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Effect of seed age and soil texture on the germination of some *Ludwigia* species (Onagraceae) in Nigeria

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Seed germination in *Ludwigia* was greatly influenced by seed age and soil type. In *Ludwigia abyssinica* germination was not influenced by seed age and soil texture. Freshly shed seeds and six month old seeds of *Ludwigia decurrens* variety B showed a very low percentage germination on all the germination media, and six month old seeds germinated significantly earlier than freshly shed seeds. *Some* soil types could significantly reduce germination of freshly shed seeds of *L. hyssopifolia, L. erecta*, *L. leptocarpa* and *L. octovalvis* var *linearis.*

Key words: germination, seed, soil, *Ludwigia*

Introduction

The genus *Ludwigia* has existed at least 50 million years and is considered one of the largest and least specialized genera of the family Onagraceae (PENG 1988). The genus is pantropical; it includes some 82 species distributed among 23 sections. Twenty five of these species occur in the Old World, including 8 of its 23 sections. A very diverse assemblage of *Ludwigia* species occur in South America, where 45 of the 82 species occur with most primitive species; this may have been the centre of origin for the genus and family the Onagraceae (RAMAMOORTHY and ZARDINI 1987, PENG 1989). In West Africa, they are represented by fourteen species (sixteen taxa) and nine species (eleven taxa) of these are found in Nigeria (WOGU and UGBOROGHO 2000). A few *Ludwigia* species are predominantly aquatic but all of the species grow in wet places where they concentrate around coastal regions, lakes, lagoons, canals, rivers, streams, seas, gutters and water logged areas. The genus contains both herbaceous and woody species. Many aquatic species are phenotypically plastic, such that their growth forms vary under different environmental conditions, which often complicates species identification and has led to a number of fluctuations in their taxonomic classifications (DUTARTRE et al. 2004). Seed dispersal and germination are phases in the reproductive cycle that are typically of great importance for species fitness. Variations in seed dispersal efficacy or germination percentage are often interpreted as reflecting

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adaptations to specific ecological conditions (VENABLE and LAWLOR 1980, GRIME et al. 1981, MARTIN et al. 1995, NISHITANI and MASUZAWA 1996). Clearly, the characteristics of the microsite occupied by a seed may strongly influence its probability of germination and subsequent survival, including germination capacity (SCHAAL 1980, DOLAN 1984, HENDRIX 1984, STANTON 1985, MARSHALL 1987, NAYLOR 1993), resistance to intra and interspecific competition (WULFF 1986, MAZER 1989, HOUSSARD and ESCARRE 1991), dormancy period (STAMP 1990), distance dispersed with respect to the mother plant (AUGSPURGER and FRANSON 1986) and seedling survival and/or growth (SCHAAL 1980, HOWE and RICHTER 1982, GROSS 1984, STANTON 1984).

Ludwigia peruviana seeds can remain dormant for two years, seeds are able to germinate while afloat, 20 percent of seeds are dormant, propagation can also be done by young stems; seed production is of 450000 seeds m^2, 65000 seeds m^2 in soil seed bank and 30000 seeds m^2 for seeds that remained on old stems (JACOBS et al. 1994). It has been reported that the capacity of seed germination in *Ludwigia* species is not known (RUAUX et al. 2009). Fruits of many *Ludwigia* species remain on the parent stem when ripened while some are detached immediately at ripening. Some seeds are dispersed freshly from fruits on parent stems in to water as fruits dehisce irregularly while some seed remain on the fruits for several months before they are dispersed. Fruits of *L. adscendens* and *L. leptocarpa* are detached from the parent stem immediately they are ripened and remain afloat in water while it takes several weeks and months for their seeds to be dispersed from the fruits. In *L. hyssopifolia* which possesses both non-endocarp and endocarp seeds, non-endocarp seeds are first dispersed at ripening of fruit while endocarp seeds remain on the parent plant for several weeks and months before they are eventually dispersed into water. Studies have reported the germination of some *Ludwigia* seeds in the field (RUAUX et al. 2009) but there are few studies on seed germination capacity in relation to soil types (WOGU and UGBOROGHO 2000). As the fruits of most *Ludwigia* species remain on the parental plant (i.e. not dispersed), it was important to study the seed aging by comparing fresh seeds with seeds stored over maternal plants for six months and determine their germination on soil types. This study intends to determine the effect seed age and soil types on germination of seven *Ludwigia* species.

