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Ecological Studies on the Macrohydrophytes in Egypt II. *Ludwigia stolonifera* (Guill. and Perr.) P.H. Raven

M.E. Abu-Ziada
Department of Botany, Faculty of Science, Mansoura University, Mansoura, Egypt

Abstract: The present study contributes information about the environmental factors controlling the distribution, variation in standing crop phytomass and chemical compositional change of *Ludwigia stolonifera*. Also, treatment with cattle manure, as source of organic waste, was made to evaluate the response of the plant to the environmental pollution. The sandy textured bottom sediments of *Ludwigia* habitat at Damira irrigating canal had higher percentages of organic carbon and total soluble salts in spring than in the other seasons while the overlying water was characterized by low total soluble salts. The phytomass and assimilating surface area were increased in spring and summer months and appeared to decline in winter. The phytochemical constituents were highly concentrated during August. As common in hydrophyte, the plant organs of *L. stolonifera* are characterized by abundance of aerenchyma, absence of cork cells and reduction of vascular tissues. Addition of cattle manure to the aquatic habitat of *Ludwigia* plant resulted in an increase of organic carbon, salinity, chloronity and in a decrease of pH value of hydrosoil and water. Heavy metals accumulation showed considerable increase due to application of cattle manure and this appeared to be a reflection to the increased concentrations of these metals in the environment.

Key words: *Ludwigia stolonifera*, macrohydrophytes, environmental pollution

INTRODUCTION

The total length of irrigation and drainage canals in the Egyptian Nile System, is approximately 47000 km. About 87% of the irrigating canals and 74% of the drains are infested with most types of aquatic weeds. This invasion could be explained due to different aspects. The degree of infestation is usually affected by the environmental factors including depth of water, physico-chemical water quality, water currents, sediments type and atmospheric temperature (Abo El-Lil, 1987; Wang *et al*., 1997).

During the last few years, macrohydrophytes have received great attention, not only for the magnitude of problems caused by them in the management of water resources, but also for the promise they hold as a new resource, for such diverse uses as animal fodder, compost, paper, energy (biogas) and above all control of pollution (Gopal, 1987; Pieterse and Murphy, 1990).

The biomass and mineral composition of the macrohydrophytes in relation to water quality in the Nile Delta canals would be very useful in development of any kind of wetland management program (Westlake, 1975). Also Ecological factors that may counteract the existence and vital activities of harmful aquatic weeds must be investigated, enhanced and multiplied.

L. stolinifera is widespread aquatic weed in canals and drains crossing the cultivated lands in the Nile Delta (Täckholm, 1974; Boulos, 2000). As many floating macrohydrophytes, *Ludwigia* plant tends to aggregate and is frequently so dense as to block the whole water way. This weed can spread out from the bank for a considerable distance on account of the floats, which support the plant. It is very easily distributed on account of its seeds being numerous and the fact that small pieces of the plant can root themselves in the mud when broken from the stem (Abo El-Lil, 1987; Khattab and El Gharably, 1990). Many studies evaluate *L. stolonifira* (water primrose) as economic plant, for example: It is used for removing a common agricultural chemicals and contaminants from water and helping to improve drinking water quality, where it took up atrazin from water (Larson, 1999). Because of the pretty and showy flowers, it is being sold as ornamental species (Zardini *et al*., 1991).

The ultimate goal of this study is to give Knowledge about the relation between the habitat conditions and the changes of growth, metabolites content and mineral composition as well as anatomical features of *L. stolonifera* plant, which inhabits many sites at El-Dakahlia province. Also, experimental study was preformed to evaluate the effect of cattle manure as organic pollutant on growth of the plant and accumulation of heavy metals by its organs.

MATERIALS AND METHODS

The site selected for the present study is Damira irrigation canal, which is located at 14 km to the north of Talkha and 6 km to the south of Bilgas (Fig. 1). Its width is about 4 m and water depth rarely exceed 1 m. It is characterized by great masses of *L. stolonifera* (Fig. 2).

The monthly mean of the climatic particulars of El-Dakahlia province during the period 1980-2000 were obtained from the Department of Meteorological, Cairo.

Hydrosoil and subsurface water samples were collected monthly from the study area for a period of one year beginning from February 2000 to January 2001 and analyzed for estimation of their physical and chemical characteristics according to the methods described by Jackson (1962) and American Public Health Association (1985).

The plant samples for growth measurements were collected monthly from naturally growing *Ludwigia* plants using quadrate 1×1 m^2 (Grieg-Smith, 1982). Other plant samples were collected for the phytochemical analyses following the methods recommended by Egyptian Pharmacopoeia (1953) and Handel (1968).

The floristic components of *Ludwigia* community type were recorded in a series of representative stands. The list of species was made including phonological aspect, cover-abundance and presence estimates (Kent and Coker, 1992).

Data of the successive estimations of the biomass and assimilating surface area were applied to assess growth characteristics according to the classical growth analysis which was described by Hunt (1978) and Coombs and Hall (1982).

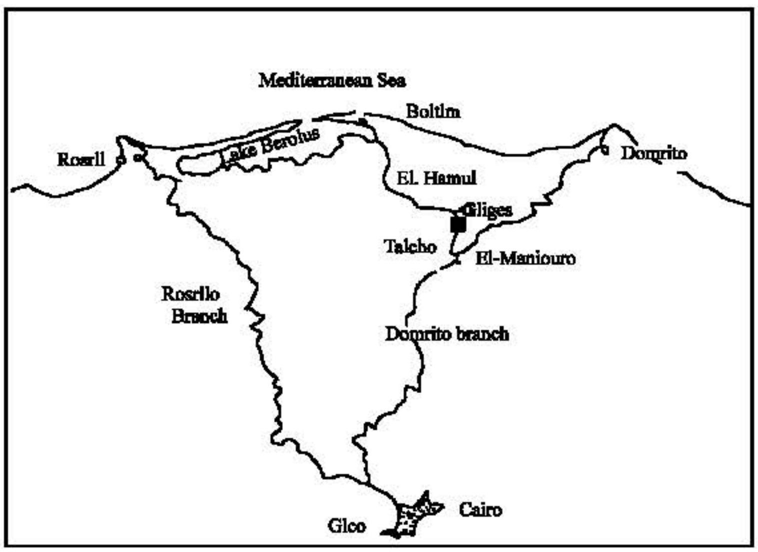

Fig. 1: Location map of the studies site

Fig. 2: General view of *L. stolonifera* stand at Damira irrigation canal

For anatomical investigation, thin sections of aerial stem, offset, leaf and root were prepared according to Peacock and Bradbury (1973).

Organic pollutant experiment: Twenty *Ludwigia* plants representing variable sizes were collected from Damira irrigation canal at mid-June 2001 and transplanted in a ditch (25 m long, 2.5 m width and 47 cm water depth) located at 1 km south of Damira village. At the start of the experiment, other five plants were collected for measuring the growth parameters and quantify the concentrations of the heavy metals in the different plant organs before application of the pollutant. hydrosoil and water samples were collected from the ditch and analyzed (control). Cattle manure was spread on water surface of the ditch at a ratio of 5% (14.68 kg/29375 L water). Five plants were harvested 60, 90 and 105 days after application of the cattle manure. The plants were separated into stems, leaves, floral buds and roots. Their dry weights were detected. Estimation of heavy metals content of both treated and untreated plants was preformed using the procedures described by Allen *et al*. (1986). At each harvesting time, hydrosoil and subsurface water samples were taken and analyzed.

RESULTS AND DISCUSSION

The climatic data of the area in which the plant abundantly grows would be of ecological importance. It is obvious from the data presented in (Table 1) that *L. stolonifera* is subjected to wide seasonal fluctuations of air temperature (6.8°C in January-34.5°C in July), relative humidity (53% in May-71% in November) and evaporative power of air (2 mm/day in January-5.5 mm/day in June). It may be concluded from the foregoing data that the luxuriant growth of *Ludwigia* plant is associated with mild atmospheric conditions caused by low relative humidity and high evaporating power at late spring- early autumn.

