensis* with N45P20K40 level followed by using N60P50K40 on *K. ivorensis* proved to be the most effective treatments to produce the thickest stem.

C -Number of main branches:

Mean number of main branches as affected by different NPK-fertilizer treatments on the tree species are given in Table(4) for the 2008 and 2009 seasons. N30P50K40 level pronouncedly increased the number of main branches, while using N45P35K40 level resulted in the least one. The trees of *K. ivorensis* gave the highest number of main branches, while *K. senegalensis* trees gave the lowest number of main branches. The interaction between tested fertilization levels and tree species indicated that fertilizing *K. ivorensis* with N30P35K40 rate gave the highest number of main branches in both seasons.

II-Nutrient contents in tree leaves:

a-Nitrogen % in tree leaves:

Trees fertilized with NPK had significantly higher foliar N concentration than leaves from unfertilized trees. The increment of nitrogen percentage in tree leaves reached to 221.62 % in the mean of seasons due to applying the N60P20K20 level compared to the control (Table 5). When there were significant differences in foliar N% of tree species, *A. indica* contained more pronounced of nitrogen in their leaves than the other tree species. The interaction between fertilization levels and the tested trees reveals that rate of N30P35K20 gave the maximum foliage content of N compared to the other treatments.

Table (2): Effect of NPK fertilizer treatments on the mean annual height growth (m) of *Khaya ivorensis. K. senegalensis* and *Azadirachta indica* trees during 2008&2009 seasons.

Treatment	First season (2008)				Second season (2009)			
	K.ivorensis	*K.senegalensis*	*A.indica*	Mean	*K.ivorensis*	*K.senegalensis*	*A.indica*	Mean
N0P0K0	0.54	0.58	0.32	0.48	0.57	0.60	0.33	0.50
N30P20K20	1.05	0.84	0.57	0.82	1.15	1.09	0.62	0.96
N30P20K40	1.15	1.33	0.60	1.02	1.32	1.48	0.67	1.16
N30P35K40	1.03	0.96	0.61	0.87	1.16	1.08	0.67	0.97
N30P50K20	1.38	1.08	0.62	1.03	1.16	1.20	0.70	1.02
N30P50K30	1.16	1.00	0.83	1.00	1.33	1.10	0.93	1.12
N30P50K40	0.96	1.57	0.67	1.07	1.06	1.18	0.74	0.99
N45P35K30	0.97	1.06	0.69	0.91	1.08	1.19	0.77	1.01
N45P20K40	1.38	1.33	0.75	1.15	1.54	1.47	0.83	1.28
N45P35K40	1.07	1.24	0.67	0.99	1.20	1.36	0.75	1.11
N45P50K20	1.19	0.94	0.65	0.93	1.33	1.04	0.73	1.04
N45P50K30	1.13	1.19	0.63	0.98	1.26	1.34	0.70	1.10
N45P50K40	1.17	1.23	0.78	1.06	1.33	1.36	0.86	1.18
N60P50K40	1.20	1.14	0.78	1.04	1.31	1.28	0.86	1.15
N60P20K20	1.11	1.17	0.69	0.99	1.20	1.31	0.76	1.09
N60P35K20	0.92	1.25	0.75	0.97	1.05	1.38	0.83	1.09
N60P35K30	1.03	0.91	0.74	0.90	1.16	1.02	0.84	1.00
N60P50K20	0.86	1.23	0.68	0.92	0.96	1.35	0.77	1.03
Mean	1.07	1.11	0.67		1.18	1.21	0.74	
LSD at 5%	A=0.19 B=0.11 AB=N.S.				A=0.13 B=0.06 AB=0.10			

A: Trees B: NPK fertilization rates AB: Interaction

Table (3) : Effect of NPK fertilizer treatments on the mean annual diameter growth (cm) of *Khaya ivorensis. K. senegalensis* and *Azadirachta indica* trees during 2008&2009 seasons.