Materials and methods

Seeds used for this study were collected from *Ludwigia* species grown in the garden from March 2006 to December 2006 at the Department of Botany, Obafemi Awolowo Universty, Ile Ife. Germination study was carried out on nine *Ludwigia* seed samples which belonged to seven *Ludwigia* species: *L. abyssinica* A. Rich, *L. adscendens* (Linn) Hara. ssp. *diffusa* (Forssk.) Raven, *L. decurrens* var A Walter, *L. decurrens* var B Walter, *L. hyssopifolia* (G.Don) Excell, *L. erecta* (Linn) Hara, *L. leptocarpa* (Nutt.) Hara, *L. octovalvis* var *linearis* (Jacq.) Raven and *L. octovalvis* var *brevisepala*. *L. decurrens* var A has big ovate lanceolate leaves, the stem is prominently winged and 5angled, it initiates flowering within (64–70) days after germination; the number of petals ranges from (4–5). It is mostly found as monotypic stands in most aquatic habitats in Ile–Ife. *L. decurrens* var B has narrow lanceolate leaves, the stem is narrowly winged and 4 angled, it initiates flowering within (30–40) days after germination, the number of petals is fixed at (4). It is found growing sparsely among *L. decurrens* var A and rarely recognized. *L. octovalvis* var *brevisepala* has short linear leaves, stem slightly bent, densely villous and the number of petals is fixed at (4). *L. octovalvis* var *linearis* has long narrow linear leaves, stem erect, subglabrous and petal number ranges from (4–5). One hundred freshly ripened seeds and six month old seeds of each species were seeded into Petri dishes of diameter 8.00 cm (4 replicates of every treatment) lined with Whatman filter-papers No 1. Also 100 seeds of freshly ripened seeds and six month old seeds of each species were seeded separately on soil surfaces into 8.00cm diameter plastic cups filled with clayey, sandy and loamy soil with four replicates for every treatment. The Petri dishes and cups were watered regularly with distilled water. Germination was recorded when the radicule emerges from the seeds every day for a period of 30 days for each treatment. Days to initial germination (appearance of radicule) and percentage germination were recorded for each of the treatments. Germinated seeds were removed from the Petri dishes and cups during each count. The experiment was carried out in the screen house of the Department of Botany, Obafemi Awolowo University, Ile-Ife under conditions of natural photoperiod and ambient temperature (20–25 ^{o}C). Soil samples used were collected from Obafemi Awolowo University campus located within (latitude 7^{o} 30 N to 7^{o} 35 N and longitude 4^{o} 30 and 4^{o} 35^{o} E). Soil textures were determined at Department of Soil Science, Obafemi Awolowo University, Ile Ife, using a mechanical analysis method. Duncan's multiple range test (DMRT) was used to compare sets of means obtained for germination regimes, at a probability level of 0.05, using system analysis software (SAS) version 9.2.

Results

The study on *Ludwigia* species reveals that percentage germinations of six months seed were very high and varied significantly from the very low percentage germinations observed in freshly shed seeds on the three types of soils with the exception of *L. abyssinica, L. hyssopifolia, L. erecta* and *L. leptocarpa* (Tabs. 1, 2). The soil media also significantly reduced the percentage germination of freshly shed seeds of (*L. hyssopifolia, L. erecta*, *L. leptocarpa and L. octovalvis* var *linearis)* when compared to their control. In *L. adscendens*, *L. decurrens* variety A, *L. decurrens* variety B, *L. hyssopifolia*, *L. erecta* and *L. octovalvis* var *linearis* six months old seeds germinated significantly earlier than freshly shed seeds; but in *L. abyssinica* and *L. octovalvis* var *brevisepala* there was no significant difference in days to initial germination between six month old seeds and freshly shed seeds on any of the germination media (Tab. 2).

Ludwigia abyssinica

Percentage germination of new seeds and six month seeds of *L. abyssinica* were very high in all the germination media with no significant differences in the percentage germinations (Tab. 1). Seeds germinated very early in all the media and there was no significant difference in days to initial germination in any of the media (Tab. 2).

Ludwigia adscendens

Very high percentage germination in six month seeds of *L. adscendens* was significantly different from the very low percentage germination of new seeds on all the germination media. Seed age affected days to initial germination, six month old seeds germinated significantly earlier than freshly shed seeds but the soil types had no significant effect on days to initial germination (Tab. 2).

Ludwigia decurrens

The high percentage germination (93.4) of six month seeds observed in the control of *L. decurrens* var A is significantly different from the very low percentage germination of freshly shed seeds in control (5.20), loamy (1.60), clayey (1.40) and sandy (13.4) soils; there were significant differences in percentage germinations of six month seeds on the three types of soils (Tab. 1). Seed age affected days to initial germination: six month old seeds germinated significantly earlier than freshly shed seeds but the soil types had no significant effect on days to initial germination (Tab. 2). The percentage germination of *L. decurrens* var B was very low in six month and freshly shed seeds in all germination media; freshly shed seeds did not germinate on the control and loamy soil, with no significant difference in percentage germination observed on the other freshly shed seeds media and six month seeds media (clayey and sandy); highest percentage germination (39.60) of six month seed was observed in the control, which is significantly different from the 34.20 observed on loamy soil (Tab. 1). Age and soil type affected days to initial germination, and six month seeds germinated significantly earlier than freshly shed seeds (Tab. 2).

