Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension
Volume 7 Number 1 January, 2008 pp 1-8
ISSN 1119-7455

ECOLOGICAL STUDIES ON THE DISTRIBUTION AND PHENOLOGY OF BUSH MANGO, *IRVINGIA WOMBOLU* (VERMOESEN) IN THE HUMID FOREST OF SOUTHEASTERN NIGERIA.

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ABSTRACT
Studies on the distribution, soil requirement for establishment and the phenology of Bushmango, Irvingia wombolu were undertaken in five selected geographic zones of Southeastern Nigeria. Enumeration and inventory of ten selected woody food tree crops were made in the homestead and outlying farms of each zone, with emphasis on Irvingia wombolu. Twenty soil samples comprising of ten samples from each of the farming zones were analysed for their physical and chemical properties. Phenological sequences of I. wombolu were made in the farming zones of the study areas. The plant species had generally very low densities. 0.3 – 2.7 trees/ha, and 1. wombolu had density 2.4 trees/ha. Irvingia wombolu occurred more in the outlying farms than in the homestead farms. Umuozu and Enugu-Ezike had higher densities of 1. wombolu in the two farming zones than the other towns. 1. wombolu had positive and significant relationship with P. macrophylla and Monodora. myristica, and positive but non-significant relationship with the other seven plant species. Soil samples obtained from different locations were heterogeneous. The species appear to thrive well in soils containing adequate amount of N, K, Ca, and C. The species' period of leaf flush appears an adaptive strategy for mobilizing nutrients for its reproductive phase, flowering and fruiting.

Key words: *Irvingia wombolu*, Distribution, soil requirement, Inventory, Phenology.

INTRODUCTION
The humid forest of Southern Nigeria is richly endowed with many under-utilized crops that have high nutritional economic and medicinal values for man, such as *Irvingia wombolu, Irvingia gabonensis, Pentaclethra macrophylla, Piper guineense,* etc. These useful crops could become extinct due to the rapid deforestation in Nigeria. Myers (1989) reported that Nigeria is among the twelve nations whose deforestation rate accounts for over 80% of the global total. At present, most of the indigenous food tree crop species in the forest zone are lesser known, under-exploited and not purposely cultivated (Okafor, 1983, Isichei, 2005). The non-cultivation of these useful plants and the under-exploitation of their resources through biotechnology could be traced to the nation's drift from agricultural productions to petroleum products exploitation and food importation. The present rise in the nation's population, poverty and unemployment among the populace, call for an urgent need for the conservation and biotechnological exploitation of her rich biodiversity. Of all the bioresources that need bioprospecting, conservation and exploitation for the economic and social growth and development of the nation, *Irvingia wombolu,* quickly strikes the mind.

Irvingia wombolu (Vermeosen), formerly known as *Irvingia gabonensis* var. *excelsa (Milber/Okafor)*, is found in the tropical rainforests of East, West and Central Africa. (Harris 1996, Tchoundjeu *et al.* 2005). In Nigeria, the species is found in the Southern States and the lower region of the Middle Belt States (Nzekwe *et al,* 2005). The species and its close relative *Irvingia gabonensis,* formerly var *gabonensis,* are collectively identified as Bushmango, due to their mango-like fruits. *Irvingia wombolu* fruit pulp is slimy to touch and very bitter to taste (Ejiofor *et al*, 1987). The desired part of the species is the kernels, the cotyledons, popularly used locally in preparing slimmy-soup. The Igbos call it "Ogbolo", Yorubas – "Oro", the tree, and "Aapon", the kernel. The Efiks call it "Nbukpab-Uyo", and the

Binis of Edo State call it "Ogwe". Okafor (1983) reported that the species is found mainly in the forest but could be protected. Keay *et, al.* (1964) reported that the trees grow to about 25m tall. Harris (1996) reported that the species flowers from October to December, while its ripe fruits are available from January to March. In most localities, the peasant farmers generate substantial revenue by selling the kernels which are obtained from the fruits of the trees in the wild. Nzekwe *et al* (2005) reported that a tree of the species can yield a revenue of ₦15, 000 – ₦25, 000 per annum. Techoundjeu, *et al* (2005) reported revenue yield of US$260, 000 per annum in trans-boarder trade from Cameroon to other neighbouring African countries. Proximate analysis of the species showed that the kernels contain protein, crude dietary fibre, fats and oil, carbohydrates, vitamins, mineral salts etc in varying proportions (Achinewhu, *et. al.* 1995, Ejiofor and Okafor, 1997).