Treatment	First season (2008)				Second season (2009)			
	K.ivorensis	K.senegalensis	A.indica	Mean	K.ivorensis	K.senegalensis	A.indica	Mean
N0P0K0	2.03	1.19	0.44	1.22	2.11	1.25	0.48	1.28
N30P20K20	3.36	1.67	0.83	1.95	3.80	1.87	0.93	2.20
N30P20K40	2.75	2.61	0.91	2.09	3.08	2.87	1.01	2.32
N30P35K40	3.11	1.91	0.59	1.87	3.45	2.16	0.65	2.09
N30P50K20	2.99	2.35	0.87	2.04	3.21	2.63	0.96	2.27
N30P50K30	3.12	1.95	0.92	2.00	3.44	2.16	1.03	2.21
N30P50K40	2.70	3.08	0.92	2.23	3.02	3.38	1.04	2.48
N45P35K30	2.71	1.95	0.50	1.72	3.03	2.15	0.55	1.91
N45P20K40	3.51	4.51	0.92	2.98	3.90	4.04	1.03	2.99
N45P35K40	3.32	3.25	0.85	2.47	3.75	3.57	0.95	2.76
N45P50K20	3.24	1.91	0.73	1.96	3.60	2.14	0.82	2.18
N45P50K30	3.61	2.76	0.65	2.34	3.97	3.11	0.71	2.60
N45P50K40	2.94	3.13	0.76	2.28	3.29	3.51	0.83	2.55
N60P50K40	3.63	2.57	1.00	2.40	4.06	2.83	1.11	2.67
N60P20K20	3.46	2.04	1.05	2.18	3.85	2.27	1.21	2.44
N60P35K20	3.69	2.49	0.64	2.27	4.06	2.78	0.71	2.52
N60P35K30	3.43	1.90	0.58	1.97	3.77	2.11	0.64	2.18
N60P50K20	3.03	2.87	0.92	2.27	3.36	3.21	1.03	2.53
Mean	3.14	2.45	0.78		3.49	2.72	0.87	
LSD at 5%	A=0.30 B=0.19 AB=0.32				A=0.12 B=0.14 AB=0.25			

A : Trees B : NPK fertilization rates AB : Interaction

Table (4) : Effect of NPK fertilizer treatments on the number of main branches of *Khaya ivorensis. K. senegalensis* and *Azadirachta indica* trees during 2008&2009 seasons.

Treatment	First season (2008)				Second season (2009)			
	K.ivorensis	*K.senegalensis*	*A.indica*	Mean	*K.ivorensis*	*K.senegalensis*	*A.indica*	Mean
N0P0K0	4.3	2.7	5.7	4.2	4.7	3.0	6.3	4.7
N30P20K20	3.7	3.3	6.3	4.4	4.3	4.3	7.3	5.3
N30P20K40	3.7	2.0	7.3	4.3	4.7	3.0	8.3	5.3
N30P35K40	7.3	4.3	6.0	5.9	8.0	5.0	7.3	6.8
N30P50K20	6.0	5.7	6.7	6.1	6.7	6.3	7.7	6.9
N30P50K30	2.7	5.7	6.0	4.8	3.7	6.3	7.0	5.7
N30P50K40	8.7	4.0	7.0	6.6	9.3	5.0	8.3	7.6
N45P35K30	5.3	4.7	4.0	4.8	6.3	5.3	5.7	5.8
N45P20K40	7.3	1.7	4.3	4.4	7.7	2.3	5.3	5.1
N45P35K40	5.7	2.7	2.0	3.4	6.7	3.7	3.3	4.6
N45P50K20	5.3	4.7	4.0	4.7	6.0	5.3	5.3	5.6
N45P50K30	7.3	5.0	4.0	5.4	8.0	5.7	5.0	6.2
N45P50K40	7.0	6.0	6.3	6.4	7.7	7.0	7.3	7.3
N60P50K40	6.0	6.7	3.7	5.4	6.0	7.7	4.7	6.1
N60P20K20	6.0	3.0	8.0	5.7	6.7	4.0	9.0	6.6
N60P35K20	5.7	6.3	5.3	5.8	6.7	7.3	6.7	6.9
N60P35K30	3.7	4.0	5.0	4.2	4.3	5.0	6.0	5.1
N60P50K20	6.3	5.7	5.3	5.9	7.3	6.3	6.7	6.8
Mean	5.7	4.3	5.4		6.4	5.2	6.5	
LSD at 5%	A=0.4		B=0.6		A=0.3		B=0.4	

A: Trees B: NPK fertilization rates AB: Interaction

Table (5): Effect of NPK fertilizer treatments on the nitrogen percentage in leaves of *Khaya ivorensis. K. senegalensis* and *Azadirachta indica* trees during 2008&2009 seasons.

