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BIOMASS ACCUMULATION OF SELECTED INDIGENOUS SPECIES UNDER FLOOD CONDITION

***Jegede, Opeyemi. C[1], Onefeli Alfred O.[2], Gbadebo Joseph .O[1] and Adeniji Ibidunni. T[1]**

[1]Forestry Research Institute of Nigeria, P.M.B, 5054, Jericho, Ibadan, Oyo State, Nigeria.
[2]Department of Forest Production and Products, University of Ibadan
*opeyemijegede20.jo@gmail.com./ jegede.oc@frin.gov.ng
***08035013569**

ABSTRACT

Nigeria is vulnerable to flooding resulting from climate change typified by deforestation. Many seasonally flooded habitat remains scanty because most tropical tree species find it difficult to survive under flood condition. Information on species that has adaptive mechanism to effectively and sustainably cope in a flooded environment is needed. Therefore, biomass accumulation and the survival ability of *Rhizophora racemosa, Alstonia congensis* and *Cleistopholis patens* subjected to two artificial flood conditions over a period of sixteen weeks were investigated. The experiment was a 2 x 3 factorial with fifty replicated in each species; factor A, the two treatments: flooded and non-flooded and factor B, the three species. Five seedlings from each treatment were randomly harvested fortnightly and separated into leaf, stem and root for biomass estimation. Wet weight of sample was determined and oven dried at 60^{o}C to obtain the dry matter component. Over the period of observation, the mean biomass showed that *A. congensis* had the highest leaf biomass(76.8 g) while highest stem and root biomass were observed on *C. patens* (65.8 g and 72.0 g, respectively). The data generated were subjected to analysis of variance (ANOVA) at 5% level of probability. ANOVA showed that there was significant difference among the species in terms of the leaves, stem and root biomass. *C. patens* in a flooded condition maintained a moderately but continuous biomass accumulation. Thus, *C. patens* which performed best in flooded regime may be adopted as a candidate species for flood management.

Keywords: Indigenous species, flood condition, survival ability, biomass accumulation

Introduction

Climate change and land use changes within river catchments have had significant effects on flooding and have increased the frequency and magnitude of intense rainstorms throughout the world (Vogel, 2000). Across the globe, floods have posed tremendous danger to people's lives and properties, causing about 30% of all deaths, injuries and damages from natural disasters (Etuonovbe, 2011). In Nigeria, the pattern is similar with the rest of world and as a result of widespread reduction of vegetation cover, all parts of the country are vulnerable to soil erosion and flooding resulting from climate change. Ladan (2019) enumerated series of flood cases across states in Nigeria between 2010 till date, many of which were traceable to deforestation, urbanization, heavy rainfall, and dam failure. Flooding in various parts of Nigeria have forced millions of people from their homes, destroyed businesses, polluted water resources and increased the risk of diseases (Edward-Adebiyi, 1997).

Availability of many flood prone areas in Nigeria and the challenge of addressing the vulnerability has received little attention (Zevenbergen, 2008).The extent to which tropical tree species may be flood tolerance has rarely been investigated. According to Natural Resources Rockford Extension Centre (NRREC, (2000), the impact of flood on many tree species is highly destructive. It deprive them of oxygen after nutrient and water uptake and subject them to wilting condition even when they are surrounded by adequate amount of water. Lack of oxygen shifts the energy metabolism from aerobic to anaerobic mode. Water tolerant plants are capable of adapting to waterlogged conditions because they have mechanisms to cope with the stress. These plants however, are able to survive, recover and resume normal functioning in water logged environment even from seedling to maturity (Sairam *et al.*, 2008). This is not farfetched from the fact that adventitious roots in such plants are induced by flooding and are more efficient in the translocation of water to the shoot via root.

