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# Allelopathic Effects of *Ludwigia decurrens* and *L. adscendens* subsp. *diffusa* on Germination, Seedling Growth and Yield of *Corchorus olitorious* L.

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**Abstract**

This study examined the allelopathic effect of *Ludwigia decurrens* and *L. adscendens* exudates on germination, seedling growth (hypocotyl and radicle elongation), seedling mortality, vegetative growth and reproductive yield of *Corchorus olitorious*. *Ludwigia decurrens, L. adscedens* exudates and tap water (control) were applied to seeds of *Corchorus olitorious* over a period of 15 days and to 3 weeks old seedling for a period of 4 weeks. *Ludwigia exudates* had no inhibitory effect on the germination percentage of *C. olitorious,* but the exudates from the two *Ludwigia* spp. induced mortality rate of the 15 day old seedlings (control: 5.00%, *L. decurrens:* 17.50%, *L. adscendens*: 26.88%) and a significant decrease in seedling elongation (hypocotyl and radicle length) of *C. olitorious.* For the vegetative growth experiment, results showed that the stem length, stem fresh weight and leaf area of *C. olitorious* were significantly inhibited during week 6 ($P<0.05$) by *L. decurrens* and *L. adscendens* exudates. For reproductive yield experiment, number of pods per plant was significantly reduced on week 11. The high percentage mortality rate observed in seedlings might be an important factor in reducing seedling survival of *Corchorus olitorious* in habitats where the two *Ludwigia spp* are dominant.

***Keywords:*** *Ludwigi*a, allelopathy, *Corchorus olitorious*, seedling growth, vegetative growth, reproductive yield

## Introduction

Allelopathy refers to the production and exudation of compounds, including secondary metabolites, harmful to other species or their functions and influencing the growth and development of Agricultural and Biological systems (Rice, 1984; Elmore and Abendroth, 2007). These allelopathic effects are due to inhibitory substances (allelochemicals) that are released directly from living plants into the environment through root exudation, leaching, volatilization, and passively liberated through the decomposition of plant residues (Rice, 1984). Many of the allelochemicals are water soluble substances which are affected by several environmental factors (Reigosa *et al*., 1999). Plants can influence each other by allelopathy which is usually harmful (Boonitee and Ritdhit, 1984) while sometimes the effect is beneficial (Newman and Andrews, 1973). There is much evidence that allelochemicals liberated from certain weeds into the soil reduce crop growth (Rice, 1979; Putnam and Tang, 1986). Stinson *et al.* (2006) reported that allelopathy has been demonstrated to play a crucial role in forests influencing the composition of the vegetation growth, while also providing explanation for the patterns of forest regeneration. Allelopathy is rather well documented for a variety of terrestrial plants, but the information on how widespread this phenomenon is among aquatic plant is scanty (Gopal and Goel, 1993).

*Ludwigia* taxa have been classified among the 200 most aggressive world plant invaders (Cronk and Fuller, 1995). The genus *Ludwigia* is a member of the family *Onagraceae* which are flowering plants belonging to the Order Myrtales, comprising 21 genera concentrated in the temperate region of the New World. The family (*Onagraceae*) is characterized by flowers with parts mostly on the plan of four (four sepals, four petals, four or eight stamens) and the ovary is inferior (Chen *et al.,* 1992). The family includes about 640-650 species of herbs, shrubs, and trees in 20-24 genera. The family is widespread on every continent from boreal to tropical regions (Ford and Gottlieb, 2007). The genus *Ludwigia* (primerose-willow) contains 82 species (Zardini *et al*, 1991) and can be found in wet places, especially in warmer parts of the Eastern and the Western hemisphere. Most *Ludwigia* species occur in wet places while a few are predominantly aquatic, ranging from annual herbs to large shrubs (Wogu and Ugborogho, 2000). The large tolerance and adaptation of these taxa to the variations of hydrological and climatic conditions, as well as their strong ability to colonize make them remarkable competitors. Their proliferation induces a silting up of aquatic ecosystems and slowing down of water circulation (Dutartre, 1988).

