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RELATIONSHIPS BETWEEN FRUITS AND SEED SIZES, GERMINATION AND EARLY SEEDLING GROWTH OF SOME EDIBLE PLANT SPECIES IN SOUTHEASTERN NIGERIAN RAINFOREST

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ABSTRACT

Relationships between fruits and seeds sizes; seed germination and early seedling growth of seedlings of 25 plant species were studied at the University of Agriculture, Umudike, Nigeria. The destruction of Nigeria rainforest without an assured method of naturally regenerating it, has contributed to some edible plant species being either fewer per hectare or endangered in abandoned farmlands. Fruits of 25 plant species were collected from the rainforest at Umudike, Nigeria. For each plant species 100 fruits and seeds were selected for the study. All the fruits contained between 1 and 30 seeds. The length, width and weight of fruits and seeds of the plant species varied within and between plant species. The biggest fruits were those of *Pentaclethra macrophylla* with length ranging of between 435.22 and 508.52 mm while the biggest seeds were those of *Plukernetia conophora* each had length range of between 60.39 and 98.14 mm.. The length and width of each fruit and seed were measured using Digimatic Mitutoyo caliper. For each fruit and seeds, the weight was measured using electric weighing balance, Ohaus Corporation, Model Scout Prospu 402. Broadcast of 100 seeds of each plant species was done on germination boxes of size 30 x 60 cm, and watered twice daily. All the viable seeds germinated, however, mechanical dormancy was observed in the fruits of *Spondias mombin*, *Tetrapleura tetraptera* and *Canarium schweinfurthii,* whose seeds were covered by fibrous material. There was no co-relationship between seed size and germination rate because both small and big seeds started germination within the same week. The observed seedling types were *Phanerocotylar* – epigeal – reserve, (52.9%), *Phanerocotylar* – epigeal – foliaceous (20%) and *Cryptocotylar – hypogeal* – reserve (12.0 %), Phenerocotylar – hypogeal – reserve (8) and Cryptocotylar-epigeal-reserve (8%). There was a significant different in the growth rate of seedlings of the plant species. The rate of growth of 0.05 m per month of seedlings of *Persea americana* and *Dacryodes edulis* was comparatively high presumably because of the food stored in the seed. The rate of growth of 0.001 m per month of *Dialium guineense* seedlings was very poor presumably because of the relatively small quantity of food stored in the seed. *Carpolobia lutea* produced numerous branches exhibiting shrubby characteristics. It is recommended that fruits should be collected from different provenances and their proximate composition analysed. Fruits having desirable qualities should be genetically improved.

KEYWORDS: Phanerocotylar – epigal – reserve, mechanical dormancy, fruits, genetic improvement.

INTRODUCTION

The Nigerian rainforest is made up of a complex mixture of woody plant species (Dike, 1992). The rainforest which occupied the southern part of the country and covered 13.6 per cent of the country's land area has been repeatedly reported as disappearing at alarming rates of between 2.99 and 4.01 per cent per annum (Okali, 1979; Okali and Fasehun, 1998; Okojie, 1998). The major causes of the disappearance of the rainforest, were due mainly to unplanned development projects, unsustainable farming systems, poverty and insufficient knowledge of the uses of most of the numerous plant species within the rainforest. Okafor, (1993) listed some plant species that were in the process of being lost. Presently, a total of 115 plant species of the rainforest, some monogeneric, have been listed as endangered (Oguntala *et al;* 2000). Meregini, (2005) also listed 30 plant species producing either edible fruits or seeds in southeastern Nigerian rainforest that were endangered. In Nigeria, degraded secondary forest regrowths of various ages occur in many rainforest areas which had been cleared, burnt and used for agricultural purposes (Okali, 1979; Dike, 2003). Regrowth in such a degraded forest consisted of over 39 per cent coppice shoots and sprouts from roots, and in their first few years of regrowth, many of these coppices, such as that of *Dialium guineense* rarely produced either flowers or many fruits as their parent plant before they were cut (Dike, 2003).

