



Journal of **Plant Sciences**

ISSN 1816-4951



Academic
Journals Inc.

www.academicjournals.com

**Growth Ecology of an Aquatic Macrophyte
Nymphaea lotus Linn from Nigerian Inland-water**

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Abstract: The study aimed at investigating the seed germinability, vegetative propagation and early growth of a rooted aquatic macrophyte, *Nymphaea lotus* from Nigerian Inland-water body. Germination test was conducted using seeds collected from a water body in the Kainji Lake Basin and sprouting test was done with rhizomes collected from Eleyele dam in Ibadan. Seedlings were raised in the ecology laboratory and transplanted into 24 plastic bowls in the crop garden of the Department Crop Protection and Environmental Biology, University of Ibadan, where the seedling growth was studied for 14 weeks. The seeds commenced germination on the 12th Day After Sowing (DAS) with 77% average germination recorded on 21st day after sowing (DAS). The rhizomes started to sprout on the 7th day after planting with a relatively low percentage (4%). The growth study showed that there was increase in the number of leaf per plant, Leaf Area (LA), Leaf Area Ratio (LAR) and the Shoot height and Root length also increased as the seedlings grew older during the fourteen weeks (14 weeks) study. The result indicated that colonization by rhizome may not be as important as colonization by seeds. More so, the seeds are capable of germinating only when the soil is completely inundated with water. The results are explained in line with phenology of the plant.

Key words: *Nymphaea lotus*, growth ecology, germination, colonization, phenology

INTRODUCTION

Waterlily is a rooted aquatic macrophyte of the family Nymphaeaceae (Stacey and Joana, 2003). It is one of the most beautiful water plants with submerged rhizomes. It possesses heart-shaped leaf, which lies flat on water surface. The rhizome is submerged with long spongy roots that firmly anchor the plant to the sediment, strongly toothed floating leaves borne on long flexible stalks/petiole that extends from the short stem and an axillary's large white flower borne on long pedicel with numerous petals and stamens (Obot and Ayeni, 1987).

The flowers of *Nymphaea lotus* are borne on slender flower stalks (pedicel) and they are solitary, showy, large (about 20 cm in diameter), have many white petals and equally as many yellow stamens (Akobundu and Agyakwa, 1998). The flower is hermaphrodite which possesses many petals. Field observation shows that the flower opens in the morning and closes in the afternoon. At 3 days after fertilization the pedicels coil to bring the flowers under water. The seeds of *Nymphaea lotus* are creamy when fresh. The seeds are dispersed into sediment where they germinate if conditions such as oxygen, light and space for growth are favourable (Julie and Fennessy, 2001).

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Waterlily is among the prominent aquatic macrophytes that have been identified in Nigerian freshwater bodies (Obot and Ayeni, 1987). Niger grass (*Echinochloa stagnina*), Duckweed *Lemna paucicostata* and Water hyacinth (*Eichhornia crassipes*) among others have been studied in detail. There is dearth of information on waterlily despite its ethnobotanical uses by the local population and the fishermen. This study reports the germination and early growth ecology of waterlily (*Nymphaea lotus*) in the laboratory and crop garden of the Department of Crop Protection and Environmental Biology University of Ibadan, Nigeria.

MATERIALS AND METHODS

The mature fresh fruits of *Nymphaea lotus* used for this study were collected from a water body in the Kainji Lake located, North Central Nigeria. It is located on 4° 23'E-4° 45'E and latitude 9° 51' N-10° 55'N (Olorok, 1993). The experiments which included seed germination, vegetative propagation by rhizome cutting and early seedling growth were conducted in the Ecology laboratory and Crop garden of the Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria (7° 30' N; 3° 54' E; 234 m above sea level), between April and October 2006. The weather data obtained during the period of this work indicate a total rainfall of 1617.8 mm, an average temperature and relative Humidity of 26.9 °C and 85.3% respectively. The rainfall pattern is bimodal with peaks in June (220.2 mm) and October (330.2 mm) (Table 1).