Members of the section *Oligospermum* (*Ludwigia peploides* (Kunth)) Raven and *L. glandiflora* (Michaux) Greuter and Burdet) to which *L. adscendens* belong have been reported to exhibit allelopathy (Dandelot *et al*., 2008). *L.*

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*adscendens* (Linn) is a perennial herb, creeping over mud rooting at the nodes, or floating and matting, common across the region from Senegal to Southern Nigeria, and generally widespread over the rest of the Tropical Africa, and into the Near East. It is reported to be a weed of rice paddy in The Gambia (Burkill, 1997) and also known for its antibacterial activity (Firoj *et al*., 2005). In aquatic habitats (Fadama) Ile-Ife and its surroundings where vegetables are grown, *L. decurrens* which is an erect annual herb have been observed to form monotypic stands serving as threats to cultivated plants in aquatic habitat.

The genus *Corchorus* is a member of the family *Tiliaceae*, native to tropical and subtropical regions throughout the World (Nath, 1976). *Corchorus olitorious* L., commonly called jute, are tall plants, usually annual herbs. The leaves are altenate, simple, lanceolate, with finely serrated or lobed margin. The flowers are hermaphrodite, and are pollinated by insects. The fruit is a multi-seeded capsule (Norman, 1972). The plant prefers light (Sandy), medium (loamy), and heavy (clay) soils (Epenhuijsen, 1974). It cannot tolerate shady environments and requires moist soil. Seeds of *C. olitorious* (Tossa jute) are small in size, grayish in colour and weight about 1 gram per 1000 seeds. Fresh leaves of *Corchorus olitorious* are a rich source of vitamin A and C. The leaves are used in the treatment of chronic cystitis, gonorrhea, and for toothache (Hillocks, 1998). A cold infusion is used as a tonic to restore the appetite and strength (Sharaf and Negm, 2005). The seeds are used for fever, as a purgative and possess broad antibacterial properties (Pall *et al*., 2006). Jute leaves are consumed in various parts of the world. It is a popular vegetable in West Africa. *Corchorus olitorius* is an important pot herb in Nigeria. Its cultivation spans both the rainy and the dry seasons in Nigeria. In the dry season, irrigation facility is paramount for successful cultivation. However, because of the peculiarity of annual fadama (wetland) cultivation the flora of the cultivated land tends to become predicable and poorly diversified with time. Very few weed species predominate in such cropping systems (Oguyemi *et al*., 2005). This study investigated the allelopathic effects of *Ludwigia decurrens* and *L. adscendens* exudates on the germination, mortality, seedling growth (radicle and hypocotyl elongation), vegetative and reproductive yield of *Corchorus olitorious.*

**Materials and methods**

In March 2009, matured flowering plants of *Ludwigia adscendens* and *L. decurrens* were randomly collected from the wild population along Ede road in Ile Ife and Ilesa. Each species of *Ludwigia* collected was rinsed in clean water to remove debris attached to the roots. Ten plants both of *Ludwigia* spp. were placed into two 10 litres plastic buckets filled with tap water and were placed in the open air for seven days before the plant exudates were used. Tap water was added constantly to maintain a constant volume. *Corchorus olitorious* seeds were purchased from Grow well Agro services stores, Ile-Ife. Twenty seeds of *C. olitorious* were sown in petridishes of 8 cm in diameter lined with Whatman Filter paper no. 1. There were four replicates for each of the treatments to be tested (control (tap water), *Ludwigia adscendens* exudates water, *L. decurrens* exudates water). 2 mls of tap water, 2 mls of *Ludwigia adscendens* exudates water and 2 mls of *L. decurrens* exudates were added daily to each Petridishes of the treatments. For each of the treatments number of germinated seeds and seedling mortality rate were recorded daily for a period of 15 days. Seeds were considered to have germinated at the emergence of the radicle. On the 15 th day five seedlings per treatment were randomly selected from each Petridishes and the radicle and hypocotyl length were measured.