Regarding the bottom sediments, data in Table 2 revealed that all soil samples are sandy textured with a sand fraction up to 98 %. The silt particles ranged from 1-9%, whereas clay particles were absent. Porosity attained moderate values allover the year (46.4-57.6%). $CaCO_3$ content was generally low and elevated to 9% in August and October. Organic carbon content (0.8-3.8%) and Total Soluble Salts (TSS) (0.13-0.34%) were relatively higher in spring than in other seasons. Chlorides content was very low (0.01-0.05%), soluble carbonates were absent while sulphates (0.025-0.164%) and bicarbonates (0.031-0.183%) seemed to be the major constituents of soluble salts. Cations determination proved that, among the macroelements Na^+ and Ca^{2+} showed relatively high concentrations (13.8-17.1 and 7.6-12.0 mg/100 g dry soil, respectively), while concentrations of K^+ and Mg^{2+} were very low (1.1-1.6 and 0.8-1.26 mg/100 g dry soil, respectively). The microelements contents were relatively low and each fluctuated within a narrow range. The soil reaction appeared all the time towards the alkaline side (pH: 7.91-8.87).

Analysis of water (Table 3) showed that the water quality was characterized by high organic carbon and low total soluble salts, Cl^-, SO_4^{--} and HCO_3^- during summer months. There were high concentrations of Na^+,Ca^{2+}, K^+ and Mg^{2+} ions, which are important structural components of plant tissues and Mg^{2+} is an essential constituent of chlorophyll. Pb^{2+} and Cd^{2+} have low concentrations while Cu^{2+}, Fe^{3+} and Mn^{2+} concentrations could be considered trace. Water reaction was alkaline allover the year.

On the basis of the above results, it is worthy to note that the chemical components of the overlying water change seasonally rather than spatially. The reverse is nearly the case with the chemical components of the underlying soil. *Ludwigia* plant is known to have low tolerance to salinity and chloronity and usually forms extensive thickets that abound on irrigation canals with

Table 1: Climatic data of El-Dakahlia District during the period taken from Cairo Meteorological Department

		Temperature (°C)					
Months	Rainfall (mm)	Mean max.	Mean min.	Mean daily	Relative humidity (%)	Evaporation (mm/day)	Mean wide velocity (km/h)
January	10.4	19.1	6.8	12.0	70	2.0	5.6
February	7.5	20.6	7.2	12.8	69	2.6	6.4
March	6.8	23.2	9.3	14.8	64	3.4	7.1
April	3.2	27.2	11.9	18.4	57	4.2	7.0
May	4.1	31.0	15.4	22.1	53	5.3	6.1
June	0.6	33.8	18.5	25.1	55	5.5	6.5
July	Tr	34.5	20.4	26.2	66	4.7	4.4
August	Tr	34.4	20.4	26.2	68	4.1	3.8
September	0.1	32.7	18.9	24.6	67	3.8	4.0
October	4.1	30.1	16.9	22.0	65	3.6	4.1
November	6.1	25.7	13.7	18.2	71	2.6	5.1
December	10.2	21.1	9.0	13.5	70	2.1	5.5
Annual mean	53.1	27.8	14.0	19.7	64	3.6	5.5

Table 2: Physical and chemical analysis of soil samples supporting *Ludwigia stolonifera* at Damira irrigation canal

	Physical characteristics				Chemical analysis characteristics analysis of 1:5 soil extract																
	% of soil fractions							Anions (%)				Cations (mg/100g dry wt)									
Month	Sand	Silt	Clay	Porosity	$CaCO_3$ %	OC %	TSS %	Cl^-	SO_4^{2-}	CO_3^{2-}	HCO_3^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	Pb^{2+}	Cd^{2+}	Cu	Fe	Mn^{2+}	pH
February	97	3.0	0.0	56.40	4.0	2.1	0.27	0.030	0.124	Un.d	0.061	16.1	1.2	7.6	1.26	0.06	0.06	0.5	1.6	0.5	8.42
March	96	4.0	0.0	54.70	5.0	1.6	0.23	0.025	0.095	Un.d	0.092	15.6	1.1	8.0	0.98	0.06	0.06	0.6	1.4	0.6	8.63
	91	9.0	0.0	56.20	3.0	1.4	0.25	0.020	0.095	Un.d	0.122										8.22
April	99	1.0	0.0	57.60	5.0	3.6	0.34	0.020	0.164	Un.d	0.107	15.7	1.5	9.0	1.21	0.08	0.06	0.6	1.1	0.6	8.58
	97	3.0	0.0	54.40	4.2	3.4	0.28	0.030	0.124	Un.d	0.107										8.67
May	98	2.0	0.0	57.16	5.6	3.2	0.32	0.010	0.164	Un.d	0.122	15.8	1.6	11.0	1.10	0.08	0.08	0.6	1.1	0.7	8.53
	98	2.0	0.0	53.20	5.0	2.4	0.28	0.010	0.124	Un.d	0.092										8.38
June	97	3.0	0.0	46.40	2.0	1.0	0.29	0.010	0.082	Un.d	0.183	17.1	1.4	10.8	1.06	0.06	0.08	0.4	1.2	0.7	8.40
	93	7.0	0.0	53.60	4.0	1.6	0.23	0.021	0.041	Un.d	0.153										8.87
July	95	5.0	0.0	50.80	3.0	0.8	0.13	0.015	0.025	Un.d	0.061	16.0	1.3	9.2	0.86	0.06	0.05	0.7	1.3	0.6	7.96
	94	6.0	0.0	49.20	5.0	0.8	0.18	0.015	0.049	Un.d	0.092										8.12
August	96	4.0	0.0	56.20	9.0	2.4	0.23	0.050	0.091	Un.d	0.061	15.8	1.1	9.4	0.80	0.08	0.05	0.5	1.2	0.8	8.40
	97	3.0	0.0	53.20	8.0	1.4	0.16	0.020	0.062	Un.d	0.061										8.37
September	98	2.0	0.0	53.60	8.0	2.6	0.25	0.030	0.124	Un.d	0.061	15.1	1.3	8.6	0.96	0.08	0.06	0.7	1.2	0.7	8.36
	96	4.0	0.0	54.40	7.0	2.6	0.18	0.015	0.074	Un.d	0.061										7.91
October	96	4.0	0.0	55.60	5.0	3.4	0.14	0.030	0.049	Un.d	0.031	16.7	1.5	11.4	1.20	0.10	0.06	0.6	1.3	0.7	8.00
	96	4.0	0.0	52.80	9.0	3.8	0.21	0.025	0.135	Un.d	0.031										8.24
November	97	3.0	0.0	53.40	8.0	2.4	0.18	0.025	0.095	Un.d	0.031	15.6	1.4	12.0	1.24	0.06	0.05	0.6	1.3	0.6	8.53
December	96	4.0	0.0	49.60	7.0	1.6	0.13	0.015	0.049	Un.d	0.061	13.8	1.1	8.6	0.98	0.08	0.05	0.7	1.1	0.6	8.23
January	98	2.0	0.0	53.20	5.0	1.0	0.17	0.030	0.092	Un.d	0.031	14.6	1.3	9.1	0.94	0.06	0.06	0.5	1.2	0.7	8.12

Table 3: Analysis of water samples supporting *Ludwigia stolonifera* at Damira irrigation Canal