Previous silvicultural experiments such as the Group Method and Tropical Shelterwood System (Okali and Fashun, 1998) aimed at naturally regenerating the rainforest failed to achieve its aims, resulting in lack of an assured method of naturally regenerating the rainforest. Consequently, the distribution pattern and density per hectare of many edible fruit plants in the rainforest are therefore not certain. With over 1.4 per cent annual increase in Nigeria population (Madu, 2001), the demand for edible fruits for the production of drinks, jams and medicines to support the large population especially during the lean periods and dry

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season is high. Also, competition for these edible fruits arise between pharmaceutical industries (Kio and Gbile, 1978); people who supplement their traditional diets with these fruits and other wide users of fruit plants (Ayak *et al;* 1999). To meet the demand, there is the intensive search of fruits of these edible plants. Over-exploitation created scarcity of seeds for natural regeneration and consequently poor representation of the species per hectare. Fruits of many under utilized plant species which were not listed as being sold in many Nigerian markets (Okafor, 1981) are presently being sold at many market places and at competitive prices.

Through indigenous knowledge, the edible plant fruits and seeds have been known and used by some communities in overcoming food scarcity and nutritional deficiencies (Burkill, 1985; Okafor, 1991). For example, nutritional deficiencies in pregnant ladies could lead to malfunction of some vital organs of the unborn child. When the brain is implicated, such a deficiency would be very difficult to correct when the child has grow to adult hood (Omololu, 1974). Many people who know the uses of some edible plant species often lack proper knowledge of their germination and early seedling growth characters. As soon as the plant species they know of have died, it then becomes very difficult to replace them either in the forests or at home gardens. There is paucity of literature on fruit and seed sizes, seed germination and early seedling growth of some edible plant species. However, it has been observed that seeds of few edible plant species of *Dacryodes edulis, Gambeya albida* germinated under the parent tree (Dike, *et al*, 1997), and that of *Canarium schweinfurthii* are difficult to germinate (Okafor, 1981). Moreover, most of the tree seedlings of *Dacryodes edulis* under the mother tree hardly survive to bear fruits.

Okali and Onyeachusim, (1991) recorded that the germination of seeds of some plant species having intermediate germination could be prolonged beyond 84 days. However, they observed that some plant species having rapid germination could complete germination before 84 days. It is, therefore, difficult and costly to germinate seeds within three weeks, without adequate seed treatment. Moreover, fruits of some edible plant species such as *Gambeya albida* and *Dialium guineense* are produced periodically and their seeds remained viable for only few months (Ng, 1980; Dike, 2001). Furthermore, seedlings of plant species having resinous bark such as *Dacryodes edulis* are difficult to bud (Okafor, 1977). There is the need to germinate the seeds of edible plant species, plant and maintain their seedlings in plantations and homestead to meet the demand from industries and people who require these fruits and seeds. This paper reports the relationship between fruit and seed sizes, seed germination and early seedling growth of some edible plant species of southeastern Nigeria rainforest. It would provide additional information to industrialists; nutritionists, researchers and farmers willing to establish these seedlings either at home gardens or distant farmers for both raw material production and local consumption.

MATERIALS AND METHOD

Study Area

The study area is the 5 – ha rainforest situated at the University of Agriculture, Umudike, Nigeria and the nearby forests. Umudike lies between latitudes $05^0 27^1$ and $05^0 32^1$N and longitudes $07^0 30^1$ and $07^0 50^1$E. The climate is of the equatorial type. The minimum and maximum topsoil temperatures are 16 and 45^0C, respectively. There are two season: the wet and dry seasons. The wet season starts from mid –March and ends in mid-November. The dry season continues till the mid-March of the following year. The dry and dusty harmattan wind from Sahara desert blows intermittently in the months of December and January. These two months have the least total monthly rainfall of less than 40 mm per month. Each year, there are two peaks in rainfall in the months of June/July and September. The total annual rainfall ranges between 1500 and 3000 mm. During the peak of the dry season, the relative humidity was above 60 percent at 0500 GMT but fluctuated between 40 and 70 percent between 1250 and 1430 GMT. After 1430 GMT, the humidity rises and would decrease again from 0630 GMT of the following day (Dike, 1992). The relative humidity is often above 60 per cent during the wet season and fluctuations are low except between 1100 and 1230 GMT; then at night, it ranges between 60 and 98 per cent.