Seeds of *Corchorus olitorious* were sown into a nursery of plastic bowls with the diameter of 23 cm and 12 cm in depth which were perforated at the base to allow good drainage and filled with top soil and watered regularly with tap water. After 2 weeks, germinated plants were transplanted into 12 plastic bowls filled with top soil, at the rate of 10 plants per bowl. There were four replicates for each of the treatments to be tested with tap water (control), *Ludwigia adscendens* exudates water and *L. decurrens* exudates water. Plants were allowed to stabilize for one week. 250 mls of tap water, 250 mls each of *Ludwigia adscendens* and *L. decurrens* exudates water were added every two days to each plastic bucket of the treatments for a period of four weeks. On a weekly basis beginning at the end of the fourth week after germination, destructive analyses were carried out on each treatment by randomly harvesting five plants per treatment. Plants were properly labeled and taken to the laboratory for data collection. The morphological characters scored include the following: Plant Stem Length, Plant Root length, Number of leaves per plant, Leaf Length and breadth, Leaf Area. The Fresh weights (F. W.) and Dry Weights (D. W.) of Stems, Root and Leaves of five plants from each treatment were obtained by weighing each plant on Mettlers Toledo (PB 153) electronic balance immediately after harvest. Each of the plants was package in separate envelopes and dried at $80^0$C in a Gallenkamp (model 1H-150) incubator for two days and weigh to obtain Dry Weights (D. W.). At the end of the $11^{th}$ week five plants were selected from each treatment and the number of pods per plant was recorded. The fresh and dry weights of pods per plant were also determined. Data obtained from germination experiment, destructive analysis and yield experiment during the course of this experiment were subjected to one way analysis of variance and means were separated with Duncan's multiple range test (DMTR), using system analysis software (SAS) version 9.2.

**Results**

Hypocotyl length of *Corchorus olitorious* control was significantly longer than that of the two treatments (*L. de-*

Tab. 1. Mean hypocotyl and radicle length, percentage germination and mortality of *Corchorus olitorious* seeds in the treatments

| Treat-ments | Hypocotyl Length (At day 15) | Radicle Length (At day 15) | Percentage Germination | Percentage Mortality (At day 15) |
|---|---|---|---|---|
| Control | 2.976$^{a}$ | 1.82$^{a}$ | 50.00$^{a}$ | 5.00$^{b}$ |
| *L. decurrens* | 2.01$^{b}$ | 1.26$^{b}$ | 59.38$^{a}$ | 17.50$^{a}$ |
| *L. adscedens* | 2.17$^{b}$ | 1.69$^{ab}$ | 53.13$^{a}$ | 26.88$^{a}$ |

*Values in each column followed by the same letter are not significantly different at P<0.05

*currens* and *L. adscendens* exudates). Radicle length of *C. olitorious* control was significantly longer than that of the two treatments, but with *L. decurrens* having more effect than *L. adscedens*. Percentage germination of *C. olitorious* control was not significantly different from the two treatments. Percentage mortality *C. olitorious* in the control experiment was significantly lower than that of the two treatments (Tab. 1).

Tab. 2. Effect of *Ludwigia decurrens* and *L. adscendens* exudates on vegetative parameters of *Corchorus olitorious* at week 4

| Treatment | Stem Length | Root Length | No.of Leaves | Stem F. W. | Stem D. W. | Root F. W. | Root D. W. | Leaf F. W. | Leaf D. W. | Leaf Area |
|---|---|---|---|---|---|---|---|---|---|---|
| Control | 6.61$^{a}$ | 4.66$^{a}$ | 5.70$^{a}$ | 0.12$^{a}$ | 0.02$^{a}$ | 0.05$^{a}$ | 0.01$^{a}$ | 0.64$^{a}$ | 0.05$^{a}$ | 13.55$^{b}$ |
| *L. decurrens* | 8.23$^{a}$ | 4.74$^{a}$ | 5.60$^{a}$ | 0.19$^{a}$ | 0.02$^{a}$ | 0.09$^{a}$ | 0.02$^{a}$ | 0.38$^{a}$ | 0.07$^{a}$ | 14.56$^{ab}$ |
| *L. adscendens* | 7.55$^{a}$ | 4.50$^{a}$ | 6.00$^{a}$ | 0.18$^{a}$ | 0.02$^{a}$ | 0.10$^{a}$ | 0.02$^{a}$ | 0.38$^{a}$ | 0.06$^{a}$ | 17.21$^{a}$ |

*Values in each column followed by the same letter are not significantly different at P<0.05

