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Full Length Research Paper

Influence of specific gravity on wood species selection for agroforestry in some Local Government Areas of Oyo State, Nigeria

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Specific gravity (SG) of wood has not been adequately reported to be a factor directly or indirectly influencing its selection for incorporation into or retention in some of the agroforestry systems. In this study, the SG of twelve wood species that top the priority ranking of respondents in Akinyele and Ido Local Government Areas (LGAs), Oyo State, Nigeria, where the predominant type of agroforestry system practiced is that of scattered trees in croplands, were evaluated and found to range between 0.42 and 0.85 with eleven of the species having values > 0.60. Ranking pattern by the respondents in the two LGAs was found not to be significantly different using Friedman chi-square analysis ($\chi^2 = 2.17$, $p < 0.05$). Data obtained for SG were subjected to two-way analysis of variance which indicated a significant variation ($p < 0.05$) in the values among the species but not within each species. Follow up test was carried out using Fisher's Least Significant Difference. The correlation analysis gave positive coefficient values ($r > 0.80$, $p < 0.05$) between SG and cumulative ranking values in the two LGAs. Conclusion and recommendations were made in line with the outcome of the study.

Key words: Agroforestry technologies, wood specific gravity, species selection, natural resources, indigenous knowledge.

INTRODUCTION

Agroforestry systems are fast receiving global attention as one of the solutions to the problems associated with availability of productive land for agriculture and forestry activities. These methods of natural resource production has been so adjudged owing to their ability to combine agronomic crops and/or livestock with woody perennials on the same land management unit either simultaneously or sequentially in a deliberate manner.

Agroforestry is far becoming recognized as a system that is capable of yielding both wood and food crops/livestock at the same time conserving and rehabilitating ecosystem (Nair, 1984; King, 1987; Birma, 1999). It is noteworthy that these systems are age-long worldwide practices particularly in many parts of Africa, but their scientific recognition and various systems modifications and development has been comparatively recent in approach. Subsequently, there is necessity for proper and adequate knowledge of the various systems in terms of species compatibility and contribution to the system, crop alignment, product utilization, community's needs and users' perception among many other factors. Consequently, the age-old experience of farmers in nurturing trees on cultivated land and the scientific knowledge generated by the modern science are important assets for the future development of agroforestry (Bonkoungou, 2001).

As wood has been identified to be one of the major products of many agroforestry systems (ICRAF, 1991) it is important to be acquainted with factors that govern its incorporation into and their sustenance in these systems. Wood is important to users as a means of income generation or for domestic uses in terms of nutritional security, health care (phytomedicine), feed for animals, fodder, firewood, charcoal, building and construction material, fibre, gums, resin, dyes among other inexhaustible importance.

Series of research activities on agroforestry systems and practices have been carried out and described especially in the areas of species compatibility, crop alignment, as well as product utilization but studies on direct or indirect influence of some intrinsic properties of wood, like specific gravity or density, on its incorporation into agroforestry systems particularly by farmers are almost unavailable in the literature. Such studies are necessary because wood specific gravity or density is an important intrinsic property that influences many of its utilization for different applications by different end users (Panshin and deZeeuw, 1980; Omorah, 2000).

Thus, experience of local people over the years on wood species selectivity for agroforestry, based on native intelligence/indigenous knowledge need to be documentted in order to contribute to information needed for policy formulation and implementation as regards agroforestry systems development by various stakeholders. The need for integration of indigenous knowledge in agroforestry research and development has also been highlighted in some studies e.g Udofia, (2001). This is necessary in order to avoid similar situations where many agroforestry schemes failed in the past due to their rejection by farmers as a result of designing agroforestry technologies using external perspectives (Mahlako, 1993).

This study was therefore carried out to evaluate the influence of wood specific gravity (SG), which has not been adequately reported in this manner to the best of author's knowledge, on species incorporation into agroforestry schemes based on native intelligence/indigenous knowledge, using trees scattered in croplands, which is the predominant type of agroforestry system practiced in Akinyele and Ido Local Government Areas of Oyo State, Nigeria as a case study.

MATERIALS AND METHODS

Study area

The wood samples for the experiment were obtained from trees sourced randomly from agroforestry plots in Akinyele and Ido Local Government Areas (LGAs) of Oyo State, Southwestern, Nigeria (Latitude 7°17'–7°26'N and Longitude 3°17'– 3°30'E) where the predominant method of agroforestry system practiced is scattered trees in croplands (with most of the trees not planted by the farmers interviewed). This study area is located in between the humid and sub-humid tropical climate.

The mean annual rainfall ranges from 1,117.1 to 1,693.3 mm. The rainfall pattern has a characteristic bimodal distribution with peaks usually in June or July and September and the period of low precipitation in August with four months of dry season (December – March). The annual temperature ranges from an average minimum of 24.6°C to average maximum of 31.5°C. The mean monthly relative humidity reaches a minimum of 52% in February and a maximum of 83% in August (IITA, 1993; FRIN, 1999).