Despite the multipurpose of the species, it is still under-exploited and not purposely cultivated like other cash crops. Following the nation's search for other sustainable sectors of generating revenue, in addition to the petroleum products, there is need to obtain information on the potentially useful bioresources in our forests, so as to properly plan for their conservation and sustainable exploitation. The aims of this study are: (i) assessment of the distribution of *Irvingia wombolu* in the humid forests of South Eastern and lower Middle Belt States of Nigeria (ii) to obtain information on the species soil requirement for establishment and (iii) the species phenology. The results of this study are anticipated to provide useful information on the species conservation, bioprospecting and sustainable exploitation through biotechnological intervention.

MATERIALS AND METHODS

The study areas.

The study covered five geographical zones. In each zone two towns were sampled as shown in Table 1.

Table 1: The study areas

States	Towns
Enugu	Enugu-Ezike, Umuozu
Benue	Igumale, Ofante
Delta	Osissa, Umunede
Imo	Ubaha, Egbema
Bayelsa	Zarama, Mbiama

Crop Enumeration and Inventory

Enumeration and Inventory of ten selected woody food tree crop species were made in the homestead and outlying (forest) farm lands of the selected towns. In each town farming zone, half a hactre (0.5ha) of land was mapped out. The plots were further demarcated into four sub-plots of 12.5m x 12.5m before enumeration. During enumeration trees were counted as present or absent. Trees on the boundary of two plots were counted for the plot having about 80% of the trees branches. Identification of the plants were made by on the sight observation and confirmed in the herbarium, using Hutchenson and Daiziel (1963). Data obtained were subjected to correlation analysis, matching presence of one plant species with the other. The correlation matrix was expressed in a diagram. The density of the species enumerated were determined for the farming zones. The density of *I. wombolu* was also determined for the two farming zones of each of the towns sampled.

Soil Sample Analysis

Twenty soil samples, made up of ten samples from each of the farming zones were collected, using soil urgur. Soil samples were collected around the trees adopting the method of Usman (1990). Three soil samples were randomly collected from each plot. These were bulked up as a sample from a plot. The soil samples were dried, crushed and sieved through 2mm mesh and were analysed for their physical and chemical properties. Emphasis was on soil organic matter (OM), Nitrogen (N), Calcium (Ca), Potassium (K), and Carbon (C). Data obtained were subjected to correlation analysis and the outcomes were used to construct a correlation map, matching plant species with soil chemical property.

Phenology

Studies on the phenology of *Irvingia wombolu* were made on the trees growing in the farming zones of the study areas. The study emphasised the species' vegetative growth, phase period of leaf loss and refoliation, and the reproductive phases (period of flowering and fruiting

RESULTS

The densities of the ten woody tree crop species are presented in Table 2:

Table 2: Average Densities of the plant species from different sampled locations.

Plant Species	Density (trees/ha)
Irvingia gabonensis	2.7a
Irvingia wombolu	2.4ab
Dacryodes edulis	2.2ab
Pentaclethra macrophylla	2.0bc
Treculia africana	1.9bc
Gambeya albida	1.5cd
Garcinia kola	1.4cd
Dennittia tripetala	0.9d
Monodora myristica	0.5d
Brachystegia eurycoma	0.3d
Mean	1.58
SE	0.76

Values with the same alphabets are not significantly different at 5% level of significance. The species densities were generally very low, despite variations between them. The species density ranged from 0.3 – 2.7 trees/ha., grand mean 1.58 trees/ha.

Irvingia gabonensis, Irvingia wombolu, Dacryodes edulis and *Pentaclethra macrophylla* had density range of 2.0 – 2.7 trees/ha, while the other six species density ranged from 0.3 – 1.9 trees/ha. *Irvingia wombolu,* the main species for this study had an average density, 2.4 trees/ha.