Tab. 3. Effect of *Ludwigia decurrens* and *L. adscendens* exudates on vegetative parameters of *Corchorus olitorious* at week 5

| Treatment | Stem Length | Root Length | No. of Leaves | Stem F.W. | Stem D.W. | Root F.W. | Root D.W. | Leaf F.W. | Leaf D.W. | Leaf Area |
|---|---|---|---|---|---|---|---|---|---|---|
| Control | 12.47$^{a}$ | 5.10$^{a}$ | 7.90$^{a}$ | 0.36$^{a}$ | 0.04$^{a}$ | 0.28$^{a}$ | 0.04$^{a}$ | 0.51$^{a}$ | 0.13$^{a}$ | 14.14$^{b}$ |
| *L. decurrens* | 9.44$^{a}$ | 4.65$^{a}$ | 6.90$^{a}$ | 0.33$^{a}$ | 0.03$^{a}$ | 0.15$^{b}$ | 0.04$^{a}$ | 0.63$^{a}$ | 0.11$^{a}$ | 14.84$^{b}$ |
| *L. adscendens* | 12.42$^{a}$ | 4.45$^{a}$ | 7.60$^{a}$ | 0.41$^{a}$ | 0.04$^{a}$ | 0.14$^{b}$ | 0.04$^{a}$ | 0.73$^{a}$ | 0.13$^{a}$ | 19.88$^{a}$ |

*Values in each column followed by the same letter are not significantly different at P<0.05

The stem length of *Corchorus olitorious* control and the two treatments were not significantly different at week 4 and 5 (Tab. 2 and 3). At week 6 and 7, the treatments significantly reduced the stem length, more evident with *L. adscendens* exudates, having more effect than *L. decurrens* exudates (Tab. 4 and 5). The Root length of *Corchorus olitorious* control and the two treatments were not significantly different at week 4, 5 and 7 (Tab. 2, 3 and 5). At week 6, the root length was significantly reduced by the treatments (Tab. 4). Numbers of leaves of *C. olitorious* from week 4 to week 7 for all treatments were not significantly different (Tab. 2, 3, 4 and 5).

Stem F. W. of *C. olitorious* control and the two treatments were not significantly different at week 4 and week 5 (Tab. 2 and 3). At week 6 and week 7 stem fresh weight of *C. olitorious* plants treated with *Ludwigia* exudates were significantly lower than the control plants but with more effect at week 7 in *L. decurrens* (Tab. 4 and 5). Stem D. W. in the control and the two treatments were not significantly different from week 4 to 7 (Tab. 2, 3, 4 and 5).

Root F. W. of *C. olitorious* control and the two treatments were not significantly different at week 4 and 7 (Tab. 2 and 5). Root F. W. of *C. olitorious* control was significantly higher than that of the two treatments at week 5 and 6, but with more effect at week 6 in *L. decurrens* (Tab. 3 and 4). Root D. W. of *C. olitorious* control and the two treatments were not significantly different at week 4, 5 and 7 (Tab. 2, 3 and 5). Root D. W. of *C. olitorious* control was significantly higher than that of the two treatments at week 6 (Tab. 4).

Leaf F. W. and D. W. of *C. olitorious* and control and the two treatments were not significantly different at week

Tab. 4. Effect of *Ludwigia decurrens* and *L. adscendens* exudates on vegetative parameters of *Corchorus olitorious* at week 6

| Treatment | Stem Length | Root Length | No. of Leaves | Stem F. W. | Stem D. W. | Root F. W. | Root D. W. | Leaf F. W. | Leaf D. W. | Leaf Area |
|---|---|---|---|---|---|---|---|---|---|---|
| Control | 23.19$^{a}$ | 11.06$^{a}$ | 9.10$^{a}$ | 1.18$^{a}$ | 0.19$^{a}$ | 0.43$^{a}$ | 0.13$^{a}$ | 1.54$^{a}$ | 0.31$^{a}$ | 18.51$^{a}$ |
| *L. decurrens* | 16.020$^{b}$ | 7.42$^{b}$ | 8.10$^{a}$ | 0.60$^{b}$ | 0.10a | 0.25$^{b}$ | 0.08$^{b}$ | 0.93$^{b}$ | 0.19$^{b}$ | 14.17$^{b}$ |
| *L. adscendens* | 15.31$^{b}$ | 5.01$^{c}$ | 9.50$^{a}$ | 0.60$^{b}$ | 0.14$^{a}$ | 0.33$^{ab}$ | 0.07$^{b}$ | 0.95$^{b}$ | 0.17$^{b}$ | 19.80$^{a}$ |