Questionnaires Survey

In order to prioritize the wood species in croplands in this study area and obtain those mostly preferred to be in their croplands by farmers, questionnaire was drawn for administration on this target group, in such a way as to utilize their indigenous knowledge/native intelligence for the prioritization of the species.

A random survey of respondents was done using questionnaires targeting two hundred and forty (240) respondents. One hundred and twenty (120) copies of a set of questionnaires were randomly administered in each LGA. This was achieved by partitioning each LGA into four (4) geographical zones i.e. North, West, South and East based on the information obtained from each LGA headquarters with a village/community randomly selected to represent each zone in each LGA as stated: Akinyele LGA: North: Aba Isale Community, South: Papa Malu Community, West: Motosho Community, East: Bagadaje Community. Ido LGA: North: Odetola Community, South: Dagilogba Community, West: Tade Community, East: Patako Community.

Thirty (30) copies of the questionnaires were randomly administered on respondents in each geographical zone in order to ensure randomization, equitable distribution and even spread of the questionnaires in the two LGAs.

The questionnaire was drawn in such a way that the respondents listed all the woody species in his/her farm and prioritize them in terms of how preferable they are for agroforestry, from his/her perspective based on experience. The respondents listed the wood species from 1 to 10 in order of preference with the species in position number 1 being the most preferred while the species in position number 10 being the least preferred out of the ten species in that order.

Numerical values of 1 to 10 were allocated to each position on the ranking. Numerical values were allocated to each position on the ranking in descending order i.e. numerical value 10 was allocated to position number 1 on the ranking while numerical value 1 was allocated to position number 10 on the ranking in that order.

Collating the numerical values allocated to each position occupied by each species on the ranking, it was found that twelve species had the highest cumulative values as against the ten species that was originally planned to be selected for laboratory analysis. These methods of questionnaires administration and allocation of values to ranking position of species were described by Erakhrumen (2005).

The number of copies of questionnaires that was retrieved from Akinyele and Ido LGAs was 83 and 96 out of the 120 administered respectively totaling 179 owing to incomplete information in and non-retrieval of some of the questionnaires totaling sixty one (61). The 179 questionnaires served as the effective sample size used in the subsequent analyses.

Wood Samples Preparation

Four trees each per species of *Annona senegalensis* Pers., *Anogeissus leiocarpus* (DC.) Guill. and Perr., *Bridelia ferruginea* Benth., *Daniellia oliveri* (Rolfe) Hutch. and Dalziel, *Detarium micro-carpum* Guill. and Perr., *Gardenia ternifolia* Schumach. and Thonn., *Hymenocardia acida* Tul., *Lophira lanceolata* Tiegh. ex Keay., *Parkia biglobosa* (Jacq.) R. Br. ex G. Don., *Terminalia avicen-nioides* Guill. and Perr., *Triplochiton scleroxylon* K. Schum. and *Vitellaria paradoxa* C.F. Gaertn. were randomly located on agro-forestry farms in the study area where the predominant method of agroforestry system is scattered trees in croplands.

Wood samples were randomly obtained from tree stems at diameter at chest height (dch) 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 radially across the bole at this position and thoroughly mixing them together to ensure randomization. The ages of the trees were unknown owing to the fact that most of them were not planted by the farmers in this study area. Samples were adequately coded for easy identification and taken to the laboratory for SG determination.

Determination of Specific Gravity

SG was measured for ten (10) samples from each of the four trees per species of predetermined weight using the mercury displace

Table 1. Twelve species that top the ranking of the wood species in agroforestry plots by respondents in the two Local Government Areas.

Species scientific names	Family
Annona senegalensis Pers.	Annonaceae
Anogeissus leiocarpus (DC.) Guill. and Perr.	Combretaceae
Bridelia ferruginea Benth.	Euphorbiaceae
Daniellia oliveri (Rolfe) Hutch. And Dalziel.	Caesalpiniaceae
Detarium microcarpum Guill. and Perr.	Caesalpiniaceae
Gardenia ternifolia Schumach. and Thonn.	Rubiaceae
Hymenocardia acida Tul.	Phyllanthaceae
Lophira lanceolata Tiegh. ex Keay.	Ochnaceae
Parkia biglobosa (Jacq.) R. Br. ex G. Don.	Mimosaceae
Terminalia avicennioides Guill. and Perr.	Combretaceae
Triplochiton scleroxylon K. Schum.	Sterculiaceae
Vitellaria paradoxa C.F. Gaertn.	Sapotaceae

Table 2. Friedman chi-square result for the ranking pattern of the respondents in the two Local Government Areas.