				Anions ($g\ L^{-1}$)				Cations ($mg\ L^{-1}$)									
Month	Depth (cm)	Organic carbon ($g\ L^{-1}$)	TSS ($g\ L^{-1}$)	Cl^-	SO_4^-	CO_3^-	HCO_3^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	Pb^{2+}	Cd^{2+}	Cu	Fe	Mn^{2+}	pH
February	44	0.15	0.98	0.08	0.518	Un.d	0.305	106	9	31.0	2.4	0.1	0.06	trace	trace	trace	8.81
March	25	0.12	0.74	0.06	0.412	Un.d	0.183	110	10	32.4	2.2	0.09	0.08	trace	trace	trace	8.64
	40	0.03	0.64	0.05	0.214	Un.d	0.244										8.73
April	90	0.42	0.51	0.04	0.165	Un.d	0.183	108	13	35.0	2.6	0.09	0.08	trace	trace	trace	8.73
	46	0.36	0.38	0.03	0.066	Un.d	0.244										8.79
May	95	0.39	0.42	0.04	0.074	Un.d	0.244	106	13	35.4	2.0	0.08	0.07	trace	trace	trace	8.76
	60	0.27	0.44	0.03	0.066	Un.d	0.244										8.58
June	43	0.06	0.68	0.06	0.256	Un.d	0.305	100	12	36.0	2.5	0.05	0.06	trace	trace	trace	8.41
	50	0.12	0.42	0.04	0.074	Un.d	0.244										8.47
July	35	0.15	0.52	0.05	0.115	Un.d	0.305	104	11	34.0	2.4	0.06	0.06	trace	trace	trace	8.69
	60	0.09	0.46	0.04	0.091	Un.d	0.305										8.46
August	40	0.15	0.62	0.10	0.28	Un.d	0.122	100	9	32.0	2.1	0.06	0.06	trace	trace	trace	8.51
	24	0.09	0.54	0.10	0.181	Un.d	0.183										8.60
September	25	0.12	0.59	0.08	0.294	Un.d	0.061	106	10	33.7	2.0	0.06	0.08	trace	trace	trace	8.95
	42	0.12	0.91	0.10	0.412	Un.d	0.366										8.91
October	34	0.18	0.79	0.10	0.206	Un.d	0.427	105	12	37.1	2.1	0.08	0.08	trace	trace	trace	8.91
	44	0.09	0.56	0.05	0.025	Un.d	0.427										8.67
November	35	0.09	0.54	0.08	0.74	Un.d	0.366	100	11	35.4	2.1	0.08	0.06	trace	trace	trace	8.51
December	60	0.12	0.48	0.10	0.298	Un.d	0.061	105	8	34.0	2.3	0.06	0.08	trace	trace	trace	8.48
January	26	0.03	0.51	0.06	0.232	Un.d	0.183	108	10	33.1	2.6	0.08	0.08	trace	trace	trace	8.76

underlying soil of aeolian sand and alluvial fine sediments that become enriched with organic matter produced from decayed offsets and fallen leaves.

It is evident from (Table 4) that this aquatic plant community includes limited number of associates, 12 perennials and 9 annuals. These associates have low presence estimates (5-40%) with exception of *Echinochloa stagnina* and *Eichhornia crassipes* with presence estimates of 65 and 60 %, respectively. *L. stolonifera* being the dominant (p = 100%), is consistently the most abundant. Its growth provides the main bulk of the vegetation cover. The total plant cover ranged from 70 to 100%.

The results obtained from the monthly changes in the standing crop phytomass and assimilating surface area (Table 5 and Fig. 3 and 4) revealed that the vegetative yield of this plant is observed all the year round with prosperous growth in spring and summer months, then declined in winter. Generally, floating hydrophytes show poor growth in winter. Such seasonal fluctuation in the growth may be attributed to temperature changes. These findings are in accordance with Pulish (1985) and Abo El Lil (1987). Regarding the aquatic weeds as energy and biomass resources, El Habibi *et al.* (1988) pointed out that the annual biomass production of free-floating hydrophytes was greater (3-10 folds) than those of both emergent and submerged ones.

The density of *L. stolonifera* appeared to increase gradually from 98 stem m^{-2} in January to 174 stem m^{-2} in September. The maximum height of the stem was 78.5 cm in September. Again, the highest number of leaves/stem (26.6) was recorded in September and the lowest leaf nomber/stem (16.1) was in January. Several studies confirmed this trend (Ho, 1979; Dinka, 1986). Concerning the influence of soil and water on growth of *L. stolonifera*, it is concluded that the biomass accumulation and assimilating surface area tended to be enhanced by decrease in salinity and pH range of 8.22-8.95.

Examining of the growth characteristics showed that the monthly changes of Relative Growth Rate (RGR), Relative Assimilating Surface Growth Rate (RASGR) and Net Assimilating Rate (NAR) were more or less similar. Their changes correspond to each other as demonstrated in (Fig. 5-10). High RGR was attained during the early stages of growth but at maturity the RGR and RASGR appeared to decline. The Leaf Weight Rate (LWR), Leaf Area Rate (LAR) and Specific leaf area (Spec. LA) were generally high. This may be_related to the high rate of photosynthesis. These results are in accordance with that obtained by Sale *et al.* (1985).

Dealing with the phytochemical investigation of *Ludwigia*, the results in Table 6 revealed that the highest values of acid-insoluble ash, total lipids, total nitrogen, sucrose and total soluble sugars were observed in the leaves, while those of total ash, water-soluble ash, crude fiber and total carbohydrates were met within the stems. Most of these constituents appeared to predominate during summer (August). The pattern of changes in reducing sugars and sucrose as well as in total carbohydrates appeared to be closely correlated with plant organs and stage of development and seems to coincide with the increases in all growth parameters of the plant. It is perhaps relevant to mention here that the photosynthetic efficiency was increased leading to enhancement of biosynthesis of carbohydrates, which are utilized in the growth of the plant. The present results seem to be in good agreement with those obtained by Pomogyi *et al.* (1984) and Serag *et al.* (1999).

Concerning the minerals content, it is clear from Table 7 that, in all seasons, *Ludwigia* leaves accumulate amounts of K^+ and Ca^{2+} higher than those accumulated by stems and roots, whereas Na^+ appeared to exhibit the highest values in root. Mg^{2+} content showed an irregular pattern of monthly variation. With respect to Fe^{3+} content, the roots accumulated the highest amount of this element. Cu^{2+} content of the leaves appeared to be less than that of the other plant parts. It maintained the highest value during March and the lowest value during October.

Regarding the anatomy of aerial stem and offset of *L. stolonifira* (Fig. 11 and 12), there is a single layered epidermis composed of thin walled cells that possessed a thin cuticular covering. Cortex is highly developed with a distinctive middle region made of aerenchymatous cells enclosing well-developed intercellular spaces. The vascular tissues are poorly developed, forming continuous cylinder traversed by narrow rays. The xylem vessels are moderately small and thicker walled in offset than in aerial stem. Sclerenchyma and cork cells appeared to be generally absent. The leaf is dorsiventral with distinct palisade and spongy tissues (Fig. 13). The palisade tissue appeared to enclose large spaces while the spongy tissue is mainly aerenchymatous. Raphides are commonly found in the spongy cells. The root is characterized by lacking of cuticle and root hairs from the epidermis. Cortex is composed of aerenchyma cells with large air spaces separated by one-cell-thick septa. The vascular system is represented by simple stellar structure (Fig. 14).