The seed germination was studied in three environments (treatments) which include;

- Petri dishes filled with water,
- 250 mL beakers half filled with soil sediment and half filled with water and
- Petri dishes laid with Whatman Number 1 filter paper moistened by administering 10 mL of water every day.

These three treatments were replicated three times and 50 seeds were placed in each replicate. All the replicates were placed near window sill in the laboratory where they received sun rays in the early hours of the day. The treatments were observed each day for germination. The observation went on for 28 days. Emergence of leaves was used as evidence of germination. The number of seeds that germinated was recorded on 7, 14, 21 and 28 days after setting (DAS) the seeds. Analysis of variance was used to compare the three treatments. The data were square root transformed [$Y+0.5^{1/2}$] (Little and Hills, 1978) for the ANOVA. Least Significant Difference (LSD) was used to compare the means at 5% level.

Table 1: Weather data for Ibadan in 2006

Months	Total rainfall (mm)	Temperature (°C)	Relative humidity (%)
January	28.0	27.0	85.0
February	25.5	28.4	80.0
March	100.1	28.0	84.0
April	127.2	29.0	82.0
May	132.6	27.5	82.0
June	220.2	27.0	83.0
July	151.8	25.3	89.0
August	204.6	24.8	90.0
September	226.1	25.1	91.0
October	330.2	27.0	88.0
November	51.4	27.0	86.0
December	20.1	27.2	84.0
Average	-	26.9	85.3
Total	1617.8	-	-

Source: National Horticultural Research Institute weather station, Ibadan

Vegetative Propagation from Rhizome

Four matured *Nymphaea lotus* plants were uprooted from the growing site at Eleyele dam in Ibadan. The rhizomes were cut at 3 cm below leaf region and 3 cm from tip end. The diameter of each rhizome varied between 3 and 4 cm. All the adventitious roots were removed and the rhizomes were cut into bits, each of 1 cm length. Twenty four bits were used for the study with 6 obtained from a rhizome. The bits were planted in four plastic bowls of 4 L capacity half filled with bottom soil sediment collected from the water body where the rhizomes were collected and were topped with stream water. A bowl was assigned to the 6 bits obtained from a rhizome. The bits were uprooted and observed for root development at 14 days after planting. The experiment was repeated three times.

Early Growth/phenological Study

Twenty four plastic bowls, each 7 L capacity with 27 cm surface diameter and 17.5 cm depth, were filled to 3 L mark with bottom soil sediments collected from Eleyele dam, Ibadan, South-west Nigeria. The bowls were arranged on Iron-net table outdoor in the Crop garden, Department of Crop Protection and Environmental Biology, University of Ibadan. The plastic bowls were top up to the brim with water collected from Eleyele dam every week. Six weeks after sowing, the 2 young seedlings all at three leaf stage were carefully pricked out and transplanted into each of the plastic bowls.

Six seedlings from three randomly selected plastic bowls were harvested at 2, 4, 6, 8, 10, 12 and 14 Weeks After Transplanting (WAT) to assess the following growth parameters;

- The number of leaf per plant
- Leaf area
- Leaf area ratio
- Shoot height and root length

RESULTS

Germination of Seeds of *Nymphaea Lotus*

The germination of the seeds commenced on the 12th day after sowing up to the 21st day in treatments where seeds were submerged in water (Treatments 1 and 2), while in treatment 3 (Petri dish + moistened filter paper) there was no germination (Table 2). The differences among the three treatments of the transformed data were significant ($p < 0.05$) (Table 3). An average of 2% germination was recorded in the repeated germination test conducted five months after collection of seeds.