The vegetation is tropical rainforest (Onochie, 1979; White, 1983). The original rainforest has been logged. In most places outside forest reserves, the primary rainforest vegetation has been cleared and burnt. Some of the areas have been put into several other uses outside forestry. Presently, many land areas, even within many forest reserves are land capable of bearing forest but in various stages of degradation. Farmers rarely preserve tree seedlings listed as economic (Lancaster, 1961; Gbile, 1984) in their farmlands (Dike, 2003). The most abundant trees species are *Alchornea cordifolia, Anthonotha macrophylla, Dactyladenia barteri, Dialium guineense, Elaeis guineensis, Pentaclethra macrophylla* and *Piptadeniastrum africanum*. Some plant species such as *Chromolaena odorata* and *Raphia hookeri* are locally abundant. Umudike lies at an altitude of between 120 and 130 m. There are no mountains and plateaux. The topography is gentle. In most places, the slope ranges between one and three degrees except at few sources of streams where the gradient ranges between four and ten degrees. According to the Federal Department of Agriculture and Land Resources (FDALAR, 1990), Umudike has both well-drained sandy clay loam and sandy clay. The soil parent material is the Pre-Cambrain Basement Complex. The people are farmers, traders and civil servants. Farming is done manually, and in most communities, a group of people would clear and burn a large area greater than 500 hectares, for cultivation. While the following year another area would also be selected by the same group. Presently, the fallow period on the same piece of land takes five years. Within that period, some coppice shoots and seedlings of *Canarium schweinfurthii* and *Entandrophragma utile* do not produced fruits for regeneration.

METHODOLOGY

The 25 plant species studied are *Afzelia africana, Anacardium occidentale, Brachystegia eurycoma, Canarium schweinfurthii, Carpolobia lutea, Cola acuminata, Cola nitida, Dacryodes edulis, Dennettia tripetala, Detarium macrocarpum, Dialium guineense, Gambeya albida (Syn. Chrysophyllum albidium), Garcinia kola, Irvingia gabonensis, Landolphia dulcis, Monodora myristica; Myrianthus arboreus, Parkia biglobosa, Pentaclethra macrophylla, Persea americana, Spondias mombin, Plukernetia conophora, Tetrapleura tetraptera, Uvaria chamae* and *Xylopia aethiopica*. A reconnaissance survey was carried out to locate the fruit bearing individual plant species within the 5 – ha rainforest. For each plant species, a total of 100 mature fruits were collected, separately marked, numbered and put in a tagged polythene bag. These bags were transported to the Ecological Centre of the University, where the length and width of 100 fruits and 100 seeds of each plant species were measured along the largest axis using Digimatic Mitutoyo, Japan Caliper, Model CD -6" M number 500 – 424. A total of 50 fruits of each plant was depulped and the number of seeds in them counted, washed with water and broadcast on a germination box containing saw dust. Another 10 seeds of each plant species were broadcast in Petri dishes containing cotton wool.

Each germinated seed was transplanted in a polythene bag containing an equal mixture of top forest soil and poultry manure. Watering was done every morning and evening. The height growth per month of each seedling was measured every 30 days using Digimatic Caliper for 120 days. The seedling types were grouped into five viz: *Phanerocotylar* – epigeal – foliaceaous, Phanerocotylar – epigeal reserve, Phenerocotylar – hypgeal-reserve. Cryptocotylar-epigeal reserve and *Cryptocotylar – hypogeal* – reserve, as described by Garwood (1996) and Hladik and Mitja, (1996). Analysis of the monthly growth rate was done using Completely Randomized Block Design to test if there were significant differences between the growth rate of plant species seedlings with time.

