SEEDLING PRODUCTION SYSTEMS FOR DIKA NUT (*Irvingea gabonensis)* ORCHARD ESTABLISHMENT IN THE RAINFOREST AGROECOLOGY SOUTH-EASTERN NIGERIA.

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Abstract
The seeds of dika nut (*Irvingea gabonensis*) were germinated in five nursery media (topsoil, sawdust, topsoil/sawdust mix, sawdust-on–topsoil) in 50:50 arrangement and control (standard nursery medium 3:2:1). These nursery media were exposed to four nursery shade intensity cubicles (0-30, 40 – 60 and 70 – 90%) respectively monitored with megatron light meter. Polybags were filled and arranged on treatment basis. One seed of dika nut was sown for treatment in polybag. There were five polybags per treatment and arranged in completely randomized design. The shaded seedlings were allowed the usual four (4) weeks phasal vernalization before field transplanting. Sawdust and sawdust-on-topsoil accelerated early germination (14 DAS of weeks) dika nut seeds nursery media irrespective of the shade intensity. Shading aggravated severe fungal disease infestation (*Aspergillus flavus)* and seedling mortality (>20.0%) especially when the seeds were sown in topsoil. At field transplanting, most shaded seedlings (30-90%) died back (100%) re-flushed late (33days), reduced field establishment (60%) and delayed (10.0years) maturity. Seedlings raised in low (0-30%) shade and in full light exposures were vigorous and had maximum (>75%) field establishment, matured early (4-5years) and produced heavy fruit yields (308 kg ha $^{-1}$). Most seedling raised under heavy shade (70-90%) failed to establish (680%), the few survivors matured late (6-10yrs) and produced poor fruit yields (116 kg ha^{-1}). For successful dika nut orchard establishment and high productivity in Southeastern Nigeria, quality seedlings of dika nut nurtured in sawdust or sawdust-on-top soil nursery medium and exposed to full light or low shade (0– 30%) is the advocated the production system.
Keywords: Irvingea, nursery, seedling production orchard establishment, yield.

Introduction

The alarming rate of deforestation powered by high population growth rate (3.6%) accelerated urban and infrastructural development, industrialization, rural electrification etc has advanced without commensurate reforestation. The result is indiscriminate destruction of crop genetic resources and soil erosion with over 46 active gully erosion sites in southeastern Nigeria alone. The scenario has therefore evolved whereby some previously classified wild or protected crop plants of ethnobotanical importance are now endangered or extinct species (Obiefuna and Ezedinma, 1986).

Most tree crops, dika nut (*Irvingea gabonensis*) inclusive, are major sources of livelihood, food security, bioconservation and poverty alleviation strategy for most Nigerians in Southeastern agroecology (Okafor, 1980), dika nut stands out clearly among numerous fruits for its dietary, nutritional, socio-cultural and economic contributions (Okafor and Okolo 1974, Uzo 1980, Njoku 1986).

These known socio-economic potentials, needs and services (Okafor, 1973, Njoku, 1986). Dika nut has been neglected in priority agricultural research and development. As an economic multipurpose plantation crop with superior investment returns at optimum production than cocoa, rubber and oil palm (Njoku, 1986), comprehensive production package for dika nut is a priority. Perhaps, the near absence of skilled pomologists of tropical fruits and plantation crops to enhance research on the appropriate domestication techniques and orchard management systems is the major constraint in indigenous fruit tree crops development in Nigeria. The national awareness of the economic resource base of the hitherto neglected indigenous crops including dika nut (Njoku, 1986) resulted in a high demand for the improved production package and product utilization technologies as already available for the exotic popular plantation crops as oil palm, cocoa, rubber, citrus which are grown extensively in the same rainforest agroecology. Development of indigenous fruit tree orchards was the advocated alternative with (*Irvingea species) (gabonensis and wombulu*) as top priority. (Okigbo, 1983). Dika nut is presently propagated by seed. Dika nut seed is both the edible product and propagule. Furthermore, dika nut fruit matures at the peak of rainy season (June-August) unfavourable for seed germination due to high humidity and disease incidence. Naturally, the regenerants are few in the natural humid tropical rainforest, characterized by restricted light penetration, high humidity and fungal diseases (Uzo, 1980). By implication, the eco-physiological factors including light intensity, relative humidity and fungal incidence are impediments to natural regeneration of dika nut (Obiefuna and Onwueme, 1986). Thus, dika nut has degenerated from semi-wild to endangered species status (Obiefuna and Ezedinma,1980). The production of quality propagules as already achieved for plantain and other exotic plantation crops in the ecozone (Ndubizu and Obiefuna, 1983; Baiyeri and Ndubizu, 1994; Baiyeri,