The density of *Irvingia wombolu* in the two farming zones of the towns sampled is presented in Table 3.

Table 3: Density of *I. wombolu* in the two farming zones of the study areas

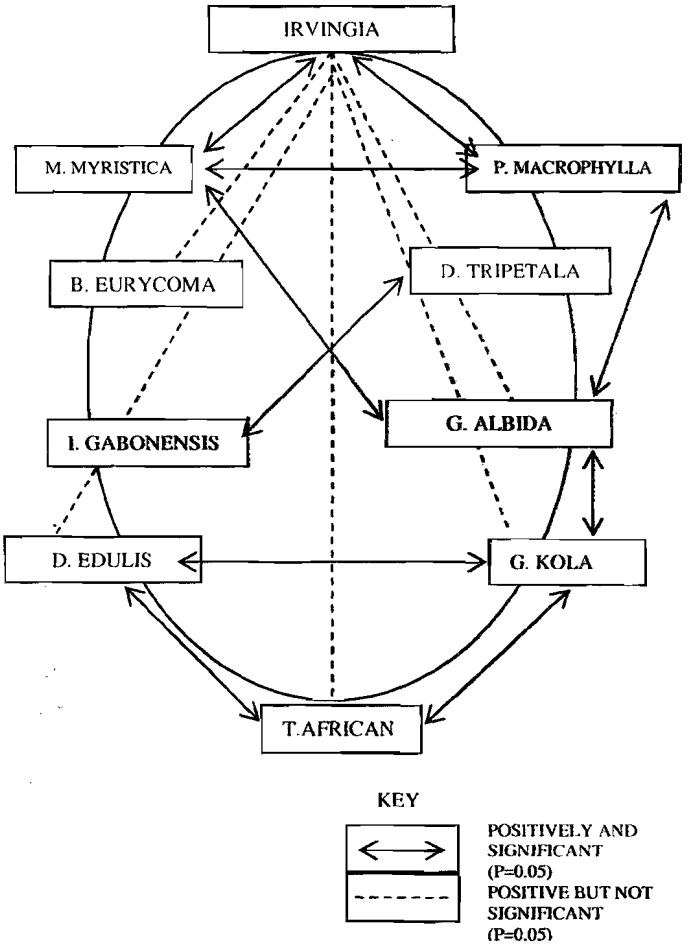
	(Density: tree/ha.)	
Study Town	**Homestead**	**Outlying farm**
Umuozu	4.2a	6.5a
Enugu-Ezike	2.4b	3.6b
Osissa	2.3b	2.6c
Umunede	1.4bc	1.8c
Ubaha	1.2bc	1.6c
Egbema	0.6bc	1.5c
Igumale	0.2c	1.4c
Ofante	0.2c	1.2c
Zarama	0.0e	1.2c
Mbiama	0.0e	0.9cd
Mean	1.25	2.23
SE	1.30	1.62

Values with the same alphabet(s) are not significantly different at 5% level of significance.

The density of the species in the two farming zones, homestead (range 0 – 4.2 trees/ha.,) and outlying farm, the forest (range 0.9 – 6.5 trees/ha) were very low. The results further show that the species occurred more in the outlying farm, (mean, 2.23 trees/ha.) than in the homestead farmland, (mean, 1.25 trees/ha.) Within the towns, Umuozu had the highest density of the species in the two farming zones, 6.5 tress/ha in the outlying farm and 4.3 trees/ha; in the homestead farmland. Next came EnuguEzike, 3.6 trees/ha in the outlying farm and 2.4 trees/ha in the homestead farmland, before Osissa, 2.6 trees/ha. in the outlying farm and 2.3 trees/ha. in the homestead. The other seven towns had below 2.0 trees/ha in their two farming zones. Mbiama and Zarama had no *Irvingia wombolu* in their homestead farm lands.

The association of the ten woody plant species enumerated in the study areas show that *I. wombolu* had positive and significant relationship with *Pentaclethra macrophylla* and *Monodora myristica*, and positive but non-significant relationship with the other seven plant species-

Fig. 1: Association of plant species in the study areas, one plant species with the other.