Organic pollution experiment: With regard to changes of hydrosoil characters, data in Table 8 revealed that the addition of cattle manure to the aquatic habitat resulted in an increase of organic carbon, salinity, chlorides and some cations contents. In accord with this finding,

Table 4: Monthly variation in the floristic composition of permanent stand dominated by *Ludwigia stolonifera* at Damira irrigation Canal

	Months																				
	Feb.	Mar.		Apr.		May.		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.	Dec.	Jan.	
No. of visits	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Total plant cover (%)	95	98	95	95	100	100	100	100	80	75	98	90	100	95	100	70	80	90	95	100	P%
Perennials																					
Ludwigia stolonifera (Guill. &Perr)	7gr	9gr	9gr	9gr	8fl	9fl	9fl	8gr	7fl	5fl	5gr	10gr	9gr	10fl	7gr	7gr	6gr	7gr	7gr	7gr	100
Echinochloa stagnina (Retz.) P.Beauv	2gr	3gr	3gr	2gr	3gr	2gr	3gr	-	3gr	3gr	3gr	-	-	-	-	-	-	3gr	1gr	1gr	65
Eichhorina crassipes (C.Mart.) Solms.	-	-	-	3gr	3gr	3gr	6gr	5fl	-	9gr	5gr	5fl	-	+d	-	-	-	6gr	6gr	5gr	60
Cyperus alopecuroides Rottb	-	1gr	1gr	1gr	-	-	-	-	-	3fl	-	-	-	4fl	3fl	-	5fl	2fl	-	-	40
Cynodon dactylon (L.) Pers	1gr	-	1gr	1gr	1gr	3gr	-	-	-	-	-	-	-	-	-	-	-	-	2gr	2gr	35
Phragmites australis (Cav.) Trin. Ex Steude	-	-	-	-	+gr	1gr	1gr	1gr	-	1gr	-	-	-	-	-	-	-	-	-	1d	35
Cyperus rotundus L.	1gr	-	1gr	-	-	-	-	-	3gr	-	-	-	-	-	-	-	-	1gr	1gr	1gr	30
Ipomoea carnea Jacq.	-	2gr	2gr	-	-	-	-	-	-	5fl	-	2fl	2fl	-	-	-	-	-	-	1gr	25
Persicaria salicifolia (Willd). Assenov	-	-	-	-	-	3fl	3fl	-	-	2fl	3fl	-	-	-	-	-	-	-	-	-	20
Mentha Longifolia (L.)Huds	-	1fl	1fl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1gr	1gr	20
Lemna gibba L.	-	-	-	-	-	-	-	-	-	-	-	-	5gr	-	-	-	-	-	1gr	1gr	15
Convolvulus arvensis L.	-	-	-	-	1gr	1gr	-	3fl-	-	-	-	-	-	-	-	-	-	-	-	-	15
Saccharum spontaneum L.	-	-	-	-	-	-	-	-	3fl	-	-	-	-	-	-	-	-	-	1gr	1gr	
Annuals																					
Rumex dentatus L.	+gr	-	1gr	1gr	2fl	1gr	1fl	1fr	2fr	-	-	-	-	-	-	-	-	-	1gr	1gr	50
Chenopodium murale L.	-	-	1gr	1gr	1gr	2gr	-	-	-	-	-	-	-	-	-	-	-	2fl	2fl	1fl	35
Conyza bonariensis (L.) Cronquist	-	1gr	1gr	1gr	-	-	-	-	2gr	-	-	-	-	-	-	-	-	-	-	-	20
Echinochloa colona (L.) Link Hort.	-	-	-	-	-	-	-	-	-	-	-	1fl	1fl	-	2fr	2fr	-	-	-	-	20
Malva parviflora L.	-	-	1gr	1gr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15
Polypogon monospeliensis (L.) Desf.	-	-	-	-	1fl	1fl	1fl	-	-	-	-	-	-	-	-	-	-	-	-	-	15
Medicago sativa L.	-	-	1gr	1gr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
Echinochloa crus-galli (L.) p.Beauv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1fl	-	-	-	-	-	5
Portulaca oleracea L.	-	-	-	-	-	-	-	-	-	-	-	1gr	-	-	-	-	-	-	-	-	5

gr: Green, fl: Flowering, fr: Fruiting, d: Dry and P: Presence

Table 5: Monthly variation in vegetative yield of *L. stolonifera* growing at Damira canal

Date of sample	Parameters	Studied plants 1	2	3	4	5	6	7	8	9	10	Mean	No. of stems/m^2	Assimilating surface area (cm^2/m^2) Leaf area	Stem area	Total	Biomass content (g.dry et./m^2) Leaf	Stem	Total
Feb.	H	33	32	30	35	33	37	36	27	30	28	32.1	98	753.2	475.6	1234.2	32.6	112	144.6
	L	17	17	16	18	17	17	18	15	17	15	16.6							
	N	16	15	14	16	15	15	16	12	16	13	14.8							
Mar.	H	38	41	33	37	30	36	42	40	36	39	38.2	110	847.8	523.9	1371.7	39.0	120	159.0
	L	17	19	16	15	16	17	19	18	17	16	17.0							
	N	15	17	15	13	15	15	17	16	15	14	15.2							
Apr.	H	45	50	52	48	51	39	46	42	36	42	45.1	124	1872.4	914.2	2786.6	45.8	154	199.8
	L	17	18	19	18	18	16	18	19	17	18	17.8							
	N	15	17	17	16	16	15	16	17	15	16	16.0							
May.	H	50	57	50	48	52	54	48	46	54	52	51.1	136	6573.2	1754.3	8327.5	64.2	178	242.2
	L	19	20	18	18	17	18	17	17	19	18	18.1							
	N	17	18	17	16	15	16	15	16	17	17	16.4							
Jun.	H	56	65	57	62	58	45	48	56	59	62	56.8	148	16432.4	8741.6	25174.0	112.0	192	304.0
	L	20	19	19	21	19	17	18	18	17	18	18.6							
	N	18	17	18	19	17	15	16	17	15	16	16.8							
Jul.	H	63	66	65	60	68	73	58	65	63	60	64.1	154	25132.0	1316.4	26448.4	124.0	226	350.0
	L	20	21	22	19	24	29	19	24	21	19	21.8							
	N	18	19	19	18	21	26	17	20	19	16	19.3							
Aug.	H	76	66	75	80	79	66	70	73	62	57	70.4	168	31281.0	1611.0	32892.0	137.0	320	457.0
	L	27	21	26	28	29	21	26	24	20	19	22.2							
	N	25	18	22	27	25	20	23	22	19	18	21.9							
Sep.	H	66	80	75	82	65	73	97	80	74	93	78.5	174	37641.0	1892.7	39533.7	159.0	338	497.0
	L	22	29	26	29	20	24	32	28	26	30	26.6							
	N	20	28	25	27	18	21	30	25	22	26	24.2							
Oct.	H	70	65	68	65	66	52	60	67	53	51	61.7	151	27134.2	1463.1	28597.3	146.4	260	406.4
	L	26	20	24	24	21	19	19	26	18	18	21.5							
	N	24	19	21	23	19	17	18	24	17	16	18.8							
Nov.	H	60	48	50	53	46	53	45	53	60	53	52.1	126	26713.2	1365.7	28078.9	118.1	242	360.1
	L	20	18	19	18	17	18	17	19	20	19	18.5							
	N	19	17	18	16	16	17	16	17	18	17	17.1							
Dec	H	32	39	38	29	36	34	36	30	31	38	34.3	100	22156.3	1178.2	23334.5	89.0	154	243.0
	L	17	17	16	16	17	17	18	17	17	17	16.9							
	N	15	16	14	15	16	15	17	15	16	15	15.4							
Jan	H	29	32	30	26	25	29	24	26	28	33	28.2	87	624.9	398.5	1023.4	38.4	160	198.4
	L	16	17	17	16	15	16	15	16	16	17	16.1							
	N	14	13	15	14	12	15	12	14	14	14	13.7							