*Values in each column followed by the same letter are not significantly different at P<0.05

Tab. 5. Effect of *Ludwigia decurrens* and *L. adscendens* exudates on vegetative parameters of *Corchorus olitorious* at week 7

| Treatment | Stem Length | Root Length | No. of Leaves | Stem F. W. | Stem D. W. | Root F. W. | Root D. W. | Leaf F. W. | Leaf D. W. | Leaf Area |
|---|---|---|---|---|---|---|---|---|---|---|
| Control | 24.92[a] | 7.27[a] | 10.00[a] | 1.39[a] | 0.23[a] | 0.43[a] | 0.11[a] | 1.75[a] | 0.39[a] | 20.75[a] |
| *L. decurrens* | 22.14[ab] | 6.80[a] | 10.30[a] | 0.97b | 0.18[a] | 0.30[a] | 0.10[a] | 1.46[a] | 0.35[a] | 20.71[a] |
| *L. adscendens* | 20.21[b] | 5.23[a] | 11.10[a] | 0.99ab | 0.15[a] | 0.36[a] | 0.10[a] | 1.64[a] | 0.34[a] | 20.91[a] |

*Values in each column followed by the same letter are not significantly different at P<0.05

4, 5 and 7 (Tab. 2, 3 and 5). At week 6, Leaf F. W. and D. W of *C. olitorious* control were significantly higher than that of the two treatments (Tab. 4). Leaf Area of *C. olitorious* treated with *L. adscendens* exudates was significantly higher than that of *C. olitorious* control and *C. olitorious* treated with *L. adscendens* at week 4 (Tab. 2). Leaf Area of *C. olitorious* control and the two treatments were not significantly different at week 5 and 7 (Tab. 3 and 5).

Tab. 6. Effect of *Ludwigia decurrens* and *L. adscendens* exudates on reproductive yield of *Corchorus olitorious*

| Treatment | Fresh Pod Weight | Dry Pod Weight | Number of Pods per Plant |
|---|---|---|---|
| Control | 2.48[a] | 0.58[a] | 4.40[a] |
| *L. decurrens* | 1.32[a] | 0.26[a] | 2.60[ab] |
| *L. adscendens* | 1.59[a] | 0.28[a] | 2.40[b] |

* Values in each column followed by the same letter are not significantly different at P<0.05

Fresh and dry weight of pods from the control plants and the two treatments were not significantly different. However, number of pods per plant in the control was significantly higher than that of the two treatments with *L. adscendens* treatment having the lowest number of pods (Tab. 6).

**Discussion**

Allelopathic effect of one plant on another plant could be through the inhibition of seed germination, for example, aqueous extract of root of *Helianthus annus* that delay and inhibits the germination and seedling growth of linseed (*Linum usitatissium* L.) and mustard (*Brassica juncea* L.) (Narwal *et al*., 2002). The two *Ludwigia* spp. exhibited similar effects on the seeds of *C. olitorious*. *Ludwigia decurrens* and *L. adscendens* exudates have had no inhibitory effect on the percentage germination of seeds of *Corchorus olitorious.* This might be due to the fact that seeds protected by their teguments, seem less sensitive to allelochemicals than seedlings (Elakovich, 1999; Quayyum *et al*., 1999). A similar result was obtained by Brucker *et al.* (2003) who found that allelochemicals from the inflorenscence extract of *Ambrosia artemisifolia* did not significantly reduce the germination of seeds of *Amaranthus hypochondriacus.* Dandelot *et al.* (2008) reported a significant reduction in percentage germination of watercress and no reduction in lettuce germination when treated with *L. pepliodes* and *L. grandiflora* exudates.