The results of the analysis of the soil sample collected from the study areas are given in tables 4a and 4b. The results showed that soils from different locations varied in their physical and chemical properties.

The results of the affinity of *I. wombolu* with the soil chemical properties are presented in fig. 2. The results showed that *I. wombolu* had positive and significant affinity with soil Organic matter, Potassium, Calcium, Nitrogen and Carbon.

Tables 4a and 4b: Soil sample analysis

(Homestead)

Location	Mechanical Analysis (%)				P.H	% Exchangeable Basis									
	% Clay	% Silt	% F. S	% C. S	H_{20}	HCL	C	OM	N	Na	K	Ca	Mg	CEC	% Sat	PPMP
Enugu-Ezike	4	4	58	32	5.8	4.0	.93	1.6	0.04	0.16	0.07	0.9	0.42	12.5	66	167
Umuozu	10	10	35	11	5.8	4.8	.91	3.2	0.12	0.10	0.10	5.0	0.64	20.0	71	100
Umuede	8	6	47	15	4.5	3.5	.48	1.8	0.18	0.15	0.90	6.0	3.90	31.5	77	96
Ossisa	10	12	40	20	5.0	4.0	.68	3.9	0.08	0.08	0.05	6.0	3.10	14.5	54	86.7
Ofante	6	4	36	27	5.6	4.1	.50	2.6	0.56	0.08	0.16	2.7	3.10	16.5	62	65
Igumale	10	8	36	28	5.7	4.5	.70	2.0	0.19	0.07	014	2.8	4.00	11.4	72	95
Ubaha	6	4	43	22	5.1	4.1	.84	1.4	0.18	0.09	0.01	3.0	1.80	12.7	71	60
Egbema	8	10	40	24	5.0	4.8	.70	3.2	0.19	0.02	0.13	3.7	3.80	15.8	57	100
Mbiama	22	10	50	20	5.1	4.1	.72	.72	0.16	0.08	0.12	5.0	4.50	14.0	48	60
Zarama	20	10	53	20	5.1	4.1	.75	.62	0.12	0.09	0.12	5.0	5.00	16.5	62	70

(Outlying farm land)

Location	Mechanical Analysis (%)				P.H	% Exchangeable Basis									
	% Clay	% Silt	% F. S	% C. S	H_{20}	HCL	C	OM	N	Na	K	Ca	Mg	CEC	% Sat	PMP
Enugu-Ezike	8	6	35	28	1.8	4.2	0.94	2.8	0.16	0.15	0.10	5.2	0.40	20.0	54	175
Umuozu	18	12	47	26	4.6	4.0	0.95	3.7	0.12	0.04	0.12	5	3.8	12.0	70	139
Umuede	10	24	38	68	5.3	4.1	0.72	0.97	0.12	0.12	0.16	6	3.91	31.5	32	167
Ossisa	14	20	38	36	5.0	3.5	0.78	3.6	0.11	0.12	0.14	7	3.0	46.5	28	100
Ofante	10	4	36	24	4.3	3.8	0.68	3.2	0.05	0.08	0.14	5	4.0	14.9	34	86
Igumale	8	6	16	52	5.1	4.1	0.90	3.6	0.06	0.07	0.18	5	4.0	11.5	47	96
Ubaha	6	4	40	58	5.2	4.2	0.94	3.6	0.05	0.02	0.11	3.1	3.7	12.7	64	95
Egbema	20	18	15	56	4.8	4.0	0.85	3.7	0.08	0.05	0.13	7.5	2.5	15.8	57	64
Mbiama	20	14	66	64	5.1	4.2	0.82	3.6	0.15	0.08	0.10	7.0	2.7	9.8	66	60
Zarama	24	10	42	62	5.0	4.0	0.80	3.5	0.12	0.09	0.09	7.5	3.1	10.5	62	50

Fig. 2: Correlation of *I. wombolu* with soil chemical properties.