2003; Okafor, 1973) is fundamentally crucial in sustainable dika nut orchard development. Such development involves appropriate nursery media and management (Peter-Onoh *et al.,* 2014). This paper assessed the efficacy of different growth media under graded shade intensity in the nursery as crucial eco-physiological factors in the dika nut seed germination, seedling quality and orchard establishment and sustainable yields in the rainforest agroecology of southeastern Nigeria.

Materials and Method

Mature fruits of dika nut were harvested in June 2004 from the Federal University of Technology dika nut orchard, Owerri. The fruits were depulped. The seeds were dried for 24 hours under a lath shade. Unviable seeds were eliminated by floatation technique.

Three shade cubes ($4.0m^2$) were constructed with bamboo frames and covered with different quantities of palm fronds to provide four shade ranges (unshaded) control 0, light shading 0-30, moderate shading 30-60 and heavy shading 60-90%, respectively. The light was monitored with megatron light metre. Five germination media (topsoil, sawdust, sawdust topsoil mix, sawdust-on- topsoil in depth arrangement (lower ½ of polybag filled with topsoil while the upper ½ is filled with sawdust) and standard fruit tree nursery mixture (topsoil, organic manure and river sand (2:1:1 by volume) were prepared. Each medium was filled into the 30 x 40cm (layflat) black perforated polyethylene bags (polybags). A total of 600 bags consisting of 120 of each medium was further arranged into 40 lots for each of the shaded and unshaded exposures. Ten (10) polybags constituted the experimental sample. The 4 x 5 factorial experiment was laid in a randomize complete block design of four replicates in the nursery.

The minimum and maximum ambient temperatures and percentage relative humidity at the nursery floor of each cube and control were measured. The media in polybags were watered to capacity using the capillary technique. Five seeds were sown in each polybag. Each seedling was fertilized five weeks after planting with 10g NPK 15:15:15 in the nursery and routinely watered once daily. Percentage seed emergence and seedling growth parameters in each treatment were recorded and analysed.

The disease severity was scored on a scale of 1–5. In April, 2005 the shaded seedlings were allowed phased 4 weeks vernalisation. In May 2005, 60 vigorous seedlings raised from each treatment (shaded and unshaded media) were transplanted with ball of earth to the prepared orchard. The seedlings and spaced 10 x 8.0m. In the field, the 5 x 4 factorial experiment was laid in a randomized complete block design of three replicates with three trees per replicate.

Thereafter, the transplant received 200g NPK 15:15:15 annually in two equal splits in May and September respectively. The orchard was weeded four times annually till maturity. Growth and first fruit yield data of dika nut were statistically analysed for significance, using genostat 20.88 discovery version and reported.

Results and Discussion

Shade significantly ($P<0.05$) increased the ambient humidity and reduced temperature. Nursery shade intensity and growth media affected the seedling emergence disease severity and growth in dika nut (Table 1). Seedling emergence from unshaded media (control) was rapid (14-15 DAS) and resulted in improved orchard establishment of high (95-100%). Seeds sown in other media except sawdust or sawdust-on-topsoil and exposed to 30-90% shading emerged late. Seedlings emerged least in topsoil medium through percentage emergence improved as shading intensity decreased. The seedling rot disease severity caused by *Aspergillus flavus*, was most severe (21.90%) among seedlings raised in heavily shaded (70-90%) topsoil media and least in exposed (unshaded) media. Seedling mortality was consistently low in seedlings raised in sawdust arranged indepth with topsoil and exposedto 0-60% shade. Heavy shade (70-90%) aggravated seedling mortality (20.0%) in other nursery media but significantly ($P<0.5$) reduced when these media were unshaded in the nursery.