RESULT AND DISCUSSIONS

The length and width of fruits and seeds varied within and between both plant families and species. The bigger types of fruits were those of *Monodora myristica, Pentaclethra macrophylla,* and *Tetrapleura tetraptera* with a length range of between 116.30 – 215.27, 435.22 – 508.52 and 106.34 -223.01 mm respectively, while the smaller sizes of fruits were those of *Carpolobia lutea* and *Dialium guineense* with fruit length ranging from 7.62 – 15.95 and 9.61 – 13.47 mm respectively. The biggest seeds were those of *Persea americana* with seed length range of between 53.36 and 61.13 mm. The smallest seeds were those of *Xylopia aethiopica* with seed length range of between 3.20 and 3.52 mm. Foster, (1986) had observed big and small seeds and attributed big seeds to plant species that established under shade while small seed were pioneers (Swaine and Whitmore, 1988). It was observed that 40 per cent of the studied plant species have more than 4 seed per fruit and presumably are multi-ovulated (Uma Shaanker and Ganeshaiah, 1990). In some of these fruits such as those of *Spondias mombin*, it was mainly one developed and viable seed per fruit that was found while the other four seeds were not developed. In *Carpolobia lutea,* (Plate 1) the length and width of seeds produced from fruits having only one viable seed were longer and wider than that of *Carpolobia lutea* whose seeds were developed. The variations in the sizes of fruits and seeds were presumably due to the fertility of the soil, the season of the year, the pollen grain deposition patterns and the health of the plant. In this study, it was observed that plants growing at infertile soil produced relatively small sized fruits while those growing at very fertile soil produced few small, many medium and big fruits. Many fruits were relatively big during the wet season, when excess water was available for plants. In this study it was observed that most of the twigs bearing the flowers of *Spondias mombin* and *Carpolobia lutea* were drooping. Although Burrows, (1975) described the primary trajectories of pollen dispersal in unsteady winds, yet gravity has a lot of influence on pollen especially at the usual wind speed of less than 3.0 ms^{-1} often recorded at height between 0.50 and 20 m above the ground, within the close forest canopy of the rainforest (Dike, 1992). Enough pollen grains might not be deposited on the mature stigma resulting in few seeds being developed. Presumably, stigmatic regulation of pollen grain germination (Uma Shaanker and Ganeshaiah, 1990) could occur in some of these plants such as *Spondias mombin* where fruits were developed but in many cases viable seeds were absent. A similar report has been made of *Lecucaena leucocephala* and *Moringa oliofolia* where pods with few seeds were produced by these plants as a result of poor pollen grain deposition on the stigma (Ganeshaiah and Uma Shaanker, 1988). It was observed that each fruit of *Spondias mombin* had over 60 per cent of its seed undeveloped or absent. While *Gambeya albida* often had 25 per cent of it's seeds undeveloped. The size of fruits of *Canarium schweinfurthii* from a particular tree was not significantly different. For some plant species such as *Gambeya albidia, Monodora myristica* and *Spondias mombin* deviations between the tree species mean length or width were not significantly different. (Table 1).

Plate 1: *Carpolobia lutea* plant having some fruits

Table 1: Sizes and weights of fruits and seeds germination types of some rainforest plants of Nigeria.