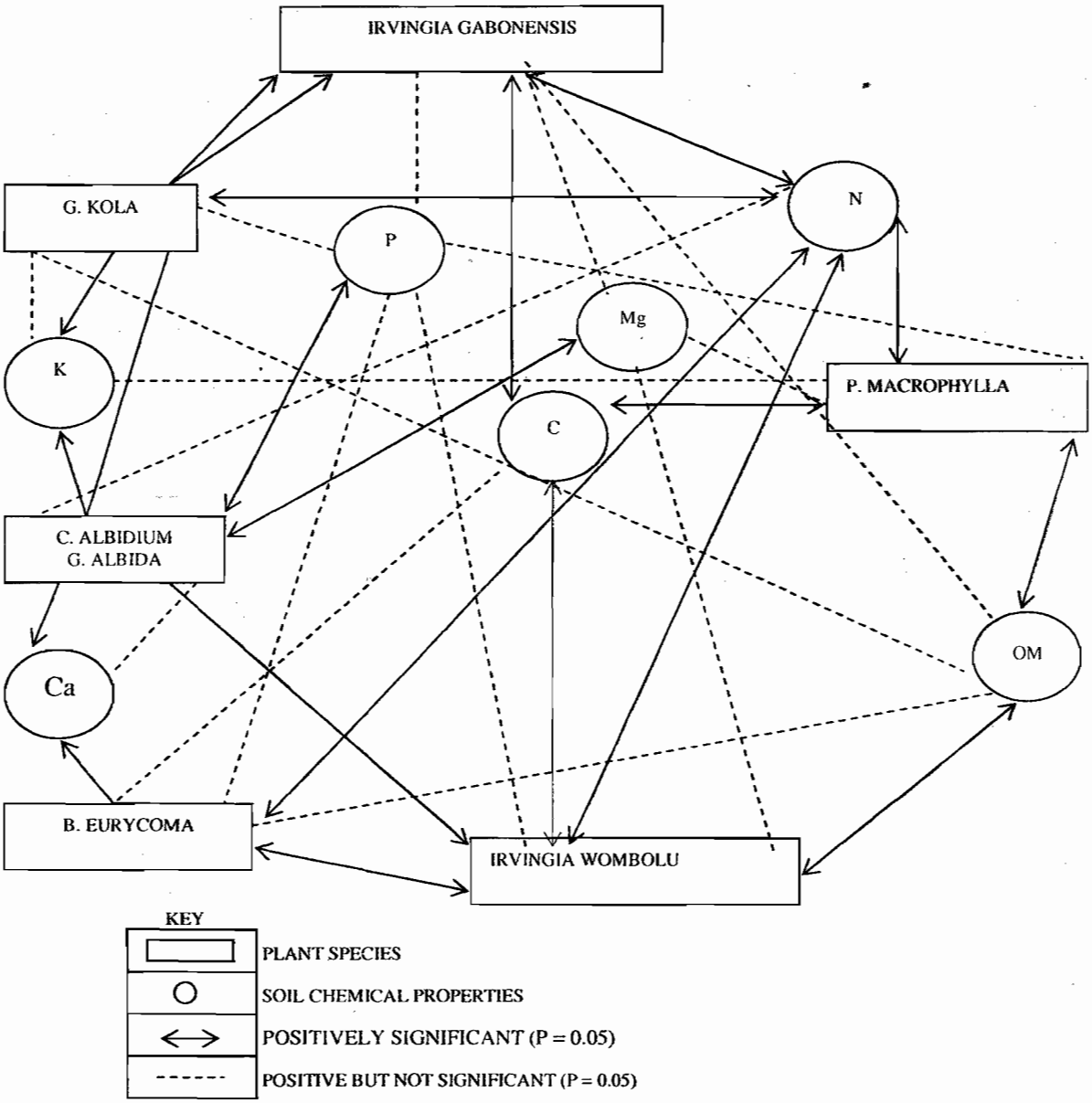


Fig . 3: Phenological sequence' of I. wombolu

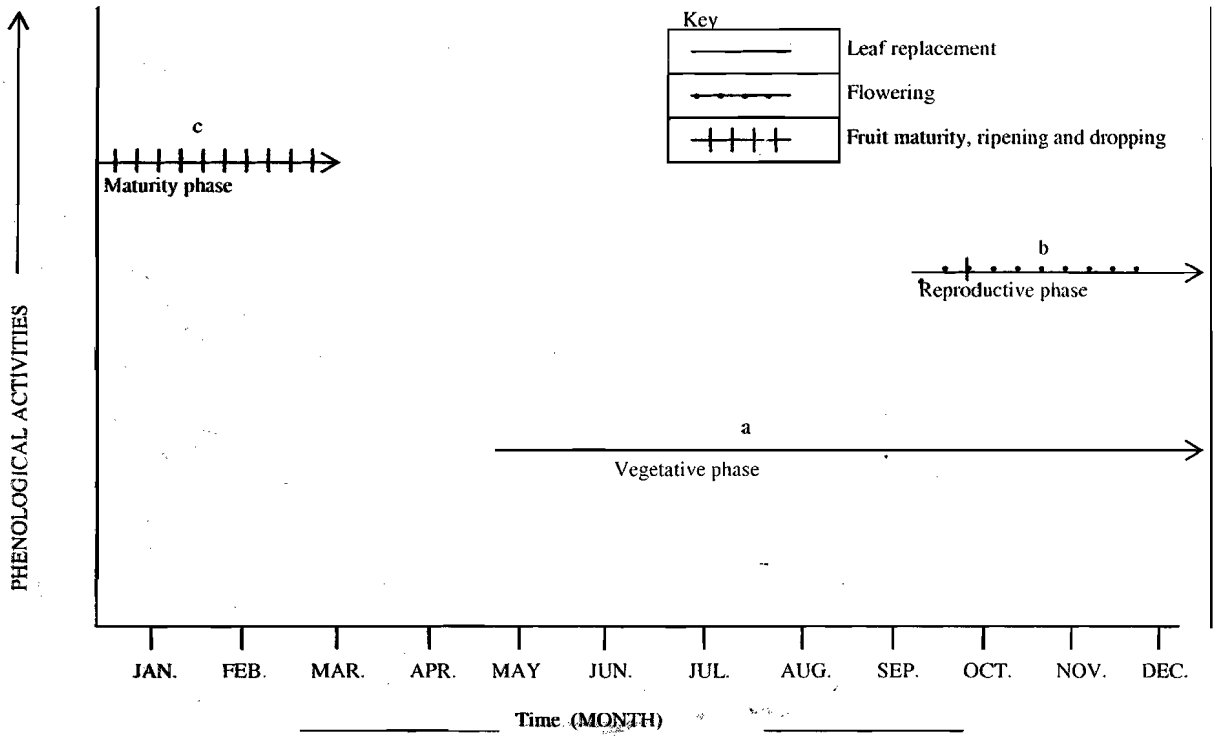


Fig. 3: gives the phenological sequences of *I. wombolu*, over a period of three years. The results show that leaf fall and leaf reformation on *I. wombolu* trees occurred simultaneously from December to May. It was observed that leaf fall starts from one branch of the tree and gradually spreads to other branches. As leaf fall spreads, the earlier defoliated branches starts forming new leaves. The results further showed that the trees flowered and fruited from October to December and the fruits mature, ripen and drop from January to March. It was also observed that in some trees where flowering and leaf formation occured at the same period, the flowers aborted while leaf formation continued. Fruiting pattern of the trees showed that a year of heavy fruiting alternated with that of little or no fruiting.

DISCUSSION AND SUMMARY

The generally very low densities obtained on the ten woody tree crop species (table 2): 0.3 – 2.7 trees/ha, were similar to that earlier reported(Okafor,1975). Okafor (1975) reported density of less than 3 trees/ha for five principal food tree crops (*I. gabonesis var. gabonesis, I. gabonesis, var. excelsa, T. africana, D. edulis,* and *P. macrophylla*) in the humid forest of Nigeria. The poor densities obtained in this study could be attributed to the disappearance of the forest, and the non-cultivation of the species as practiced for some timber and cash crop species. Myers (1989) reported that Nigeria is among the twelve nations whose deforestation rate accounts for over 80% of the global total. Okafor (1983) attributed the non- cultivation of the indigenous tree food crops to the late appreciation of the importance of their resources. Nzegbule and Mbakwe (2001) indicted the long period of the species seed dormancy and gestation.