Shade intensity %	Media	Days to 50% emergence	Seedling emergence (%)	Disease severity (%)	Seedling mortality (%)	Humidity% Temperature% within cubicle
70 – 90	Nursery mixture Topsoil	18.65	86.50	8.45	19.36	85-90% 20-22^{0}C
	Sawdust	21.81	58.46	48.45	28.08	
	Sawdust/	14.62	95.04	18.60	22.04	
	Topsoil mix	18.28	82.02	18.24	18.60	
	Sawdust- on-topsoil	14.80	96.22	16.06	15.48	
Mean		**17.63**	**83.65**	**21.96**	**20.71**	
40 – 60	Nursery mixture Topsoil	16.44	92.04	5.24	6.45	75-85% 25-28^{0}C
	Sawdust	20.62	69.68	12.82	12.06	
	Sawdust/	14.46	90.16	8.43	8.24	
	Topsoil mix	16.82	92.84	12.91	8.06	
	Sawdust-on - topsoil	14.44	98.80	8.63	3.62	
Mean		**16.56**	**88.70**	**9.61**	**7.69**	
10 – 30	Nursery mixture Topsoil	18.42	92.60	8.64	5.42	70-80% 28-30^{0}C
	Sawdust	18.40	74.55	8.80	10.24	
	Sawdust/	14.24	98.46	3.62	7.66	
	Topsoil mix	16.48	94.06	5.05	7.85	
	Sawdust on topsoil	14.08	98.62	1.94	4.24	
Mean		**16.32**	**19.66**	**5.61**	**7.08**	
0.0 Control	Nursery mixture Topsoil	14.54	98.82		5.47	65-70% 30-35^{0}C
	Sawdust	15.16	95.60	1.84	6.86	
	Sawdust topsoil mix	14.48	100.00	4.16	5.08	
	Sawdust-on - topsoil	14.60	98.82	1.64	4.66	
		14.58	96.86	1.82	4.84	
Mean		14.67	98.02	1.89	5.38	
$LSD_{0.05}$ Shade		**2.02**	**1.45**	**4.11**	**3.25**	
$LSD_{0.05}$ Media		**1.21**	**2.06**	**2.41**	**3.05**	
$LSD_{0.05}$ Shade x Media		**0.84**	**2.14**	**2.06**	**2.12**	

At the time of transplanting to the field (Table 2) growth characteristics of dika nut seedlings showed that roots for seedlings under heavy shade developed tall shoots, few short but broad leaves. However, seedlings exposed to light were stout with pronounced feathery (multiple branches) roots and high leaf proliferation.

Table2. Growth characteristics at transplanting in May 2005 of dika nut seedlings raised in different media under different shade variations and media in the nursery.