H = Height of stems, L = Leaf number per stem and N = Node number per stem

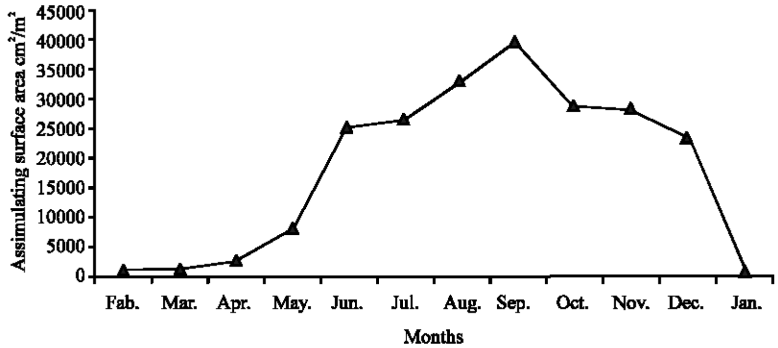

Fig. 3: Monthly variation in biomass content of *L. stolonifera*

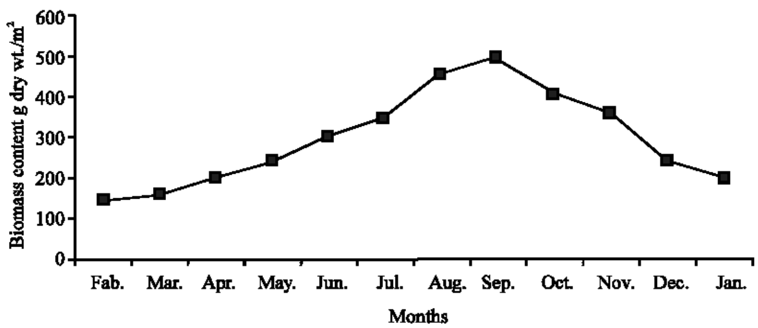

Fig. 4: Monthly variation in assimilating surface area of *L. stolonifera*

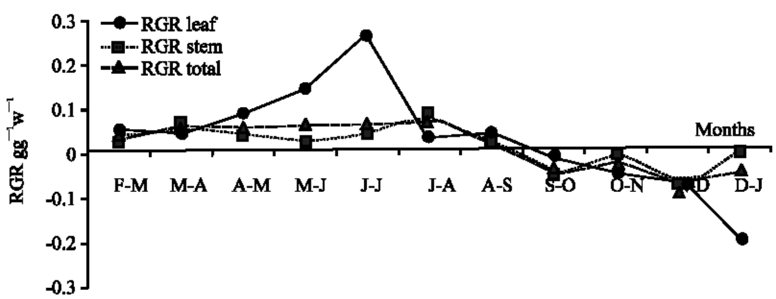

Fig. 5: Monthly variation in relative growth rate of *L. stolonifera*

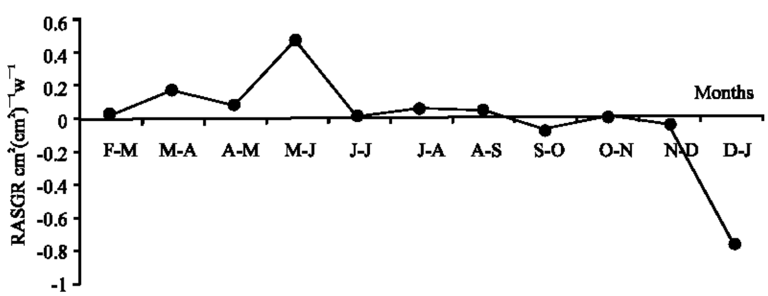

Fig. 6: Monthly variation in relative assimilating surface growth rate of *L. stolonifera*