The results of the association of the ten woody plant species (fig. 4), one species with the other show that *I. wombolu* has positive and significant relationship with *Pentaclethra macrophylla* and *Monodora myristica*. But positive and non-significant relationship with the other seven woody plant species. As reported on the association of plant species, one species with the other appears scarce. The results obtained in this study suggest that *I. wombolu* could possibly thrive well with *P. macrophylla* and *M. myristica* respectively in an agrofestry farm, producing wide range of fruits`. However, since other factors influencing plant growth and development in an agroforestry farm, except soil, were not investigated in this study, information given in this report appear to provide a bench mark for further investigations.

The very low densities, (0.0–4.2 trees/ha.), in the homestead and (0.9–6.5 trees/ha.) in the outlying farm of *I. wombolu* obtained in the study areas (table 3), agreed with Okafor (1983). The author reported density of 1.12 trees/ha., for the then two varieties of *Irvingia,* presently *I. wombolu* and *I. gabonensis*. The very low density obtained in this study suggests that the species is endangered and could be extinct if not conserved. The endangered state of the species can be better appreciated, when the results reported in this study (0.0-4.2trees/ha., homestead, and 0.9-6.5trees/ha., outlying farms) are compared with 204 tree/ha., and 100 trees/ha of the species in plantations established by adopting 7m. x 7m. and 10m. x 10m. spacing respectively. The results further implied that vigorous steps should be taken to conserve the species, in order to ensure its sustainability and full exploitation through biotechnological intervention. Despite the generally low density, the results show that the species density varied from one town to the other and also within the farming zones. The differences in the occurrence of the species in the areas studied appear to conform with the values the people attached to the resources (kernels) of *Irvingia wombolu*. The crop species abound in areas where their resources are highly valued than in areas that have little regards for the resources (Williams, 1976; Hillig and Lezzani, 1988). Information obtained during the enumeration survey and ethnobotanical interviews held with *I. wombolu* owners showed that Umuozu and Enugu-Ezike generate substantial revenue by selling the species kernels. It was further observed that in these two towns Umuozu and Enugu-Ezike, various measure were in place for protecting the trees of the species in both farming zones. Such measures include, ownership, penalties for fruit poachers, *I. wombolu* tree fellers, and customary laws for protecting trees on communal plots of land. It appeared that these protective measures were responsible for the relatively high density of the species in Enugu-Ezike and Umuozu. The results (table 3), show that the species occurred more in the outlying farms (mean, 1.62 trees/ha), than in the homestead farms, (mean, 1.30 trees/ha). The results agree with Okafor (1983), who described *I. wombolu* as a forest species.

The results of the soil sample analysis showed that soils from different locations were heterogeneous, and varied in their physical and chemical properties. The results of the relationship between plant species and soil chemical properties (fig. 2); showed that *I. wombolu* had positive and significant relationship with soil Organic matter, Nitrogen, Potassium, Calcium and Carbon. The results implied that *I. wombolu* can thrive in soil containing good amount of these soil chemical nutrients. Reports on the association between *I. wombolu* and soil chemical properties appear scarce. Okafor (1983) reported that the species thrives well in well-drained, upland, loamy soil. It is likely that the availability of the chemical nutrients could be adequate in the environmental conditions reported by Okafor (1983). The results further showed that outlying farmland with appreciably higher density of the species also had higher percentages of these soil chemical nutrients (table 4a and 4b). This may be due to; slash-and-burn farming activities, decay of woody biomass and the symbiotic activities of soil microorganism, which are more prevalent in the outlying farmland than in the homestead farmland.It is probable that some stands of the tree had to give way to other domestic crops and constructions around homesteads.