The mitigation approach to flood problems by establishing appropriate species in flood prone environment and preventing continuous devastating occurrence that has become a serious threat in Nigeria has therefore call for an urgency. Hence, indigenous tropical water tolerance species that have potentials for remediating, controlling and managing flooded landscape in Nigeria needs to be identified. The family *Caesalpinioideae* and *Bombacaceae*; a tropical species were recorded to demonstrate high flood-tolerance when subjected to flood prone environment even though, these species experienced little or no flooding in their natural habitat (Joly and Crawford, 1982). Indigenous tree species such as *Cleistopholis patens* BENTH., *Alstonia congensis* ENGL. and *Rhizophora racemosa*G.MEY.are indigenous water tolerant species that could be suggested for flood tolerance due to their natural existence around waterlogged areas. The need to investigate the adaptability of these species to inundation resulting from flood occurrence is therefore imperative. Therefore, this study investigated the biomass accumulation of these indigenous tree species under artificialflood condition and recommended the best of them for adoption in the management of flood prone environment in Nigeria.

Materials and Methods

Seeds of the two species: *Alstonia congensis* and *Cleistopholis patens* were collected from mother trees at various locations within Nigeria. *A. congensis* seeds were collected from Ibadan, Oyo-State (Southwest) while *C. Patens* seeds were collected from Ore, Ondo State (Southwest). In the case of *Rhizophora racemosa* seeds, which are viviparous, sprouted seeds (propagules) were obtained from its mother tree at Onne, Rivers State (South East). Seeds of these species were germinated separately in germination trays containing sterilized river sand at the silviculture nursery of the Department of Sustainable Forest Management, Forestry Research Institute of Nigeria, Ibadan.

Two weeks after seedling emergence, ten (10) uniform seedlings that have produced two or three fully expanded leaves from each of the species were prickled-out and transplanted into polythene pots (of 25cm length and 20cm width) containing 2kg of a 5:3:2 mixture of forest soil, sterilized river sand and organic manure (cured horse dung). The experiment was laid out in a 2x3 factorial experiment in a Complete Randomized Design (CRD) with a total of 300 seedlings (at 50 replicates per species per treatment Factor A (flooding condition) was at two levels: Level 1(flooded) an artificial flood condition was made and potted seedlings were submerged in water filled containers with a water level of 3-5cm above the potted soil surface considering the seedlings height at the point of transplanting according to Dalmolin *et al.* (2012). The cotyledon of seedlings were under the water but all true leaves were above the water level. Level 2 (Non-flooded). Factor B (Tree species) were the three species used. Biomass of each plant was evaluated fortnightly for the period of sixteen weeks after separating the plants into leaf, stem and root. An initial record of the wet weight of each plant part using an electronic sensitive weighing balance was obtained. Subsequently, the dry matter (Biomass) was determined by oven drying the wet samples for 72 hours to a constant weight of 60^{o}C and calculated in percentage form using standard procedure.

The data collected were analyzed using descriptive statistics and analysis of variance (ANOVA) to compare the biomass accumulation between the flooded and non-flooded among the three species. Where ANOVA was significant, Duncan Multiple Range Test was used to separate the mean difference ($p<0.05$).

Results and Discussion

Results

Table 1 show the comparism of mean biomass accumulation (%) under flood condition in leaf, stem and root over the assessment period. *A. congensis* had the highest leaf biomass (80.4) and (73.24) followed by *C. patens* (73.51) and (71.92) while the least (70.84) and (69.28) was observed in *R. racemosa* for both flooded and non-flooded. For stem and root biomass, *C. patens* took the lead, followed by *A. congensis* and the least in *R. racemose* with the values 66.15 and 73.73; 63.88 and 68.47; 54.94 and 63.29 respectively for flooded. For Non-flooded, the same trend follows for stem and root biomass with the values 65.62 and75.23; 60.97 and 62.28; 54.02 and 57.00 respectively.

Table 2 shows the results of analysis of variance for leaf biomass, stem biomass and root biomass of the three species grown under flooded and non-flooded condition. ANOVA for leaf biomass revealed that there were no significant differences($p<0.05$) in the interaction between the treatments and the species but there was significant difference between the treatments and also among the tree species.For stem biomass, ANOVA indicated a significant difference among the tree species ($p<0.05$) but there was no significant difference between the treatments as well as the interaction between the treatments and species. Significant difference ($p<0.05$) was also observed among the tree species and in the interactions between the treatment and the species but there was no significant difference between the treatments in the root biomass.