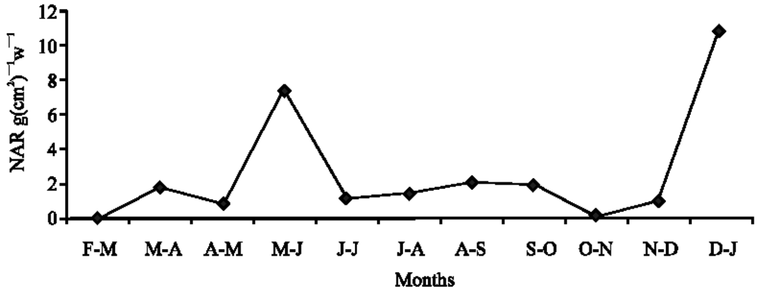

Fig. 7: Monthly variation in net assimilating rate of *L. stolonifera*

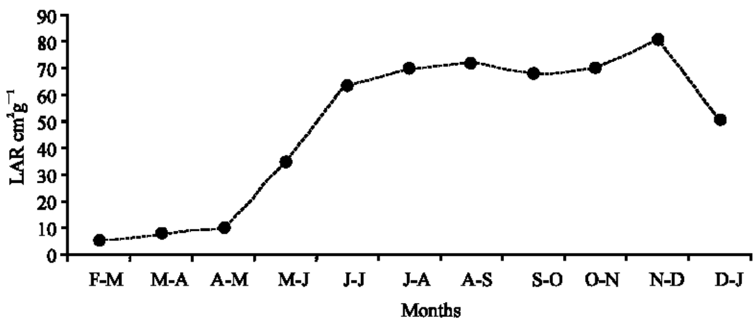

Fig. 8: Monthly variation in leaf area ratio of *L. stolonifera*

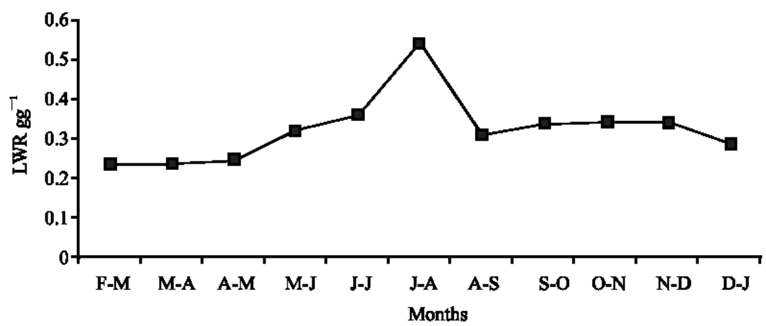

Fig. 9: Monthly variation in leaf weight ratio of *L. stolonifera*

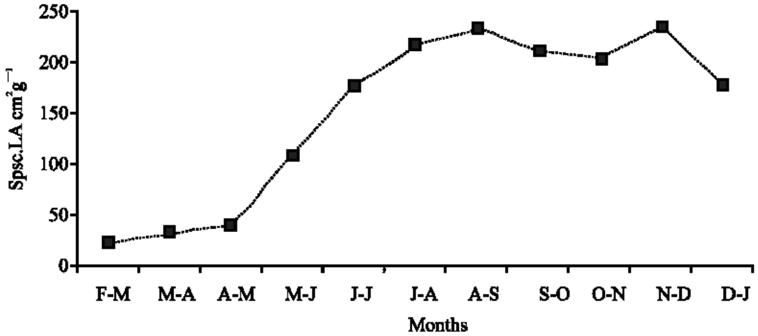

Fig. 10: Monthly variation in specific leaf area of *L. stolonifera*

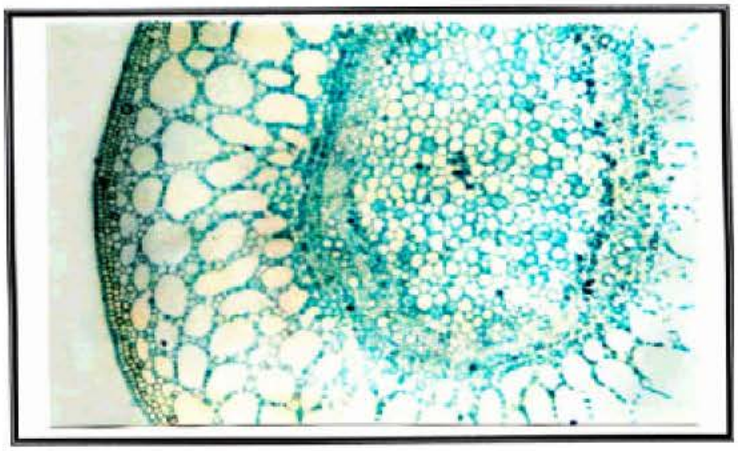

Fig. 11: Light microscopy of transverse section of stem of *L. stolonifera*

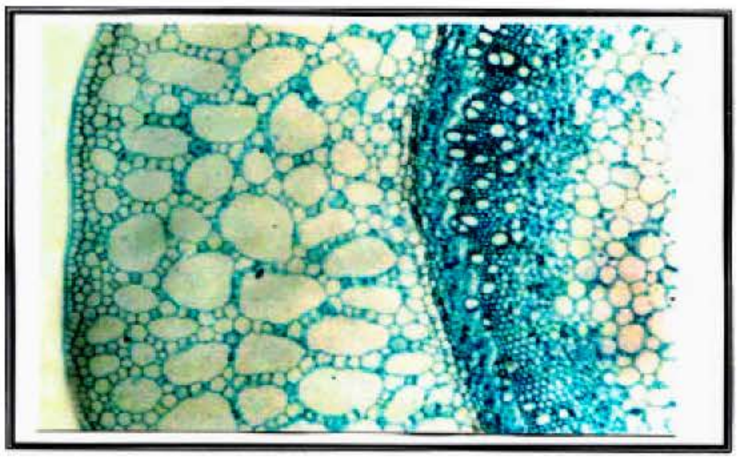

Fig. 12: Light microscopy of transverse section of offset of *L. stolonifera*

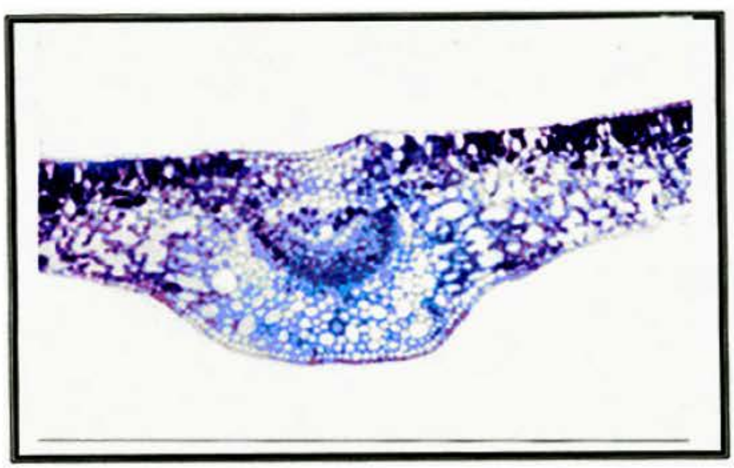

Fig. 13: Light microscopy of transverse section of leaf of *L. stolonifera*

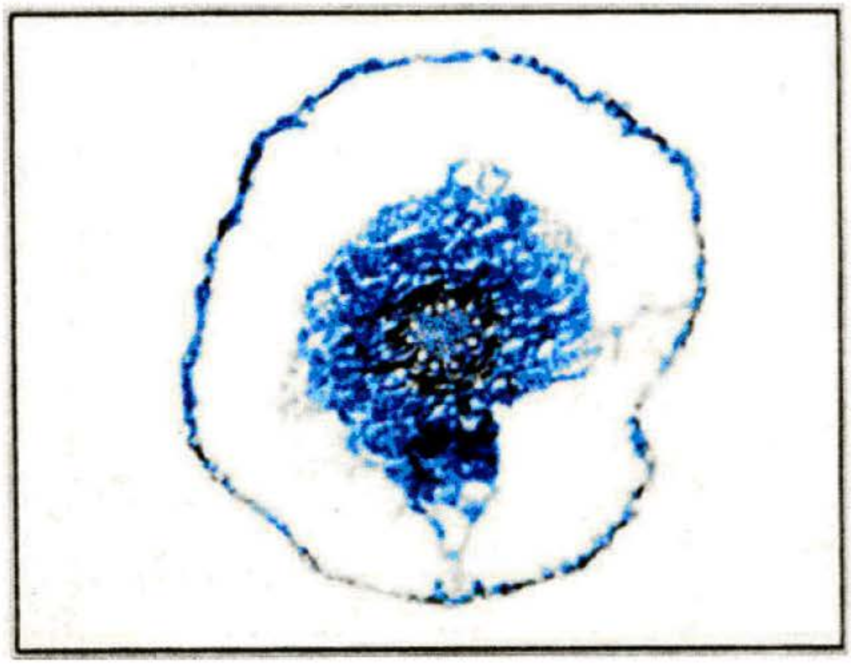

Fig. 14: Light microscopy of transverse section of root of *L. stolonifera*

Table 6: Analysis of *Ludwigia stolonifera* plants growing at Damira Canal

	Total ash (%)		Water-soluble ash (%)		Acid-insoluble ash (%)		Crude fibers g/100 g dry wt.		Total lipid g/100 g dry wt.	
Month	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem
February	9.9±0.61	10.3±0.80	3.61±0.24	7.40±0.60	3.75±0.25	2.62±0.14	10.00±0.90	15.10±1.10	2.10±0.16	1.90±0.14
March	9.6±0.52	9.8±0.62	3.48±0.21	6.05±0.50	3.12±0.21	2.45±0.45	10.30±0.91	16.60±1.32	2.30±0.20	1.60±0.12
April	10.7±0.80	11.1±0.93	4.80±0.39	8.12±0.69	4.20±0.30	3.10±0.21	17.30±0.24	18.24±1.41	2.16±0.17	1.90±0.13
May	10.2 ±0.80	10.4±0.90	4.00±0.31	6.74±0.54	3.80±0.27	2.76±0.15	11.15±0.92	23.60±1.72	1.82±0.14	1.86±0.13
June	11.4±0.92	11.5±1.00	3.82±0.26	7.60±0.60	2.65±0.12	2.10±0.12	11.59±0.93	15.95±1.34	1.96±0.16	1.92±0.14
July	12.3±0.94	12.7±1.10	4.30±0.30	9.40±0.74	3.82±0.27	2.12±0.12	18.80±1.31	16.70±1.41	2.16±0.14	1.60±0.12
August	13.2±1.10	13.6±1.20	4.60±0.35	10.40±0.90	4.24±0.31	3.15±0.21	19.80±0.46	21.85±1.96	1.70±0.12	1.40±0.11
September	12.8±0.93	13.0±1.10	4.42±0.30	10.00±0.90	4.00±0.29	3.00±0.23	19.8±1.48	24.20±2.00	2.12±0.17	2.00±0.17
October	11.9±1.00	12.1±1.10	3.90±0.24	9.40±0.71	3.54±0.24	2.43±0.16	13.85±1.12	23.60±2.10	1.98±0.15	1.70±0.12
November	11.2±0.96	11.6±0.94	3.49±0.21	8.55±0.64	2.76±0.18	2.12±0.12	14.20±1.10	18.50±1.53	2.10±0.17	1.90±0.17
December	10.6±0.74	11.0±0.90	3.90±0.27	8.21±0.60	2.91±0.20	1.92±0.96	12.80±0.96	20.00±1.74	1.90±0.14	1.60±0.12
January	10.2±0.80	10.4±0.82	4.10±0.31	7.56±0.64	3.70±0.28	2.57±0.15	11.20±1.00	19.00±1.64	2.20±0.18	1.50±0.11