Results of the observations on the phenology of *I. wombolu* (fig. 3) show that the species leaf loss and leaf formation occur simultaneously, without the tree being leafless at any period. The results implied that *I. wombolu* is a semideciduous species. The results also showed that leaf fall occurs before the tree's reproductive phase: flowering and fruiting. The results suggest an adaptive strategy for nutrient mobilization. It appears that the large quantity of leaves lost by the trees in the dry season. December – April, may create a mulching mat of leaves for the trees and these decay during the rainy season, June – November, to provide nutrients to the plants for subsequent flowering and fruiting. The observed period of flowering and fruiting, October – December and the period of fruit availability, January – March, agreed with the reports of earlier workers (Okafor, 1975; Harris, 1996, and Tchoundjeu *et al* 2005). The results implied that *I. wombolu* trees flower and fruit once in a year. The results further show that mature ripe fruits drop from the trees from January to March. The results agreed with earlier workers (Okafor, 1983, Harris, 1996). The implication of the results is that the fruits of the plant needed for propagating the species can be collected within January to March.

In summary, the study has shown that *I. wombolu* is endangered and that vigorous conservation measures are needed to ensure its sustainance and full exploitation. The study further established that the species requires soil rich in soil Organic matter, Nitrogen, Potassium, Calcium and Carbon for healthy growth and development.

REFERENCES

Achinewhu, C. S. Ogbonna, C. C. and Hart, A. D. (1995). Chemical Composition of Indigenous Wild Herbs, Fruits, Leafy Vegetable Used as Food: *Plant Human Nutrition 48*:341-348.

Ejiofor, M. A. N. and Okafor, J. C., (1997). Prospects for Commercial Exploitation of Nigerian Indigenous Trees, Vegetables, Fruits and Seeds through Food and Industrial Products Formulation. *The International Tree Crop Journal 9*: 119 – 129.

Ejiofor, M. A. N., Okonkwo, S. N and Okafor, J. C. (1987). Developing Improved Methods of Processing and Utilization of Kernels of *Irvingia gabonensis* var. *gabonensis*. *The International Tree Crop Journal 4:* 283 – 290.

Harris, D. J. (1996). A Revision of the Irvingiaceae in Africa. *Bulletin Jard Bot Belg. 65*: 143 – 196.

Hillig, K. W. and Lezzani, A. F. (1988). Multivariate Analysis of a Soar Cherry Germplasm Collection. *Journal of American Society of Horticultural Science 113*: 928 – 934.

Hutchenson, J. and Daiziel, J. M (1963). *Flora of West Tropical Africa* vol. II Crown Agent for Oversea Govts and Administration. Millbank. London, 544pp.

Isichei, A. O. (2005). The Role of Plant Resources in Nigeria's Economic Recovery Agenda. *Nigerian Journal of Botany.. 18*: 1 – 22.

Keay, A. W. J., Onochie, C. T. A. and Stanford, O. (1964). Irvingiaceae. In: *Nigerian Trees*. Vol. II Department of Forest Research, Ibadan, 495pp.

Myers, N. (1989). Deforestation Rates In Tropical Forest and Their Climatic Implication. *Friends of the Earth*. London: 6 – 8.

Nzegbule, E. and Mbakwe, Roy (2001). Effect of Pre-sowing and Incubation Treatment on Germination of *Garcinia kola* Seeds. *Fruits.. 56 (6):* 437 – 442.

Nzekwe, U., Ojieifo, I. M. and Emuh, F. N. (In Press). Assessment of Kernel Economic Yield of *Irvingia gabonensis* (wildmango) in South Eastern Nigeria. *The Nigerian Journal of Research and Production..* 7 (4): (Accepted for Pub.,2005)

Okafor, J. C. (1983). Horticultural Promising Indigenous Wild Plant Species of Nigerian Forest Zone. *Acta Horticulturalis. 123*: 185 – 196.

Okafor, J. C. (1975). Varital Delimitation in *Irvingia gabonensis* (Irvingiaceae) *Bull Jard. Nut. Belg. 45*: 211 – 221.

Tchoundjeu, Z., Atangana, A. R. and Degrade, A. (2005). Indigenous Method in Preserving Bushmango Kernel In Cameroon. *American Journal of Applied Science 2, 9:* 1337 – 1342.

Usman, S. S. (1990). Ecological studies of Opi Lake Savan Woodland. Ph.D Thesis, Dept: of Botany, University of Nigeria Nsukka. 162PP.

William, W. T. (1976). *Pattern Analysis in Agricultural Science*. Elsevier Sci. NY. 372pp.