The hypocotyl and radicle length of *C. olitorious* was inhibited by *L. decurrens* and *L. adscendens* exudates. The two treatments increased the mortality of *C. olitorious* seedlings at day 15. This is similar to the findings of Dandelot *et al.* (2008) in which *Ludwigia peploides* and *L. grandiflora* reduce the seedling elongation and causes an increase in mortality of water lettuce during all season. Allelopathic effect could be concentration dependent as reported by Kayode and Ayeni (2009) when they examined the allelopathic effects of aqueous extracts from Sorghum stem and rice husks on the germination and growth of maize. The extracts brought about considerable inhibitions in the germination of maize seed and in the growth of radicle and plumule. In both extracts, the degree of inhibition increased with the increase of the concentrations of the extracts thus suggesting that the effects of the extracts were concentration dependent. The effect could also depend on the age of plant. (Otusanya *et al*., 2007) examined the susceptibility of *Amaranthus cruentus* Linn. to phytotoxic effects of *Tithonia diversifolia* (Hemsl) A. Results showed that the germination, growth parameters and fresh and dry matter production of *Amaranthus cruentus* were retarded by all four different aqueous extracts applied and the retardation was more pronounced on the older plants of *Amaranthus cruentus.* This explains the mild effects by *Ludwigia* exudates on most growth parameters of *C. olitorious* at later stage of development. The exudates of *L. decurrens and L. adscendens* were observed to retard the stem length of *C. olitorious* by the end of week 5 till the end of the experiment with more inhibitory effect being produced by *L. adscendens* exudates. Allelochemicals from *Wedelia trilobata* L. was also found to reduce the plant height of rice (Chengrong *et al.,* 2005). The root length of *C. olitorious* was inhibited by *L. decurrens* exudates and *L. adscendens* exudates at week 6 with *L. adscendens* exudates producing more inhibitory effect by week 7 root lengths were similar to that of the control experiment. This may be due to the fact that the inhibition of the stem length at week 6 destabilized the root length, but by week 7, the inhibitory effects of the exudates on the root length were outgrown.

The two treatments were first observed to have a stimulatory effect on the leaf area at the beginning of this experiment (week 4) till the end of the week 5, as the leaf area could be seen to be low in the control experiment and in

*C. olitorious* treated with *L. decurrens*. But by week 6, the leaf area were reduced in the two treatments and became similar to the control by the end of the seedling growth experiment. The inconsistent growth in the leaf area may affect the proper growth of plant since reduced leaf area could result in lower photosynthetic capacity for a plant and ultimately limit growth (Sin Clair, 1990; Federics and Comberato, 1995). The pod fresh weight and pod dry weight were similar to that of control in yield experiment, but the number of pod per plant were reduced in *C. olitorious* treated with *L. decurrens* and *L. adscedens* exudates. This may result in a decrease in seed, and production of C. *olitorious* spp. can be limited due to lack of seeds (Adebooye *et al*., 2005).

The mild inhibitory effect of *Ludwigia* exudates on three weeks seedling for the period of study might be as result of *C. olitorious* trying to withstand the concentration of the available allochemicals. According to Gross (2003) allochemicals released by donor oraganism into the water need to be sufficiently hydrophilic and reach their target organisms in effective concentration despite considerable dilution. The effect of *Ludwigia* exudates will be felt more on plants during the dry season when water level is low and many of them flourish in their habitats. The study of allelochemicals in *Ludwigia* will be complex because *Ludwigia* spp. synthesize tannins, trierpines, flavoniods,polyphenols, alkaloids, linoleic acids, saponins, etc (Ghani, 1998) that can in synergy exert either phytotoxic or allelopathic effects (Singhvi and Sharma, 1984). Allelopathic interactions can play a key role since they may alter physiological processes and thus influence the structure of communities (Rice, 1992; Bais *et al*., 2003; Inderjit and Duke, 2003).

In conclusion, exudates of both *Ludwigia decurrens* and *L. adscendens* inhibited early seedling growth of *Corchorus olitorious,* leading to high mortality of the young seedlings. But seedlings that were already established were not affected. Higher concentrations of *Ludwigia* exudates are likely to increase mortality rate of 15 day old seedling. Farmers are advised to cultivate the young seedlings of *C. olitorious* in control nurseries for the first two weeks of germination before transplanting them to the field, because plants will be strong enough to outgrow the effect of *Ludwigia* exudates at this age. There is the need for further studies to be carried out on identifying the inhibiting allelochemicals in the two *Ludwigia* spp. investigated.

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