Table 6: Continued

	Total nitrogen mg/100 g dry wt.		Sucrose mg/100 g dry wt.		Total soluble sugars mg/100 g dry wt.		Total carbohydrates g/100 g dry wt.	
Month	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem
February	1.23±0.11	0.31±0.02	0.61±0.04	0.51±0.04	3.22±0.24	2.46±0.21	18.10±1.2	26.1±2.1
March	1.16±0.09	0.28±0.02	0.58±0.04	0.43±0.04	2.82±0.18	2.41±0.16	18.90±1.6	25.7±2.2
April	1.10±0.12	0.24±0.02	0.59±0.03	0.43±0.03	2.95±0.20	3.36±0.17	19.71±1.6	28.8±1.9
May	1.12±0.09	0.26±0.10	0.620±0.05	0.44±0.03	2.99±0.21	2.84±0.20	19.80±1.7	29.1±2.0
June	1.04±0.08	0.32±0.02	0.612±0.05	0.46±0.02	3.00±0.25	2.56±0.19	19.60±1.1	27.4±2.3
July	1.10±0.11	0.30±0.02	0.60±0.04	0.42±0.03	3.10±0.24	2.60±0.21	19.92±1.6	27.6±1.8
August	1.18±0.08	0.24±0.01	0.61±0.04	0.46±0.03	3.23±0.24	2.76±0.21	20.14±1.7	27.1±1.8
September	1.20±0.09	0.31±0.02	0.60±0.05	0.51±0.04	3.27±0.26	2.51±0.19	19.20±1.6	28.9±2.2
October	1.36±0.11	0.34±0.02	0.58±0.03	0.50±0.04	3.31±0.30	2.42±0.19	18.42±1.4	27.1±2.4
November	1.21±0.10	0.28±0.02	0.56±0.03	0.46±0.03	3.21±0.24	2.51±0.20	18.80±1.4	27.2±2.4
December	1.18±0.11	0.24±0.01	0.59±0.04	0.48±0.03	3.14±0.26	2.30±0.18	18.10±1.6	27.4±2.5
January	1.29±0.12	0.31±0.02	0.57±0.04	0.45±0.04	3.18±0.26	2.46±0.21	17.43±1.2	27.1±2.3

Table 7: Monthly variation in elements content of *Ludwigia stolonifera* plant growing at Damira Canal

	Na^+ mg/100 g dry wt.			K^+ g/100 g dry wt.			Ca^+ g/100 g dry wt.		
Month	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root
February	0.61±0.04	0.66±0.05	0.76±0.06	1.82±0.14	1.76±0.13	1.48±0.11	0.41±0.13	0.38±0.03	0.36±0.03
March	0.61±0.04	0.64±0.04	0.74±0.05	1.84±0.14	1.81±0.14	1.42±0.10	0.42±0.03	0.36±0.03	0.38±0.03
April	0.62±0.04	0.68±0.05	0.76±0.06	1.86±0.15	1.82±0.14	1.51±0.12	0.43±0.03	0.36±0.02	0.38±0.03
May	0.64±0.04	0.69±0.06	0.79±0.06	1.91±0.15	1.82±0.14	1.46±0.11	0.45±0.04	0.34±0.02	0.36±0.03
June	0.65±0.05	0.66±0.05	0.74±0.05	1.86±0.14	1.86±0.15	1.43±0.10	0.47±0.04	0.36±0.03	0.38±0.03
July	0.65±0.05	0.69±0.05	0.74±0.05	1.94±0.16	1.86±0.15	1.51±0.12	0.48±0.04	0.35±0.03	0.36±0.03
August	0.66±0.05	0.69±0.05	0.74±0.05	1.98±0.17	1.81±0.14	0.48±0.11	0.49±0.04	0.37±0.03	0.38±0.03
September	0.66±0.05	0.67±0.05	0.76±0.06	1.95±0.16	1.87±0.15	1.46±0.10	0.47±0.04	0.37±0.03	0.33±0.02
October	0.62±0.04	0.66±0.05	0.75±0.06	1.89±0.15	1.78±0.13	1.56±1.12	0.43±0.03	0.38±0.03	0.32±0.02
November	0.62±0.04	0.64±0.04	0.71±0.05	1.96±0.17	1.82±0.14	1.51±0.12	0.41±0.03	0.36±0.03	0.32±0.02
December	0.61±0.04	0.64±0.04	0.74±0.05	1.94±0.16	1.79±0.13	1.53±0.12	0.410.03	0.36±0.02	0.37±0.03
January	0.62±0.05	0.66±0.05	0.78±0.06	1.89±0.15	1.81±0.14	1.48±0.10	0.42±0.03	0.38±0.03	0.37±0.03

Table 7: Continued

	Mg^{2+} mg/100 g dry wt.			Fe^{3+} mg/100 g dry wt.			Cu^{2+} mg/100 g dry wt.		
Month	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root
February	0.26±0.02	0.28±0.02	0.21±0.01	7.8±0.61	7.6±0.61	9.2±0.80	0.61±0.04	0.71±0.05	0.92±0.07
March	0.29±0.02	0.26±0.02	0.22±0.01	7.2±0.52	7.1±0.52	8.4±0.72	0.56±0.04	0.76±0.06	0.94±0.07
April	0.28±0.02	0.26±0.02	0.24±0.01	6.8±0.51	7.0±0.52	8.6±0.78	0.61±0.04	0.66±0.05	0.86±0.07
May	0.31±0.02	0.28±0.02	0.23±0.01	7.4±0.52	7.1±0.52	7.9±0.70	0.61±0.04	0.71±0.05	0.91±0.07
June	0.26±0.02	0.26±0.02	0.23±0.01	7.4±0.52	6.8±0.51	7.8±0.68	0.59±0.04	0.72±0.05	0.84±0.06
July	0.26±0.02	0.27±0.02	0.24±0.01	6.8±0.51	7.2±0.52	8.1±0.69	0.58±0.04	0.73±0.05	0.82±0.06
August	0.28±0.02	0.24±0.01	0.22±0.01	7.2±0.52	7.2±0.25	8.2±0.69	0.56±0.04	0.68±0.05	0.74±0.05
September	0.26±0.02	0.24±0.01	0.23±0.01	7.4±0.52	7.6±0.61	8.8±0.78	0.62±0.04	0.62±0.04	0.79±0.06
October	0.26±0.02	0.27±0.02	0.21±0.01	7.6±0.61	7.3±0.61	8.6±0.75	0.61±0.04	0.68±0.05	0.72±0.05
November	0.24±0.01	0.26±0.02	0.24±0.02	7.6±0.61	7.4±0.52	8.2±0.72	0.62±0.04	0.73±0.05	0.81±0.06
December	0.26±0.02	0.28±0.02	0.24±0.01	7.3±0.52	7.6±0.61	8.4±0.72	0.62±0.04	0.72±0.05	0.86±0.07
January	0.26±0.02	0.26±0.02	0.22±0.01	7.2±0.25	7.2±0.25	8.3±0.72	0.61±0.04	0.68±0.05	0.84±0.06

Table 8: Periodical changes in soil samples supporting *Ludwigia stolonifera* during the experiment of cattle manure effect

	Physical characteristics				Chemical analysis characteristics analysis of 1:5 soil extract																
	% of soil fractions							Anions (%)				Cations (mg/100 g dry wt)									
Date of sampling	Sand	Silt	Clay	Porosity	$CaCO_3$ (%)	OC (%)	TSS (%)	Cl^-	SO_4^{--}	CO_3^-	$HCO^-_3{}^-$	Na^+	K^+	Ca^{2+}	Mg^{2+}	Pb^{2+}	Cd^{2+}	Cu^{2+}	Fe^{3+}	Mn^{2+}	pH
15 June	95.0	5.0	0.0	50.0	1.3	3.0	0.180	0.015	0.062	Un.d	0.061	18.4	1.3	11.6	2.13	0.117	0.10	Un.d	Un.d	Un.d	8.64
15 August	96.5	3.5	0.0	54.7	1.9	8.5	0.195	0.035	0.077	Un.d	0.186	19.8	0.6	11.9	2.13	0.180	0.10	Un.d	Un.d	Un.d	8.39
15 September	97.0	3.0	0.0	53.5	2.6	7.5	0.220	0.023	0.099	Un.d	0.061	19.9	1.7	11.7	2.50	0.170	0.08	Un.d	Un.d	Un.d	8.14
30 September	96.0	4.0	0.0	54.4	2.6	7.0	0.260	0.015	0.074	Un.d	0.061	21.9	1.7	12.2	2.60	0.170	0.09	Un.d	Un.d	Un.d	7.91