Treatment	First season (2008)				Second season (2009)			
	K.ivorensis	*K.senegalensis*	*A.indica*	Mean	*K.ivorensis*	*K.senegalensis*	*A.indica*	Mean
N0P0K0	1.07	1.17	1.08	1.10	1.08	1.17	1.09	1.11
N30P20K20	1.12	2.11	2.05	1.76	1.16	2.17	2.09	1.81
N30P20K40	1.82	1.90	1.86	1.86	1.89	1.96	1.90	1.92
N30P35K40	1.99	1.62	1.68	1.76	2.07	1.65	1.73	1.82
N30P50K20	1.80	1.85	2.35	2.03	1.96	1.91	2.42	2.10
N30P50K30	1.57	1.72	2.06	1.78	1.60	1.77	2.12	1.83
N30P50K40	1.87	2.06	1.62	1.85	1.91	2.14	1.65	1.90
N45P35K30	1.74	1.78	2.14	1.89	1.79	1.83	2.18	1.93
N45P20K40	1.89	1.89	2.31	2.03	1.93	1.95	2.40	2.09
N45P35K40	1.80	1.74	2.08	1.87	1.84	1.78	2.12	1.91
N45P50K20	2.03	1.91	2.01	1.98	2.08	1.95	2.07	2.03
N45P50K30	1.67	1.44	1.69	1.61	1.72	1.49	1.74	1.65
N45P50K40	1.77	1.96	1.87	1.87	1.81	2.04	1.92	1.92
N60P50K40	1.52	1.76	2.19	1.83	1.59	1.83	2.23	1.88
N60P20K20	2.16	1.64	1.99	1.93	2.24	1.69	2.03	2.99
N60P35K20	1.84	1.96	2.20	2.00	1.89	2.02	2.29	2.07
N60P35K30	1.58	2.14	2.61	2.11	1.61	2.19	2.66	2.15
N60P50K20	1.81	1.39	1.98	1.73	1.86	1.43	2.04	1.78
Mean	1.73	1.78	1.99		1.78	1.83	2.04	
LSD at 5%	A=0.09 B=0.01 AB=1.15				A=0.05 B=0.06 AB=0.10			

A: Trees B: NPK fertilization rates AB: Interaction

b -Phosphorus % in tree leaves:

The fertilized trees had significantly more P% in their leaves than unfertilized ones (Table 6). However, N45P35K30 fertilization increased phosphorus content in tree leaves compared to the other treatments. *A. indica* shows an apparent response to NPK fertilization in its foliage during the two successive seasons, whereas the least response was *K. senegalensis* tree. The interaction between fertilizer treatments and tree species for P% in the foliage was significant. Repeated N45P35K30 fertilization level on *A. indica* trees for

two seasons produced more P content in their foliage than the other treatments.

c -Potassium % in tree leaves:

Significant increase was observed in leaf K content as a result of using different NPK- fertilizer treatments. The highest K content in leaves resulted from applying N2P2K2 fertilization level while, the lowest K content was observed in the control(N0P0K0) as shown in Table (7). Concerning the general effect of different tree species on potassium content regardless of treatments, it is obvious that differences between trees were significant. The highest K content was recorded with *A. indica* leaves and the least one was *K.ivorensis*. The interaction between NPK treatments and tree species was significant, applying N45P35K30 level with *A. indica* proved to be the most effective treatment to produce more K content.

III-Specific gravity of wood (SG):

Table (8) showed highly significant variation in the data obtained for the specific gravity from each species as affected by NPK treatments. Generally, *K. senegalensis* had the lowest value(0.593) of SG while *A. indica* had highest with a value of 0.674. On the other hand, the highest values of SG in wood samples of the tested trees resulted from using N45P20K40 fertilization level followed by N45P50K40 one.

v-Soil properties :

The results of soil properties as shown in Table (9) indicated that fertilization increased most soil nutrients. Positive changes in chemical properties of soil under trees, particularly in Ca, Mg, N, P, K, and organic matter, were recorded two years after fertilization treatments.

Table (6) : Effect of NPK fertilizer treatments on the phosphorus percentage in leaves of *Khaya ivorensis. K. senegalensis* and *Azadirachta indica* trees during 2008&2009 seasons.