Table 2: Mean number of germinating seeds and percentage of seeds of *Nymphaea lotus* 28 days after sowing

Treatments	Mean No. of seeds germinated	Mean germination (%)
Petri dish + water (T ₁)	37.33±1.08	74.67±2.16
Beaker +soil + water (T ₂)	40.00±0.71	80.00±1.41
Petri dish + filter paper (T ₃)	0.00±0.00	0.00±0.00

Values shown are mean±SE, n = 3

Table 3: Mean cumulative germination (square root transformation) of *Nymphaea lotus* seeds in three media. Decode using $(Y + 0.5)^{1/2}$

Treatments	Mean germination (transformed)	Mean germination (untransformed)
T ₁	6.15	37.33
T ₂	6.36	40.00
T ₃	0.71	0.00
LSD _(0.05)	0.18	-

Table 4: Number and percentage of Rhizome bits that Sprout 7 days after planting in soil sediments

No. of trials	No. of bits planted	No. of Sprouted	Sprouting (%)
1	24	1	4
2	24	1	4
3	24	1	4

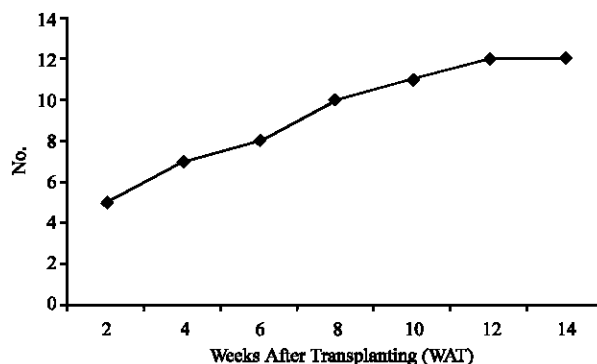


Fig. 1: Average number of *Nymphaea lotus* over a 14 week period

Vegetative Propagation from Rhizome

The rhizome sprouted at 7 day after planting (DAP). One out of the 24 bits planted in the soil sediment sprouted in each of the three trials (Table 4). The average sprouting percentage was 4%. There were no differences in the three trials. Those that did not sprout had started to decay at 14 days after planting in the soil.

Early Growth of Seedlings

Assessment of Number of Leaves per Plant

There was an increase in the average number of leaves from 5 to 12 per plant in the 2nd week after transplanting (2 WAT) up to 12th week after transplanting, while in the 14th week after transplanting (14 WAT) there was no changes in the number of leaves per plant (Fig. 1). It was observed that the leaf blade changed from smooth edges and became serrated 10 weeks after transplanting (WAT).

Assessment of the Leaf Area (LA)

There was no much difference in the increased in Leaf Area (LA) measured from 2 to 6 weeks after transplanting (WAT) (15 to 128 cm²), while in the 8th week after transplanting (WAT) it increased to 400.6 cm² and there was a rapid increase in the Leaf Area (LA) from 10th to 14th week after transplanting (WAT) (1,978.77 to 508.66 cm²) (Fig. 2).

Assessment of the Leaf Area Ratio (LAR)

The highest value 4040.19 cm² g⁻¹; Leaf Area Ratio (LAR) was obtained in the sampling taken at 10 weeks after transplanting, while the minimum value 99.65 cm² g⁻¹ was obtained at 6 weeks after transplanting (Fig. 3)

Assessment of Shoot and Root growth

The shoot height and root length measured at 2, 4, 6, 8, 10, 12 and 14 Weeks After Transplanting (WAT) showed a slow shoot and root development in the 2nd and 4th week sampling while there was a rapid development of the shoot and root in the 6th to 10th week. The sampling in

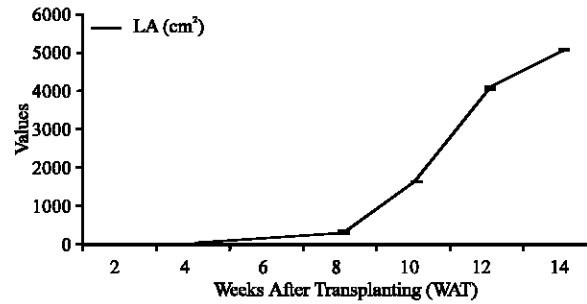


Fig. 2: Leaf Area (LA) of transplanted seedlings of *Nymphaea lotus* over a 14 week period. Values are mean±SE (n = 6)