Ludwigia hyssopifolia

There was no significant difference in the high percentage germination observed in six month and freshly shed seeds of the control; six month seeds in the soil media showed a significantly higher percentage germination than freshly shed seeds on the soil media (Tab. 1). Seed age and soil type affected days to initial germination; six month old seeds germinated significantly earlier than all other species throughout the experiment (Tab. 2).

Ludwigia erecta

There was no significant difference in percentage germination of six month seeds and freshly shed seeds in the control; the high percentage germination of six month seeds varied significantly from the low percentage germination of new seeds on the three soil media. Seed age affected days to initial germination, six month old seeds germinated significantly earlier than freshly shed seeds. Soil type had no significant effect on days to germination (Tab. 2).

Ludwigia leptocarpa

There was no significant difference in percentage germination of six month seeds of control, loamy, clayey soils and the control of freshly shed seeds, which varied significantly from the low percentage germination of freshly shed seeds in loamy, clayey and sandy soils (Table1). Seed age and soil type affected days to initial germination, and six months old seeds germinated significantly earlier than freshly shed seeds (Tab. 2).

Ludwigia octovalvis

In *L. octovalvis* var *linearis* the high percentage germination (88.60) in six month seeds of the control is significantly different from the 74.20 percentage germination in the freshly

Tab. 1. Media growth mean values of percentage germination of freshly shed seeds and six month old seeds on germination media.

	FRESHLY SHED SEEDS				SIX MONTHS OLD SEEDS			
	CONTROL	LOAMY	CLAYEY	SANDY	CONTROL	LOAMY	CLAYEY	SANDY
Ludwigia abyssinica	94.40a	90.60a	94.20a	94.20a	92.20a	93.40a	92.80a	92.80a
L. adscedens	1.80c	2.40c	1.00c	1.00c	90.80a	90.00a	89.20a	85.20b
L. decurrens var A	5.20f	1.60f	1.40f	13.40f	93.40a	63.20b	38.00c	27.40d
L. decurrens var B	0.00c	0.00c	1.00c	1.00c	39.60a	34.20b	1.60c	1.20c
L. hyssopifolia	93.20a	5.20d	3.40d	32.40c	96.00a	91.60b	91.20b	90.20b
L. erecta	94.20a	16.00e	28.00d	44.00c	94.00a	94.80a	93.80a	86.60b
L. leptocarpa	89.40a	33.80d	34.80d	59.60c	84.40a	86.80a	82.40a	71.80b
L. octovalvis var linearis	74.20b	5.40e	11.80d	15.20d	88.60a	85.80a	77.40b	68.60c
L. octovalvis var brevisepala	32.20c	37.40c	35.20c	34.80c	91.40a	82.40b	85.60a	83.20b

Means in each row followed by the same letter(s) are not significantly different at 5% level of significance

Tab. 2. Media growth mean values of days to initial germination of freshly shed seeds and six month old seeds on germination media.

	FRESHLY SHED SEEDS				SIX MONTHS OLD SEEDS			
	CONTROL	LOAMY	CLAYEY	SANDY	CONTROL	LOAMY	CLAYEY	SANDY
Ludwigia abyssinica	4.20a	4.20a	4.0a	4.40a	4.00a	4.00a	4.20a	4.00a
L. adscedens	17.6a	16.60a	17.00a	17.60a	3.80b	4.20b	4.40b	4.80b
L. decurrens var A	12.60a	12.60a	12.80a	12.40a	3.40b	4.00b	4.20b	3.80b
L. decurrens var B	0.00d	0.00d	7.40a	7.60a	4.60c	4.60c	6.60b	6.80b
L. hyssopifolia	10.20c	11.60b	12.60a	12.80a	3.20ef	4.00d	3.80ed	3.00f
L. erecta	6.40a	6.40a	6.40a	6.60a	4.00b	3.80b	3.80b	4.00b
L. leptocarpa	5.40bc	6.00ba	6.60a	6.60a	4.40d	4.80dc	4.40d	5.40bc
L. octovalvis var linearis	6.00b	6.60ba	6.60ba	6.80a	3.40d	4.40c	4.00dc	4.20c
L. octovalvis var brevisepala	3.60a	3.60a	3.80a	3.80a	3.60a	3.60a	3.80a	3.80a

Means in each row followed by the same letter(s) are not significantly different at 5% level of significance shed seeds of the control; high percentage germinations (85.80, 77.40 and 68.60) in six month seed on the soil media also varied significantly from the very low percentage germinations (5.40, 11.80 and 15.20) in freshly shed seeds of the soil media. The situation is quite similar in *L. octovalvis* var *brevisepala* in which a high percentage germination (91.40) of old seeds in the control is significantly different from low percentage germination (32.20) in the control of freshly shed seeds; high percentage germinations (82.40, 85.60 and 83.20) in six month seeds on soil media also varied significantly from the very low percentage germinations (37.40, 35.20 and 34.80) in freshly shed seeds on the soil media (Tab. 1).