Treatment	First season (2008)				Second season (2009)			
	K.ivorensis	*K.senegalensis*	*A.indica*	Mean	*K.ivorensis*	*K.senegalensis*	*A.indica*	Mean
N0P0K0	0.125	0.097	0.133	0.120	0.140	0.100	0.140	0.127
N30P20K20	0.194	0.143	0.207	0.183	0.210	0.153	0.213	0.192
N30P20K40	0.153	0.120	0.257	0.184	0.187	0.120	0.267	0.191
N30P35K40	0.124	0.137	0.233	0.173	0.157	0.140	0.243	0.180
N30P50K20	0.154	0.133	0.187	0.162	0.177	0.143	0.197	0.172
N30P50K30	0.183	0.090	0.260	0.177	0.183	0.090	0.270	0.181
N30P50K40	0.107	0.177	0.230	0.179	0.137	0.170	0.233	0.180
N45P35K30	0.172	0.203	0.237	0.201	0.170	0.213	0.243	0.209
N45P20K40	0.121	0.120	0.227	0.160	0.143	0.127	0.243	0.171
N45P35K40	0.109	0.163	0.183	0.160	0.140	0.177	0.183	0.167
N45P50K20	0.123	0.133	0.243	0.170	0.140	0.143	0.250	0.178
N45P50K30	0.191	0.150	0.270	0.199	0.183	0.160	0.273	0.206
N45P50K40	0.173	0.113	0.240	0.177	0.183	0.120	0.250	0.184
N60P50K40	0.176	0.127	0.207	0.157	0.143	0.130	0.217	0.163
N60P20K20	0.161	0.140	0.210	0.169	0.160	0.147	0.217	0.174
N60P35K20	0.183	0.160	0.213	0.178	0.163	0.170	0.223	0.186
N60P35K30	0.156	0.130	0.250	0.177	0.160	0.157	0.250	0.189
N60P50K20	0.161	0.157	0.217	0.184	0.183	0.163	0.227	0.191
Mean	0.157	0.139	0.222		0.164	0.146	0.230	
LSD at 5%	A=0.008 B=0.005 AB=0.008				A=0.008 B=0.005 AB=0.009			

A: Trees B: NPK fertilization rates AB: Interaction

Table (7) : Effect of NPK fertilizer treatments on the potassium percentage in leaves of *Khaya ivorensis. K. senegalensis* and *Azadirachta indica* trees during 2008&2009 seasons.

Treatment	First season (2008)				Second season (2009)			
	K.ivorensis	*K.senegalensis*	*A.indica*	Mean	*K.ivorensis*	*K.senegalensis*	*A.indica*	Mean
N0P0K0	0.69	0.72	0.84	0.75	0.70	0.73	0.85	0.76
N30P20K20	1.13	0.79	1.30	1.13	0.83	0.98	1.33	1.05
N30P20K40	0.83	1.11	1.16	1.03	0.85	1.15	1.19	1.06
N30P35K40	0.76	1.17	1.16	1.03	0.78	1.19	1.18	1.05
N30P50K20	0.86	1.07	1.07	1.00	0.88	1.09	1.10	1.03
N30P50K30	1.01	1.07	1.13	1.07	1.04	1.09	1.16	1.10
N30P50K40	0.93	0.80	1.07	0.93	0.94	0.83	1.09	0.95
N45P35K30	0.93	1.16	1.53	1.21	0.96	1.20	1.58	1.24
N45P20K40	0.91	0.77	1.16	0.95	0.93	0.79	1.18	0.97
N45P35K40	0.93	1.08	1.20	1.07	0.96	1.10	1.23	1.10
N45P50K20	0.93	1.23	1.28	1.15	0.96	1.27	1.31	1.18
N45P50K30	1.01	0.93	1.14	1.02	1.04	0.95	1.16	1.05
N45P50K40	0.90	1.00	1.07	0.99	0.92	1.02	1.09	1.01
N60P50K40	0.91	1.00	1.14	1.02	0.93	1.03	1.17	1.04
N60P20K20	0.70	1.01	0.96	0.89	0.71	1.04	0.99	0.91
N60P35K20	0.96	1.08	1.01	1.02	1.00	1.12	1.03	1.05
N60P35K30	1.12	0.99	1.25	1.12	1.14	1.01	1.29	1.15
N60P50K20	0.87	1.00	1.04	0.79	0.90	1.02	1.06	0.99
Mean	0.91	1.01	1.14		0.91	1.03	1.17	
LSD at 5%	A=0.05 B=0.03 AB=0.06				A=0.06 B=0.05 AB=0.08			

A: Trees B: NPK fertilization rates AB: Interaction

Table (8): Wood specific gravity response to NPK- fertilizer treatments in *Khaya ivorensis*, *K. senegalensis* and *Azadirachta indica* trees during 2009 season.