Local Government Areas (LGAs)	Friedman chi-square value	Critical value	Decision
Akinyele LGA			No significant difference
Ido LGA	2.17	3.84	

$p < 0.05$

ment method (ASTM, 1989) at mean ambient temperature of 25°C after oven drying the wood samples. 80ml volume was used in a 100 ml beaker which made it possible to measure the wood SG directly with or without bark as obtained.

Statistical Analyses

Friedman chi-square analysis was employed in analyzing the ranking pattern of the prioritized species by the respondents in the two LGAs. SG values obtained from all the species were subjected to basic descriptive statistical analyses such as mean, standard deviation and standard error of mean. Two-way ANOVA was used to determine if there was significant variation in the data obtained for SG within individual species and among all the species put together.

Fisher's Least Significant Difference (LSD) was used as a follow-up procedure to identify which pairs of treatment means differed significantly while Pearson's moment correlation coefficient values between cumulative ranking values in each LGA and wood SG was calculated. The statistical packages used for the analyses were SPSS 11 and Minitab 13 for Windows.

RESULTS

The twelve woody species that were at the top of the priority ranking of the respondents based on the cumulative numerical values attached to each position on the ranking are tabulated in Table 1 while Table 2 shows the Friedman chi-square result ($p < 0.05$) for the ranking pattern of the respondents in the two LGAs.

The mean SG and other descriptive statistics for the twelve species are presented in Table 3 below. The mean SG value for the twelve species put together was 0.75; *T. scleroxylon* had the lowest value of 0.42 while *V. paradoxa* had the highest with a value of 0.85.

Table 4 have the ANOVA result for SG data obtained for samples from each species, showing no significant variation in the data obtained for individual species, although, the result of ANOVA for data from all the species put together showed that there was significant varia-tion in the data obtained ($p < 0.05$). The LSD of pair of means for SG for all the species is tabulated on Table 5 while Pearson's moment correlation coefficient values between cumulative ranking values in each LGA and wood SG values is on Table 6.

DISCUSSION

The success of any agroforestry system has been reported in the literature to be largely dependent on farmer's cooperation and participation which thus, informed the idea of using their ranking and prioritization of woody component of scattered trees in croplands, which is the predominant agroforestry system in this study area, as the basis for selecting woody species for this re-search.

Owing to the fact that listing and prioritization of wood species were done by each respondent, many species made their lists and subsequent rankings but the twelve that featured mostly and had the highest cumulative prioritization values were the ones selected for the laboratory analysis. The necessity for prioritization of tree and shrub species for agroforestry purpose has also been

Table 3. Descriptive statistics for wood specific gravity values for all the species at mean ambient temperature of 25°C.

Species	Mean SG at 25°C	Standard deviation	Standard error of Mean
Lophira lanceolata	0.81	0.01	0.03
Vitellaria paradoxa	0.85	0.03	0.08
Triplochiton scleroxylon	0.42	0.03	0.06
Daniellia oliveri	0.64	0.03	0.02
Terminalia avicennioides	0.79	0.05	0.01
Annona senegalensis	0.71	0.03	0.07
Detarium microcarpum	0.73	0.02	0.03
Hymenocardia acida	0.81	0.02	0.04
Gardenia ternifolia	0.81	0.03	0.08
Parkia biglobosa	0.83	0.03	0.07
Anogeissus leiocarpus	0.83	0.02	0.03
Bridelia ferruginea	0.81	0.02	0.05
Mean	0.75		

Values are means for 10 test samples per tree.

Table 4. Within species ANOVA for wood specific gravity values for all the species.

Species	Source of variation	DF	F-Cal	F-Tab	P-Value
Lophira lanceolata			0.66ns		0.582
Parkia biglobosa			0.25ns		0.863
Vitellaria paradoxa			0.34ns		0.800
Gardenia ternifolia			0.71ns		0.552
Hymenocardia acida	Number of trees	3	0.36ns		0.781
Triplochiton scleroxylon	Error	36	2.68ns	2.84	0.062
Daniellia oliveri	Total	39	0.38ns		0.770
Bridelia ferruginea			0.71ns		0.551
Terminalia avicennioides			2.15ns		0.111
Anogeissus leiocarpus			1.63ns		0.201
Annona senegalensis			1.18ns		0.333
Detarium microcarpum			1.87ns		0.152

ns Denotes not significant ($p < 0.05$).

highlighted by Popoola et al. (1996).The Friedman chi-square value revealed that there was no significant differrence in the ranking pattern of the twelve species by the respondents in the two LGA. This implies that preference for these species for incorporation into agroforestry systems and or their preservation or retention in croplands was similar among the respondents in this study area based on native intelligence/indigenous knowledge. This observed trend is likely to be noticed in many other communities with similar characteristics.