Shade intensity (%)	Media	Height (cm)	Girth (cm)	Taproot length (cm)	Number of Roots	Number of Leaves	Leaf area (cm^2)
70 – 90	Nursery mixture	90.60	3.24	130.60	38.4	20.00	128.02
	Topsoil	156.82	3.06	121.46	24.6	20.00	120.80
	Sawdust	68.65	3.28	146.40	56.4	20.00	128.06
	Sawdust/ topsoil mix	98.66	3.45	140.45	32.5	20.10	126.44
	Sawdust-on-topsoil	96.42	3.42	142.42	48.6	20.00	130.68
	Mean	**102.23**	**3.29**	**136.27**	**40.1**	**20.02**	**126.80**
40 – 60	Nursery mixture Topsoil	80.78	3.80	108.44	46.8	22.50	104.26
	Sawdust	80.22	3.61	96.62	37.2	22.62	96.44
	Sawdust/topsoil mix	60.50	3.92	94.24	58.6	22.01	108.60
	Sawdust-on-topsoil	73.15	4.16	110.48	41.6	23.24	114.54
		76.48	4.28	106.84	56.0	23.00	124.02
	Mean	**74.23**	**3.95**	**103.32**	**48.04**	**22.67**	**109.57**
10 – 30	Nursery mixture Topsoil	81.44	4.70	105.46	54.5	24.65	96.06
	Sawdust	80.96	4.52	112.66	56.4	24.88	80.68
	Sawdust/topsoil mix	60.85	4.62	98.58	56.6	25.68	82.00
	Sawdust-on-topsoil	72.40	4.64	120.06	55.2	25.00	98.26
		74.66	4.88	108.42	56.0	25.48	108.44
	Mean	**74.06**	**4.67**	**109.04**	**55.74**	**25.14**	**93.09**
0.0 Control	Nursery mixture Topsoil	96.84	6.50	144.65	66.42	25.08	186.48
	Sawdust	92.64	6.48	142.80	60.54	24.02	95.68
	Sawdust/topsoil mix	86.52	5.54	145.66	60.85	23.40	92.56
	Sawdust-on-topsoil	98.64	6.46	138.58	69.55	24.50	96.06
		106.54	6.58	156.42	69.74	24.56	196.28
	Mean	96.24	6.31	145.62	65.42	24.31	133.41
$LSD_{0.05}$ Shade		**12.60**	**0.42**	**8.02**	**6.24**	**2.82**	**6.04**
$LSD_{0.05}$ Media		**6.44**	**1.04**	**4.46**	**4.12**	**0.86**	**4.46**
$LSD_{0.05}$ Shade x media		**4.08**	**0.84**	**6.08**	**5.04**	**1.18**	**2.62**

The seedlings raised under various nursery conditions showed remarkable variations in shoot die back, re-flush, field establishment, maturity and yield (Table 3). Most seedlings raised under heavy shade (70-90%) died back (100%) and re-flushed late (29 – 34) days after transplanting. The seedlings raised in sawdust, sawdust mix and sawdust arranged indepth in an open or lightly shaded (0-30%) flushed very early (16-18 days). Maximum field establishment was obtained from seedlings in the unshaded nursery environment, followed by those raised in low shade (10-30%). Most seedlings raised under heavy shade (70 – 90%) failed to establish in the field while the few survivors showed retarded growth and development resulting in delayed maturity and poor fruit yield.

Table 3. Field establishment, growth and yield of dika nut seedlings raised under different shade intensity and media in the nursery