Treatments	***K.ivorensis***	***K.senegalensis***	***A.indica***	**M**
N0P0K0	0.597	0.510	0.630	0.579
N30P20K20	0.623	0.523	0.670	0.605
N30P20K40	0.630	0.600	0.680	0.636
N30P35K40	0.623	0.573	0.660	0.618
N30P50K20	0.640	0.570	0.683	0.631

A= Trees B= NPK fertilization rates AB= Interaction

Table (9): Some chemical properties of soil under Khaya ivorensis, K. senegalensis and Azadirachta indica plantations during the 2008& 2009 seasons.

Characters		First season(2008)			Second season (2009)		
		K.ivorensis	*K.senegalensis*	*A.indica*	*K.ivorensis*	*K.senegalensis*	*A.indica*
EC.ms/s		0.29	0.27	0.21	0.28	0.30	0.23
pH		8.3	8.3	8.4	8.3	8.2	8.1
$CaCo_3$ %		4.1	5.0	5.1	5.0	5.2	5.0
Soluble cations Meq/L	Ca^{++}	1.41	1.55	1.16	1.30	1.70	1.30
	Mg^{++}.	0.69	0.47	0.30	0.72	0.50	0.44
	Na^{+}	0.61	0.47	0.34	0.52	0.42	0.32
	K^{+}	0.15	0.14	0.15	0.15	0.22	0.16
Soluble anions Meq/L	CO^{2-}_3	--	--	--	--	--	--
	HCO_3^{-}	1.60	1.78	1.50	1.28	1.24	1.42
	CI^{-}	0.40	0.35	0.26	0.26	0.29	0.22
	SO_4^{2-}	0.87	0.51	0.24	0.55	0.40	0.10
	N%	0.26	0.23	0.20	0.27	0.25	0.22
	P mg/kg	1.95	1.99	2.02	2.14	2.18	2.20
	K mg/kg	80.2	85.5	83.1	94.7	95.3	91.1
	O.M.%	0.42	0.49	0.40	0.47	0.52	0.51

Discussion

Growth responses:

The soil type on which the experiment was established has been defined as loamy sand (newly reclaimed) soil , and large growth increases have been obtained on this soil type from applications of fertilization (Sayed, 2001).However, the constraint on growth from nutrient deficiency, measured as low of the major elements concentration in the foliage before fertilizing at this site, was relieved with application of fertilization resulting in an increase in stem volume, compared with unfertilized trees.

Large growth responses resulting from applied N fertilizer could be sustained by further fertilizer additions, recycling of N within the trees, or supply from

mineralization of accumulated soil N (Neilsen et al, 1992).

The results of this study indicated that species of the tested trees may respond differentially to fertilizer treatments. These results suggest that research into the possible use of nutrient manipulation as a means of influencing growth of wood in the newly reclaimed soil is needed. Moreover, NPK application to *Khaya ivorensis*, *K. senegalensis* and *Azadirachta indica* plantation resulted in increases in their growth that depend on NPK level. Moreover, NPK application at N2P1K3 rate resulted in the highest values of annual height and diameter growth, while using the N1P3K3 level pronouncedly increased the number of main branches of trees. On the other hand, application of NPK fertilizer levels stimulates growth by increasing the availability of nutrients generally, thereby enhancing crown development and the size of photosynthesizing surfaces. These results are in agreement with those reported by Aro (2000) on scots pine and Caisse *et al.* (2008) on black spruce.

The most obvious effect of fertilizer addition on nutrient- limited sites is an increase in growth rates. This has been demonstrated for different conifer species in different locations (Nicholls, 1971; Bendtsen, 1978; Cown and McConchie, 1981 and Shepard, 1982).

Specific gravity responses:

Of all indices that characterize wood properties, specific gravity is used universally to define wood quality. The strong relationship of specific gravity to mechanical properties, fiber yield, and other properties relevant to the end use of forest products, and the relative ease of its determination, make it a simple and a good descriptor. However, it appears that density is little affected by rapid growth induced by fertilizer. In the present study, applying NPK fertilizer resulted in significantly increased of wood specific gravity and the most pronounced effect was due to using the N2P1K3 rate. In this respect, slightly increased specific gravity in trees from fertilized stands has been shown in tests involving red oak and white ash (Mitchell, 1972). Zobel and Talbert (1984), after a review of findings by a number of investigators and found several observations; these observations are interesting since they raise the possibility of adjusting fertilizer formulations to achieve wood quality as well as growth rate objectives. Otherwise, as Larson (1969) explained fertilization may have an adverse effect by reducing the rate of crown recession and prolonging the juvenile period.