		Germination type	Edible part of plant fruit and seed	Range of fruit		Range of Seed		Observed number of seeds per fruit	Range of weight of a seed (g)	Range of weight of a fruit (g)
				Length (mm)	Width (mm)	Length (mm)	Width(mm)			
Anacardiaceae	*Anacardium occidentale*	CER	Fruit, seed cotyledons	42.49 – 63.93	34.45 - 42.91	29.66-32.92	12.72-19.65	1	5.21-7.88	30.41-70.82
	Spondias mombin	PEF	Fruit meso and endocarps	22.42-34.68	15.01-22.64	20.63-20.11	13.14-17.81	5	1.24-3.26	3.36-7.06
Annonaceae	*Dennettia tripetala*	PER	Whole fruit and seed	15.56–27.55	12.99– 14.22	10.80-11.65	5.81 - 8.50	2-14	0.21-0.58	4.25-7.02
	Monodora myristica	PER	Seed meso and endocarps	116.30-215.27	110.06-115.10	15.40-19.86	9.02 - 12.70	10-67	0.56-0.79	217.10-311.49
	Uvaria chamae	PER	Fruit meso and endocarps	11.95-53.91	10.71– 13.71	8.13-10.44	4.95 - 6.28	14-21	0.09-0.12	1.21-7.52
	Xylopia aethiopica	PER	Whole fruit and seeds	40.12-50.14	4.13 - 4.94	3.91-4.85	3.20 – 3.52	4-18	0.01-0.04	0.63-0.89
Apocynaceae	*Landolphia dulcis*	CHR	Fruit meso and endocarps	54.80-87.45	26.59-34.39	12.06-15.68	9.40-11.35	6-8	0.34-0.89	10.01-13.04
Burseraceae	*Canarium schweinfurthii*	PER	Fruit ecto, meso and endocarps	9.49 - 13.49	7.09 – 12.03	5.88 -6.76	1.53 - 3.11	1	1.08-3.09	4.04-6.90
	Dacryodes edulis	PER	Fruit ecto, meso and endocarps	63.27 - 68.75	26.02– 28.45	33.13 -43.37	15.00-18.83	1	14.74-18.92	14.76-81.41
Caesalpinaceae	*Afzelia Africana*	PER	Seed meso and endocarps			17.38-31.53	7.95 – 15.94	2-13	3.01-3.36	
	Brachystegia eurycoma	PER	Seed meso and endocarps			15.69-21.83	14.82-17.77	2-7	0.59-0.73	
	Detarium microcarpum	PER	Seed meso and endocarps	27.77 - 46.36	25.48-31.96	25.48-31.96	19.61-24.85	1	3.61-5.99	
	Dialium guineense	PER	Fruit meso and endocarps	7.62 – 15.95	7.62 – 12.92	5.43-8.56	3.13-3.74	1	0.12 - 0.24	0.35 - 0.83
Euphorbiaceae	*Plukernetia conophora*	CER	Seed meso and endocarps	134.03 – 142.71	72.32-88.71	60.39-98.14	50.07-67.60	1-4	17.17-24.31	70.25-202.49
	Myrianthus arboreus	CHR	Seed meso and endocarps	98.00 – 112.94	70.43-86.02	13.02-16.40	7.33-10.80	72-91	0.41 - 0.72	239.66-260.77
Guttiferae	*Garcinia kola*	CHR	Fruit meso and ectocarps. Seed meso and endocarps	69.04 – 73.85	67.36-69.85	18.49-43.32	13.16-10.80	1-4	5.78 - 8.67	57.94 - 87.27
Irvingiaceae	*Irvingia gabonensis*	PER	Fruit meso and ectocarps; seed meso and ectocarps	57.95 – 66.66	55.60-63.27	44.13-49.13	26.47-34.05	1-2	11.31–17.48	91.48-149.06
Lauraceae	*Persea Americana*	CHR	Fruit meso and endocarps	83.46 - 96.41	80.06-83.81	53.36-61.13	43.95-59.76	1	50.40-60.09	246.07-272.78
Mimosaceae	*Parkia biglobosa*	PER	Seed meso and endocarps	139.76– 223.01	13.52 -20.19	7.50-9.37	6.31-7.57	5-23	0.18-0.23	10.94 -24.74
	Pentaclethra macrophylla	CHR	Seed meso and endocarps	435.22-508.52	70.97-78.21	36.06-80.82	30.31-47.90	2-14	10.46 -14.34	347.29-511.59
	Tetrapleura tetraptetra	PER	Fruit dispersal appendage	106.34-223.01	26.19-56.63	8.16-10.08	5.69-7.30	11-21	0.12 - 0.14	45.03 – 83.04
Polygalaceae	*Carpolobia lutea*	PEF	Fruit ecto, meso and endocarps	9.61-13.47	9.56-11.25	3.78-5.97	4.75-4.77	1-4	0.36 – 0.39	1.04 – 2.94
Sapotaceae	*Gambeya albida*	PEF	Fruit meso and endocarps	47.64 - 61.81	44.92-48.02	25.02-28.89	12.85-17.39	5	2.53 – 2.95	56.39 - 64.49
Sterculiaceae	*Cola acuminate*	CHR	Seed meso and endocarps	102.72 –150.97	32.01-58.98	31.89-34.61	26.01-36.04	1-5	16.62–35.09	90.12-285.15
	Cola nitida	CHR	Seed meso and endocarps	66.43-158.87	51.51-99.86	30.25-43.68	21.00-36.75	1-10	19.89-32.09	102.68-288.83