Shade intensity (%)	Media	Die back (%)	Days to 50% reflush	Establishment (%)	Years to 50% fruiting	First fruit weight (g)	Fruits/ yields (kg ha^{-1})
70-90	Nursery mixture	100.00	33.60	68.82	8.25	147.64	115.68
	Topsoil	100.00	31.42	62.48	10.42	146.22	114.66
	Sawdust	98.57	28.84	60.24	8.44	148.24	116.65
	Sawdust/ Topsoil mix	96.86	28.64	62.06	8.48	147.44	118.64
	Sawdust-on-topsoil	84.66	28.80	68.28	6.26	148.60	118.48
	Mean	**96.02**	**30.26**	**64.38**	**8.37**	**147.63**	**116.82**
40-60	Nursery mixture	86.42	21.46	89.40	5.08	146.46	126.46
	Topsoil	86.62	21.28	86.54	5.25	148.82	126.60
	Sawdust	84.50	21.64	85.14	5.56	148.45	136.82
	Sawdust/ Topsoil mix	80.08	19.40	82.44	5.06	148.72	136.45
	Sawdust-on-topsoil	82.66	18.82	90.66	5.02	149.26	138.80
	Mean	**84.06**	**20.52**	**86.84**	**5.19**	**148.34**	**133.03**
10-30	Nursery mixture	40.05	18.08	96.42	5.81	249.26	144.00
	Topsoil	36.54	18.46	95.84	5.80	248.04	142.45
	Sawdust	36.80	16.44	98.65	5.84	2.48.60	143.24
	Sawdust/ Topsoil mix	34.00	16.82	97.26	5.84	248.46	142.56
	Sawdust-on-topsoil	34.08	16.46	98.84	4.86	248.64	144.62
	Mean	**36.29**	**17.25**	**97.40**	**5.63**	**248.6**	**143.37**
0.0 Control	Nursery mixture	32.56	16.04	97.64	4.86	249.65	248.80
	Topsoil	32.84	18.00	96.54	5.02	248.68	248.52
	Sawdust	26.46	16.42	95.28	50.6	248.56	344.60
	Sawdust/ Topsoil mix	24.08	16.06	96.48	4.88	249.32	248.54
	Sawdust-on-topsoil	24.86	16.02	98.84	4.84	250.42	308.65
	Mean	**28.16**	**16.51**	**96.96**	**4.93**	**249.32**	**279.29**
$LSD_{0.05}$ Shade		**7.04**	**5.04**	**4.82**	**1.26**	**2.64**	**12.22**
$LSD_{0.05}$ Media		**6.02**	**2.52**	**2.64**	**0.68**	**1.06**	**8.68**
$LSD_{0.05}$ Shade x Media		**6.14**	**2.16**	**2.08**	**0.80**	**0.88**	**6.04**

Shading is a conventional nursery practice in the tropics. However, seeds of dika nut are available and usually seeded in the peak of rainy season (July) characterized by low ambient temperature and high humidity (Njoku, 1986; Baiyeri, 2003). Shade probably created additional humidity and unfavourable nursery environment for the germination of dika nut seeds (Peter-Onoh *et al.*, 2014). Exposure to the light increased the ambient temperature and ameliorated the unfavourable

conditions for dika nut of germination necessitated by shading and high humidity (Table 1). The cumulative effects reduced seedling emergence, accelerated fungal disease infestation and low seedling survival in the nursery (Obiefuna and Onwueme, 1986). The scenario simulates high humidity and increased the disease load in the rainforest often reported for the loss of viability of dika nut seed (Okafor, 1973; 1985).

This natural unfavourable environment may have accounted for low volunteer juvenile populations in the wild and not necessary hard seed coat dormancy (Obiefuna and Onwueme, 1986; Okafor, 1973). Additionally, poor quality transplants may be further complicated when the seedlings are transported over a distance to the farmers field (Okafor, 1973). Consequent economic loss in time labour material and yield may frustrate the growers. Under field conditions, seedlings raised under shade (above 30%) died back considerably and delayed reflush with resultant high seedling establishment failure in the field (Baiyeri, 2003). This shade effect may explain the usually reported poor field establishment for dika nut (Okafor, 1985). Apparently, two weeks pre-transplanting vernalization of shaded seedlings appears ineffective and calls for further study.

The delayed regrowth of shaded seedlings may be further complicated by advserse weather conditions after transplanting or late field transplanting. The nursery media namely, sawdust, sawdust mix or sawdust-on-topsoil arranged indepth as nursery media significantly enhanced the success of seedling growth, development and field establishment probably by stimulated massive roots development and seedling hardening in full light. Among the media evaluated, sawdust arranged indepth with topsoil without shade remains the most appropriate medium for an enhanced emergence, seedling vigour and field establishment and productivity in dika nut (*Irvingea gabonensis*) orchard development in the rainforest agroecology of southeastern Nigeria.

Conclusion

The establishment of plantation crop demands quality planting materials for early maturity and sustainable production in the tropical rainforest agroecology. The importance of quality planting materials in plantation agriculture is widely recognized for most tropical plantation agriculture including plantains. The availability of quality planting materials for farmers guarantees positive return on investment in plantation agriculture of dika nut.

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