Seed age and soil type affected days to initial germination in *L. octovalvis* var *linearis*, and six month old seeds germinated significantly earlier than all other species throughout the experiment with the exception of *L. hyssopifolia.* (Tab. 2).

Discussion

The very high percentage germination shown by six month old seeds as compared to freshly shed seeds of *Ludwigia adscendens, L. decurrens* var A and B and *L. leptocarpa* reveals that freshly shed seeds of these species exhibit some degree of dormancy and the dormancy was relieved at six months, because the seeds germinated early showing a very high percentage germination. The high percentage germination of six month old seeds and freshly shed seeds of *L. abyssinica*, *L. hysopifolia*, *L. leptocarpa*, and *L. octovalvis* in the control indicate there is no dormancy. The very low percentage germination of freshly shed seeds can be regarded as primary dormancy according to (KARSSEN 1982); this is a state in which freshly shed seeds do not germinate under any set of environmental condition until dormancy is relieved. Six month old seeds are expected to have higher desiccation than freshly shed seeds. Depending on the weed species, desiccation of seeds either improves germination or does not affect germination at all (KARSSEN et al. 1988). Reduced germination at high densities may be a population maintenance mechanism. A weed species can produce seeds copiously under favourable conditions, while having only a few germinating at any time, thus maintaining a seed reservoir over extended periods (PALMBLAD 1968, MUOGHALU and CHUBA 2005). Higher percentage germination in dense arrays will result in greater competition. It is also possible that when several seeds germinate together the combined force of several roots growing simultaneously may help them to penetrate a hard soil. Many plants however have specific requirements for germination and subsequent establishment (YAN 1976).

Soil type might not be a critical factor in the distribution of six month old seeds of *Ludwigia* species because they showed very high percentage germination on all the three types of soils except in *L. decurrens* var A and B in which percentage germination was very low (Tab. 1). The significantly very low percentage germination of freshly shed seeds of (*L. hyssopifolia, L. erecta*, *L. leptocarpa and L. octovalvis* var *linearis)* on the three soils indicates that the higher percentage of freshly shed seeds of these *Ludwigia* species will not germinate immediately on dispersal in their natural habitat. Seed dormancy observed in some *Ludwigia* species will ensure that they survive adverse conditions in their environment as dormant seeds only germinate when the environmental conditions favour the survival of their seedlings. But the very high percentage germination of freshly shed seeds of *L. abyssinica* indicates that the seeds will germinate readily on three types of soils and the plant is not likely to have a soil seed bank. Influence of soil factor on germination of seeds is based on transmittance of light through the soil, which includes particle size, moisture content, particle colour and presence of organic matter (TESTER and MORRIS 1987). Studies have noted the decrease in soil transmittance with decreased particle size (BLISS and SMITH 1985). However, there have been no detailed measurements of the penetration of light through soil mixtures of widely different particle sizes, as would often be found in field situations. Depending on the soil type, moisture content either increases or decreases the light transmittance of the soil. When sand is saturated the transmittance will increase, whereas saturation of clay and loam decreases the transmittance of light. This difference is probably attributed to a reduction in the reflection of light by the soil particles. When the particles are translucent, as in sand, transmission can increase through the particles; but in dark soil, reduced reflection only leads to increased absorption by the particles (BLISS and SMITH 1985). The darker particles are thought to absorb the light. Another explanation is the increased reflection by particles of the paler coloured soils, whereas the reflection in dark soils is lower (TESTER and MORRIS 1987). Six month old seeds are likely to contribute more to plant population in *Ludwigia* species, in which they germinated significantly earlier than freshly shed seeds.

Seed age and soil type have been found to affect germination in the *Ludwigia* species studied. Six month old seeds of *Ludwigia* species are more likely to contribute to plant populations than the freshly shed seeds germination media investigated. Retention of fruits and seeds on *Ludwigia* stems at maturity might be a strategy for maintaining plant population density. There is a need for further investigation of variations because of the very significant higher percentage germination than freshly shed seeds shown by *L.* species on growth media as well as seed germination at one year to determine seed contribution to plant populations at this age.

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