Table 3 display a follow-up test that show the mean separation among tree species using Duncan Multiple Range Test (DMRT). DMRT revealed *A. congensis* having the highest leaf biomass accumulation (76.8%) while the highest stem and root biomass was observed in *C. patens*65.8 and 72.0 respectively. However, there was no significant difference between *C. patens* (65.8) and *A. congensis* (62.4) in stem biomass and between *A. congensis* (62.9) and R. racemose (59.7) in root biomass.

Table 1: Comparism of mean biomass accumulation in leaf, stem and root of selected species under flood condition over the assessment period.

Treatments	Flooded			Non-flooded		
	Leaf	Stem	Root	Leaf	Stem	Root
A. congensis	80.40	63.88	68.47	73.24	60.97	62.28
C. patens	73.51	66.15	73.73	71.92	65.62	75.23
R. racemose	70.84	54.94	63.29	69.28	54.02	57.00

Table 2: Analysis of variance for leaf biomass, stem biomass and root biomass of three species grown in a flood condition

Leaf biomass

SV	DF	SS	MS	F-cal	F-tab
Flooding	1	1022.58	1022.58	5.61*	3.842
Species	2	1481.17	740.59	4.06*	2.996
Flooding*Species	2	360.66	180.33	0.99ns	2.996
Error	294	53621.3	182.39		
Total	299	56485.7			
Stem biomass					
Flooding	1	97.23	97.23	0.57ns	3.842
Species	2	3649.2	1824.6	10.73*	2.996
Flooding*Species	2	54.02	27.01	0.16ns	2.996
Error	294	49980	170		
Total	299	53780.4			
Root biomass					
Flooding	1	61.71	61.71	0.25ns	3.842
Species	2	5423.21	2711.6	11.04*	2.996
Flooding*Species	2	1654.03	827.01	3.37*	2.996
Error	294	72242.3	245.72		
Total	299	79381.3			

*Significant and ns= not significant ($p<0.05$)

Table 3: Follow-up test (DMRT) showing the significant differences among tree species

Tree species	Leaf	Stem	Root
R. racemose	70.1^{b}	54.4^{b}	59.7^{b}
C. patens	72.7^{ab}	65.8^{a}	72.0^{a}
A. congensis	76.8^{a}	62.4^{a}	62.9^{b}
p-value	0.011*	0.003*	0.000*

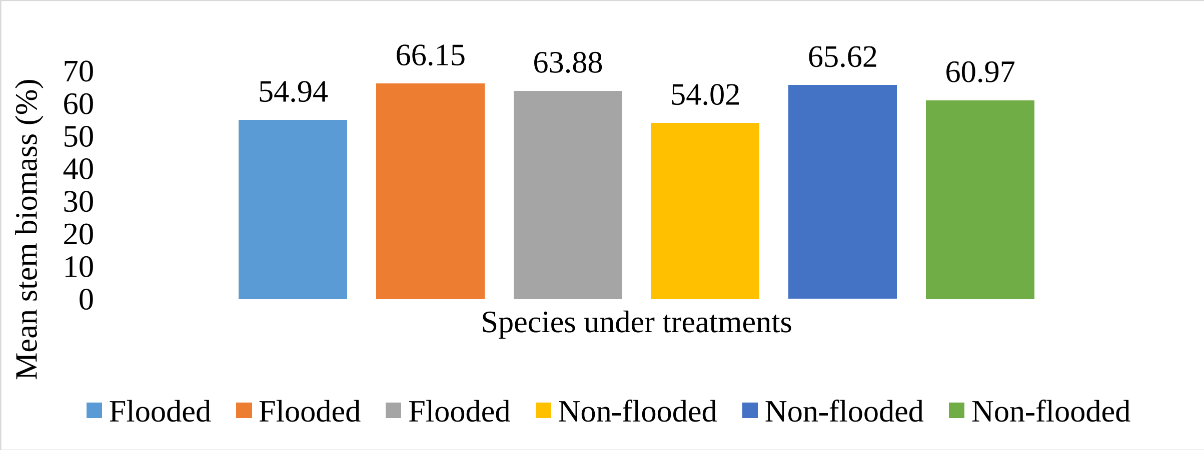

Figure 1. Effect of flooding on leaf biomass (%) across the sixteen weeks after transplanting