Table 9: Periodical changes in water samples supporting *Ludwigia stolonifera* during the experiments of cattle manure effect

				Anions ($g L^{-1}$)				Cations ($mg L^{-1}$)									
Date of sampling	Depth (cm)	Organic carbon ($g L^{-1}$)	TSS ($g L^{-1}$)	Cl^-	$So^-_4{}^-$	CO^-_3	$HCO^-_3{}^-$	Na^+	K^+	Ca^{2+}	Mg^{2+}	Pb^{2+}	Cd^{2+}	Cu^{2+}	Fe^{3+}	Mn^{2+}	pH
15 June	47	0.09	0.55	0.05	0.165	Un.d	0.153	105	10.6	30.7	2.1	0.06	0.05	Un.d	Un.d	Un.d	8.44
15 August	23	0.12	0.58	0.1	0.231	0.06	0.275	105	12	34	2.2	0.06	0.06	Un.d	Un.d	Un.d	8.56
15 September	34	0.12	0.75	0.09	0.35	0.06	0.214	107	11	33.4	2.1	0.06	0.07	Un.d	Un.d	Un.d	8.93
30 September	25	0.12	0.91	0.1	0.412	0.06	0.366	108	11	34.2	2.3	0.07	0.08	Un.d	Un.d	Un.d	8.91

Ismail *et al.* (1996) had concluded that cattle manure was the richest material to induce total amounts of Pb^{2+}, K^+, Fe and Mn^{2+} in comparison with the other organic wastes sources (sewage sludge and town refuse). Concerning the changes of water characters, it might be concluded from the results in Table 9 pH were slightly increased. At the end of the experiment, the % of total soluble salts, Cl^-, SO^{--}_4 and HCO^-_3 reached their highest values. It is interesting to note that, soluble carbonates were detected in water after treating with cattle manure. The highest values of Na^+, Mg^{2+}, Pb^{2+} and Cd^{2+} (10.8, 2.3, 0.07 and 0.08 mg L^{-1}, respectively) were obtained at the third harvesting period. The results obtained from vegetative growth measurements (Table 10) showed that cattle manure was able to elevate the vegetative growth at all harvesting periods compared to control plants.

Table 10: Periodical changes in vegetative yield of *L. stolonifera* during the experiment of cattle manure effect

	Start of experimental 15/6/2001						First harvest 15/8/2001						Second harvest 15/9/2001						Third harvest 30/9/2001					
	Aerial shoots						Aerial shoot						Aerial shoot						Aerial shoot					
Parameters	1	2	3	4	5	Mean	1	2	3	4	5	Mean	1	2	3	4	5	Mean	1	2	3	4	5	Mean
Height	17	18	10	13	13	14.2	22	27	28	32	25	26.8	52	64	60	40	40	51.200	90	84	70	65	62	74.2
Node No.	11	8	9	9	8	9.0	13	17	16	19	15	16.0	25	22	24	20	24	23.000	30	27	28	27	29	28.2
Leaves No.	13	9	12	11	9	10.8	15	20	20	20	19	19.0	31	30	29	28	30	29.600	34	30	31	32	22	29.8
Flowers No.	0.0	0.0	0.0	0.0	0.0	0.0	1	4	2	2	1	2.0	11	8	10	7	5	8.200	9	3	6	7	2	5.4
Fruits No.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2	2	4	7	5	4.00	8	6	7	9	5	7.0
Branches No.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8	8	13	9	9	9.400	6	16	10	7	17	11.2
Leaves wt.	0.16	0.082	0.11	0.107	0.11	0.1147	0.855	1.118	0.158	1.416	1.222	1.154	1.367	1.657	1.599	1.261	1.326	1.442	3.389	3.315	1.573	1.567	1.066	2.184
Stem wt.	0.30	0.234	0.120	0.150	0.161	0.193	0.303	0.446	0.641	0.820	0.406	0.523	1.043	1.536	1.359	0.926	0.961	1.165	3.836	3.171	1.661	1.584	0.953	2.241
Root wt.	0.007	0.005	0.005	0.002	0.006	0.005	0.058	0.07	0.122	0.115	0.082	0.089	0.020	0.050	0.050	0.006	0.034	0.054	0.100	0.048	0.070	0.019	0.022	0.052
Flowers wt.	0.0	0.0	0.0	0.0	0.0	0.0	0.001	0.023	0.010	0.020	0.002	0.011	0.096	0.072	0.072	0.039	0.037	0.063	0.060	0.021	0.035	0.045	0.002	0.033
Fruits wt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.109	0.074	0.048	0.429	0.323	0.255	0.180	0.153	0.268
Total plant wt.	0.470	0.321	0.235	0.259	0.277	0.312	1.217	1.657	1.931	2.371	1.712	1.777	2.526	3.315	3.315	2.241	2.432	2.772	7.823	6.878	3.594	3.395	2.196	4.777
Leaf A.S.A	21.5	14.01	19.56	18.08	18.27	18.28	327.2	276.04	313.07	354.46	169.19	307.99	404.5	576.71	576.71	375.66	434.94	462.31	236.64	1207.8	564.8	504.55	488.7	800.49
Stem A.S.A	10.68	11.31	6.28	8.17	8.16	8.92	14.00	21.21	14.08	20.36	12.57	16.444	26.15	50.29	50.29	25.46	25.46	33.11	70.71	79.86	35.19	32.68	519.8	49.92
Total A.S.A	32.18	25.32	25.84	26.25	26.43	27.204	341.2	297.25	327.15	374.82	281.76	324.43	430.6	627.0	627.0	401.12	460.4	495.42	307.35	1287.66	599.99	537.23	519.88	850.41

Table 11: Periodical changes in heavy metals content of *L. stolonifera* during the experiment of cattle manure effect

Date of sampling	Plant organs	Cu	Fe	Mn^{2+}	Pb^{2+}	Cd^{2+}
15/June	Leaf	0.54	0.63	Trace	0.31	Trace
	Stem	0.63	0.71	Trace	0.34	Trace
	Root	0.81	0.82	0.28	0.36	Trace
	Floral bud	0.21	0.20	Trace	Trace	trace
15/August	Leaf	0.56	0.68	Trace	0.33	Trace
	Stem	0.64	0.71	Trace	0.36	Trace
	Root	0.62	0.86	0.29	0.39	Trace
	Floral bud	0.23	0.24	Trace	Trace	Trace
15/September	Leaf	0.58	0.72	Trace	0.32	Trace
	Stem	0.68	0.73	Trace	0.36	Trace
	Root	0.84	0.84	0.29	0.38	Trace
	Floral bud	0.23	0.21	Trace	Trace	Trace
30/ September	Leaf	0.61	0.72	Trace	0.32	Trace
	Stem	0.68	0.73	Trace	0.36	Trace
	Root	0.84	0.82	0.29	0.38	Trace
	Floral bud	0.24	0.21	Trace	Trace	Trace

Concerning the total biomass and the total assimilating surface area, both were increased approximately to 6 and 12 folds, respectively at the first harvesting period and to 15 and 30 folds, respectively at the third harvesting period. As regards the heavy metals accumulation by *L. stolonifera*, it is obvious from (Table 11) that the concentration of most metals showed progressive increases due to application of cattle manure. Cyerman and Kempers (2001) reported that, the increased concentrations of heavy metals in plants seem to be a reflection of the increased concentrations of these metals in the environment. As evident from the experimental results, all tested heavy metals were much higher in the roots than in stems, leaves and floral buds. Mn^{2+} was recorded with detectable values in the floral buds only. Cd^{2+} was detected as traces in the different plant organs. These results are in agreement with those obtained by Sprenger and McIntosh (1989) and Ali and Soltan (1999).

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