All the germinated seeds revealed five seedling types: *Cryptocotylar-hypogeal* reserve, (12.0%). *Phanerocotylar–epigeal*-reserve,(52.0%). *Phanerocotylar – epigeal foliaceous* (20.0%), Phenerocotylar-hypogeal reserves (8.0%); and Cryptocotylar-epigeal-reserve (8.0%) (Plate 2). The time taken by a plumule and a ridicule of these plant species to emerged varied within and between plant species. It was observed that the plumule and radicule emerged between 10 and 24 days after broadcast in *Afzelia africana; Carpolobia lutea; Gambeya albida* and *Persea americana.* The germination pattern agreed with the rapid germination as described by Okali and Onyeachusim, (1991). It was observed that mature and ripened fruits of *Dacryodes edulis* had both growing plumule and radicle. In the fruits of *Canarium schweinfurthii; Spondias mombin* and *Tetrapleura tetraptera* some of the seeds germinated within 15 and 200 days after broadcast. Each fruit of *Canarium schweinfurthii* has a seed whose cotyledons were covered by hard and fused material. A fruit of *Spondias mombin* had five seeds that were covered by fibrous material. A fruit of *Tetrapleura tetraptera* had between 11 and 21 black seeds which were covered with hard fibrous material. In this study, it was observed that when the seeds were separated from the fruit and broadcast made, germination occurred within 9 and 24 days. A similar observation was reported for some Malaysian woody plants, (Ng, 1980) and some Nigerian trees (Okali and Onyeachusim, 1991). Moreover, physiological dormancy has been described for conifers and few angiosperms (Baskin and Baskin, 2004). Foster (1986) suggested that big seeds might have more nutrients to accommodate metabolic requirements during dormancy period.

Plate 2: Germinating seeds of (i) *Plukernatia conophora* (ii) *Irvingia gabonensis* (iii) *Cola acuminate* (iv) *Myrianthus arboreus* and *Garcinia kola* at Umudike, Nigeria.

The weight of fruits varied within and between plant species and families (Table 1); Plate 3. The weight of seed varied. The range of seed weight was from 0.01 to 2.80 g. Foster and Janson (1985) reported seeds of tropical moist forest trees seed weighing between 0.001g and 100.0g but Foster, (1986) observed that seeds of lowland tropical rainforest pioneer and climax tree species had a mean weight of between 0.139 and 8.20g, respectively. Within the period of the study, *Dacryodes edulis, Persea americana* and *Gambeya albida* seedlings had the growth rate of 0.01m, 0.03 m and 0.05 m per month, respectively. The fast growth rates were attributed to the large quantity of food stored in their seedlings. The least growth rate was obtained in *Dialium guineense* seedlings. It took 200 days for *Dialium guineense* seedlings to grow 0.5 centimeter. In all other species the growth rate were slow after germination. It was observed that after 68 days after transplanting, the growth rate increased in most tree species. Seedlings of *Carpolobia lutea* have already exhibited shrubby characters.

(i)

(ii)

(iii)

Plate 3: Various sizes of fruits of (i) *Garcinia Kola,* (ii) *Landolphia dulcis* and (iii) *Myrianthus arboreus* from Umudike, Nigeria.

CONCLUSION AND RECOMMENDATION

The plant species were collected mainly from the wild and Okafor (1981) had described their distribution. However, for these plant species there is paucity of literature on the selection of the provenances that had larger fruits and seeds. Little work has also been done on the genetic improvement of the sizes of both the fruits and seeds. The paucity of literature on the genetic improvement could have resulted in the variations in sizes of the fruits and seeds. It is recommended that genetic improvement on the sizes, and quality of fruits and seeds should be done to enable industrialists to be more interested in the species. Generally, improved species should be raised at the Department of Forestry and Environmental Management Nursery. These should be distributed freely to farmers willing to establish these seedlings in their farms. The interest by industrialists would enable more attention and studies on these plants species and to minimize their being listed as rare or lost.

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