Figures 1, 2 and 3 indicates the average biomass (g) of the indigenous tree species between flooded and non-flooded (expressed in percentage) over sixteen weeks. In figure 1, *A congensis* had the highest leaf biomass under flooded (80.4) and non-flooded (73.24). Closely following it was *C patens* (73.51) and (71.92) while the least biomass for both flooded and non-flooded

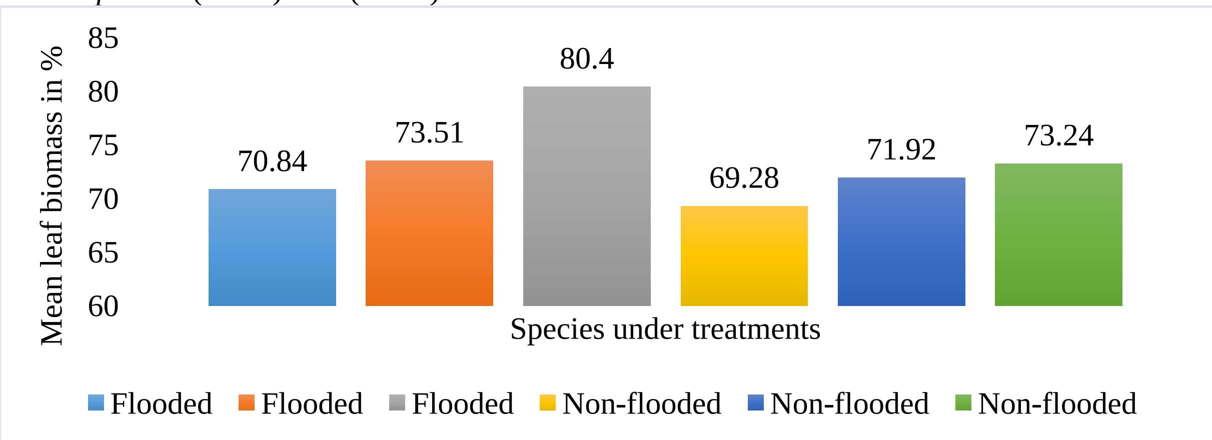

Figure 2. Effect of flooding on Stem biomass (%) across the sixteen weeks after transplanting

Regarding the stem biomass (Fig.2), *C. patens* had the highest values for both flooded (66.15) and non- flooded (66.62). *A. congensis* was the next; for flooded, it had (63.88) and (60.97) for non-flooded and the least was recorded for *R. racemosa* at flooded (54.94) and (54.02).

Figure 3 clearly show that*C. patens* had the highest root biomass (73.73) and (75.23). This was closely followed by *A. congensis* (68.47) and (62.28) while*R. racemosa* had the least biomass for both flooded (63.29) and non-flooded (57.00).

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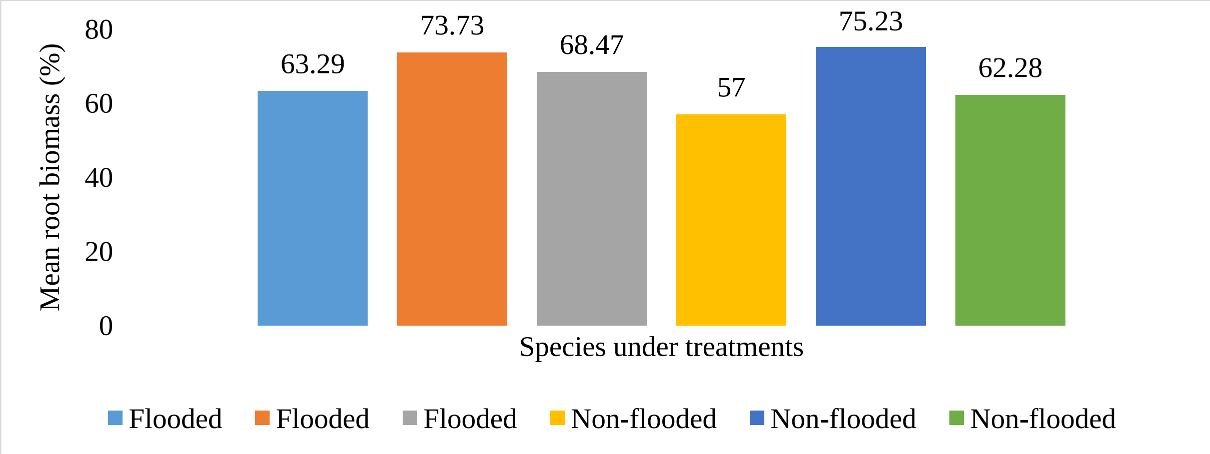