Apart from the mean SG value for *T. scleroxylon* which was 0.42, the remaining eleven species had values ranging between 0.64 and 0.85, values comparable to the ones obtained for some wood species obtained from some agroforestry systems by Shanavas and Kumar, (2006).

These SG values obtained for the twelve species in this study are high enough to make it an important factor in species selectivity for agroforestry in this study area, particularly when it has been established that this intrinsic factor has influence on wood quality and many of its other properties (Panshin and deZeeuw, 1980; Larson et al., 2001). It is also said to indicate the amount of actual wood substance present in a unit volume of wood (Zobel and Jett, 1995). It is important to note that many other factors, that were not part of this study, influence the SG of wood e.g. source of wood material along and across the stem (Akachuku, 1980; Ogunsanwo and Onilude, 2000; Espinoza, 2004; Shanavas and Kumar, 2006), age of trees, silvicultural and or management regimes, geo-

Table 5. Fisher's Least Significant Difference (LSD) of pair of means for wood specific gravity for all the species.

Species	Mean S.G
Lophira lanceolata	0.81^{a}
Parkia biglobosa	0.83^{a}
Gardenia ternifolia	0.81^{a}
Bridelia ferruginea	0.81^{a}
Hymenocardia acida	0.81^{a}
Anogeissus leiocarpus	0.83^{a}
Vitellaria paradoxa	0.85^{a}
Terminalia avicennioides	0.79^{a}
Annona senegalensis	0.71^{b}
Detarium microcarpum	0.73^{b}
Daniellia oliveri	0.64^{c}
Triplochiton scleroxylon	0.42^{d}

Means with the same superscript are not significantly different ($p < 0.05$)

Table 6. Pearson's moment correlation coefficient values between cumulative ranking values in each LGA and wood specific gravity values.

		ADVAK	ADVID	SPEGRAV
ADVAK	Pearson Correlation	1.000	0.860	0.832
	N	12	12	12
ADVID	Pearson Correlation	0.860	1.000	0.851
	N	12	12	12
SPEGRAV	Pearson Correlation	0.832	0.851	1.000
	N	12	12	12

$p < 0.05$ Where: ADVAK = Cumulative ranking values for the twelve species in Akinyele Local Government Area.**.** ADVID = Cumulative ranking values for the twelve species in Ido Local Government Area. SPEGRAV = Specific Gravity of each species. N = Number of species.

graphical and site factors (Akachuku, 1980; Bada, 1990), genetic influence among others. Subjecting the data obtained for SG to ANOVA, it was observed that values obtained for samples from each species did not significantly vary but there was a significant variation in the values among data for samples from all the species put together. This is not unexpected as stated earlier owing to the fact that various intrinsic and extrinsic factors relating to individual species influence different wood properties in different ways.

The LSD used in separating the mean SG values showed that *L. lanceolata*, *P. biglobosa*, *G. ternifolia*, *B. ferruginea*, *H. acida*, *A. leiocarpus*, *V. paradoxa* and *T. avicennioides* had mean SG that were not significantly different while *A. senegalensis* and *D. microcarpum* also had means with similar values while *T. scleroxylon* and *D. oliveri* had mean values that differed significantly and with those of others.

Although, the choice of the woody species were not directly influenced by their SG from the respondents' response to questionnaires in this study area, as most of them were not planted by the respondents in farmlands in the study area, but from the Pearson's moment correlation coefficient values between cumulative ranking values in each LGA and wood SG values obtained, it could be seen that relatively high positive values existed between them in the two LGA.

Therefore, the implication of these correlation coefficient values is that wood species selectivity for or retention in croplands in this study area might have been indirectly influenced by their SG or density.

Conclusion

Studies of many agroforestry systems have revealed that species incorporation into it and or their sustenance is systematically determined by many factors that are mostly influenced by the possible outcome or results expected from the system design and its components for the diverse categories of users.

This study has been able to show that specific gravity/density is an intrinsic property that indirectly determines wood species incorporation into or retention in agroforestry schemes in this study area where the predominant type of agroforestry system practiced is that of scattered trees in croplands.

Although, this intrinsic property may not have been or was not deliberately used as a factor for incorporation or retention of woody species in croplands but the uniformity in species preference in the two LGAs, relatively high SG values coupled with positive correlation coefficient values obtained between cumulative ranking values and mean SG values point to the fact that it is indirectly influencing the decision of farmers as regards the woody species to be incorporated or retained in their farmlands irrespective of the fact that effects of other factors on the correlation coefficient values obtained was not investigated in this study.

This wood intrinsic property which has not been well highlighted as a factor that influence, either directly or indirectly, the wood species preference for agroforestry is therefore recommended for conscious consideration as one of the factors when woody species are to be selected or recommended for agroforestry schemes development in this study area and others with similar characteristics.

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