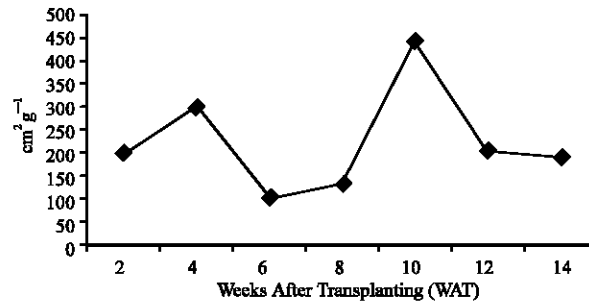


Fig. 3: Leaf Area Ratio {(LAR) (cm² g⁻¹)} of *Nymphaea lotus* over a 14 week period. Values are mean±SE (n = 6)

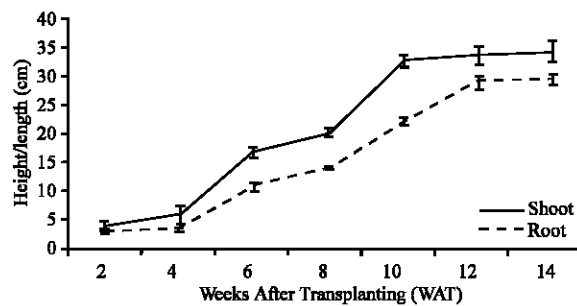


Fig. 4: Mean shoot height and root length of transplanted seedlings of *Nymphaea lotus* over a 14 week period. Values are mean±SE (n = 6)

the 12th and 14th week showed a stable growth development (Fig. 4). The seedling plants were still actively growing at the time that this study was terminated.

DISCUSSION

Germination of Seeds and Sprouting of Rhizome Bits

In the germination study high germination percentage (80%) was recorded in the seeds sown in soil + water collected from the dam where the macrophyte was found growing and (74%) average germination percentage was also recorded in seeds sown in water collected from the dam. Water, probably supported the germination of seeds of aquatic macrophytes. This confirmed the definition

of Noggle and Fritz (1976), that the beginning of plant's growth from seed involved the process of water imbibitions. The zero percentage germination observed in seeds placed on moistened filter paper which was wetted every day for 14 days may be an indication that seeds of *Nymphaea lotus* will not germinate when the soil is moistened but only when the soil is completely inundated with water. Repeated germination test conducted five months after collection of seeds confirmed that the seeds have lost viability. This indicates that seedlings should be raised immediately after seed collection or one should probably explore the possibility of vegetative propagation.

Low sprouting percentage (4%) was recorded in the three trials conducted. Probably colonization of *Nymphaea lotus* may not be by rhizome or the buds might not be physiologically matured.

Phenology of *Nymphaea lotus*

Plant growth could be described as increase in their size as a result of the accumulation of organic compounds obtained from carbon-dioxide fixations during the process of photosynthesis. The continuous increase in the height growth throughout the 14 weeks study confirmed the increase in the dry matter during the seven harvests. More so, these components (Soil and Water) probably supported the growth and development of aquatic vegetation in providing the aquatic environment and supplying nutrients to the growing macrophytes (Adesina, 2003).

The increasing root-shoot ratio was due to the fact that seedlings need well established root system for effective absorption of mineral salts from the soil at the initial stage and anchor itself firmly in the soil sediment under the water. The dry matter accumulation of the shoot was same as the root (shoot/root = 1) at the early growth stage. However, as the plant grew older and becoming more established the dry matter accumulation of the shoot was greater than that of the root.

The net assimilation rate (NAR) which is a measure of increase in the weight per unit of leaf area (LA) or mass (Kramer and Kozlowski, 1979), reveal the level of photosynthetic activity and growth. There was a general decrease in Net Assimilation Rate (NAR) which indicates a drop in photosynthetic efficiency as the seedlings grew older. This study revealed that the seeds of *Nymphaea lotus* are capable of germinating only when the soil is completely inundated and seeds lost viability within five months in storage. Multiplication by fragmentation may be low as shown by poor sprouting of rhizome bits.

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