Figure 3. Effect of flooding on root biomass across the sixteen weeks after transplanting

Discussion

All the selected species for this study survived the 16-weeks period of subjecting them to flooding condition although, there were significant variation from one species to the other and the rate of biomass accumulation in these species indicated their adaptation to long period of flooding. This is in line with Lopez and Kursar, (1999)**,** who stated that most tropical tree species are relatively tolerant of flooding even though they defers in their tolerance level in inundated habitats. Closer observation of these species revealed from the accumulated biomass that water loving plants do not respond in the same way to flood condition.

The impact of flooding on the three selected species was more pronounced in the root compared to the leaf and stem. This may be due to the fact that the root was the major part that was completely covered by water and has affected the root hydraulic conductance which measures the ability of complete root system to move large water quantity. (Tyree *et al*., 1995). According to Visser *et al.* (2003)**,** plant experience stress when the roots are inundated by floodwater due to lack of ample quantity of oxygen. In other words, plant growth are retarded because influx of carbon dioxide, which is essential for the process of photosynthesis, is inhibited.

Species accumulated more biomass at the end of the experiment under flooded condition than non-flooded condition. However, biomass accumulation maintain a steady increase per time, attained its peak at the end of assessment and was higher across the species on the leaves followed by the root while the least was found in the stem. This is in agreement with this assertion that the relative amount of biomass present in various organs is not fixed but may vary over time across environment and among species (Hendrik *et al*., 2011). The distribution patterns and variation in biomass present in plants organs is determined by the capacity of such plant to take up carbon, water and nutrient for future use (Evans, 1992).

However, the concept of functional equilibrium assert that when the growth limiting factor is below the ground, such as nutrient deficiency, draught condition, flood, inundation and so on, plants tends to allocate more biomass to the root (Brouwer, 1963). *A. congensis* and *C. patens* were able to store more biomass in leaves and root than the stem because they have more developed adaptive mechanism than *R. racemose*. This allowed the rooting system to progressively tolerate the flood condition and as such, an accelerated growth rate which was observed was an evidence of nutrient up take which reallocated more biomass to both the root and the leaves than the stem. This is in line with the statement of fact that leaves and roots are generally the resource–acquiring organs where plants tends to allocate more biomass especially when the growth limiting factor is below the ground (Kirschbaum *et al*, 1992; Shpley and Meziana, 2002; and Hendrik *et al*., 2011).

Conclusion and Recommendation

Apparently, this study has revealed that not all water tolerant species are able to grow appreciably well or withstand flooded condition. *Cleistopholis patens* will be considered the most flood tolerance of the selected species used in the experiment because, it had the highest root and stem biomass and also had a moderately high performance in leaf biomass accumulation. This result has proven that the dry matter present in the root of *C. patens* is high and in turn has high potentials for growth by conducting more water and other nutrients from the soil, translocate them through the trunk up to the leaves.

This is therefore coming as a charge for the silviculturists and forest experts to intensify on the plantation establishment of these species to sloppy terrain or flood prone environment. Therefore, *C. patens* was recommended because as much as it could withstand periods of prolong flooding, it also has an ability to maintain extensive and deeper rooting system developed during flooding condition which could serve as an adaptive mechanism for seedling to survive water stress that could be imposed by a succeeding dry season. Therefore, creation of awareness should be intensified in order to promote propagation and planting of these tree species so as to improve environmental sustainability and climate change.

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