Nutrient content in leaves:

Increased growth in this study was associated with increased in foliar N, P and K content and improved visual and actual health of the tested tree species. However, the highest values of K and P contents in leaves resulted from applying N2P2K2 rate, while the

highest value of N content responses have been obtained with the level N3P1K1 application. Following fertilizing, increased nutrients in tree leaves have been noted by several studies; Hunter and Hoy (1983); Ballard(1984); Neilsen *et al.* (1992); Abd El-Aziz(2000) ; Sayed (2001) and Abdou and El-Sayed(2002) .

Soil chemical properties:

There are many reports of forest management, including fertilization, on chemical properties of soil and can be compared in a broad sense with our results. A similar trend was evident in *Eucalyptus regnans* plantations (Weston and Attiwill, 1996) where concentrations of total organic and inorganic matter increased in surface soil after fertilization treatments. On the other hand, the primary processes held responsible for the formation of high fertility soils around trees relate to enhanced biological processes with the seasonal and long – term return of nutrients accumulated in trees to the soil through litter fall, root decay and exudation and their mineralization , as well as leaching of nutrients stored in canopies (Boffa, 1999) .

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Assiut J. of Agric. Sci., 41 (3) (43 - 60)

تأثير التسميد(ن- فو- بو) على النمو والمحتوى الكيميائى و الثقل النوعى للخشب لبعض الأشجار الخشبية النامية بمحافظة أسوان- مصر

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أجريت هذه التجربة خلال عامى 2008 ، 2009 على ثلاثة أنواع شجرية تابعة لعائلة الماهوجنى هى الكايا السنغالى ،كايا ايفورنسس ،و النيم والتى تم زراعتها فى خريف 2002 فى أراضى رملية طمية مستصلحة حديثا تابعة للمزرعة الاستوائية بكوم أمبو-أسوان(جنوب مصر). وقد استخدم 18 معاملة تسميد (ن- فو- بو) حيث كانت مستويات النيتروجين 30-45-60و الفوسفور 20-35- 50 والبوتاسيوم 20-30- 40 جم سماد/ شجرة. أضيفت معاملات التسميد المختلفة على ثلاث دفعات(أغسطس، سبتمبر، أكتوبر) فى كلا الموسمين. و كان الهدف من الدراسة هو تأثير مستويات التسميد المختلفة على نمو وجودة هذه الأشجار النامية فى تربة فقيرة وتحديد المستوى الملائم للحصول على أشجار جيدة تلائم الأغراض المنشودة منه

وكان أهم النتائج المتحصل عليها ما يلى :

- أعطت المعاملة N2P1K3 (45:20:40 g/tree) أكبر القيم من حيث ارتفاع الشجرة والقطر عند مستوى الصدر للأشجار موضع الدراسة ، بينما نتج عن المستوى السمادى N1P3K3 (30: 50: 40 g/tree) أعلى القيم بخصوص عدد الأفرع الرئيسية للأشجار.
- تسميد أشجار الكايا ايفورنسس بمستوى N2P1K3 نتج عنه أكثر الأشجار ارتفاعا ، واستخدام نفس المستوى مع أشجار الكايا السنغالى أدى للحصول على أكبر القيم الخاصة بقطر الأشجار عند مستوى الصدر، بينما كان للتفاعل بين أشجار كايا ايفورنسس والتسميد بمعدل N1P3K3 كبير الأثر فى الحصول على أكبر القيم من حيث عدد الأفرع الرئيسية .
- تفوقت أشجار النيم عن باقى الأنواع موضع الدراسة من حيث المحتوى الغذائى فى أوراقها ، فقد أعطت أكبر القيم الخاصة بمحتوى النيتروجين ، الفوسفور، البوتاسيوم خلال عامى الدراسة .
- استخدام مستوى N2P2K2 (45:35:30 g/tree) فى تسميد الأشجار أدى الى زيادة محتوى الأوراق من عنصرى الفوسفور والبوتاسيوم مقارنة بباقى المستويات ، بينما كان أفضل محتوى نيتروجينى نتيجة لاستخدام المستوى N3P1K1 (60:20:20 g/tree) .

-زادت قيم الثقل النوعى للأشجار موضع الدراسة معنويا باستخدام مستويات التسميد المختلفة وقد تفوقت أشجار النيم عن باقى الأنواع فى هذه الصفة.

- استخدام مستوى N2P1K3 أدى الى زيادة قيم الثقل النوعى للخشب فى أشجار عائلة الماهوجنى مقارنة بمستويات التسميد الأخرى .