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BIOLOGY OF *EVOLVULUS ALSINOIDES* (L.) L. AND *E. NUMMULARIUS* (L.) L.: EFFECT OF LIGHT INTENSITY, SOIL MOISTURE AND POPULATION DENSITY

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The effect of available light intensity, soil moisture and population density was evaluated on the growth behaviour of *Evolvulus alsinoides* (L.) L. and *E. nummularius* (l.) L. in pot culture experiment. Both the species responded similarly to the change in light intensity and soil moisture regimes with higher growth performance under highlight intensity and low soil moisture regimes. However, *E. nummularius* exhibited higher vegetative growth as compared to *E. alsinoides* whereas the latter showed higher reproductive growth than the former. It was also observed that *E. alsinoides* showed the ability to absorb density stress whereas *E. nummularius* is sensitive to increased population density. Hence it may be concluded that higher tolerance of low light intensity and low moisture regime, higher reproductive effort under stressed situations and ability to absorb population density stress by *E. alsinoides* may be attributed to its wide spread distribution in various habitats than *E. nummularius* in Alwar district of Rajasthan.

Keywords: Biomass; Density stress; Flowers; Fruits; Leaf area.

Introduction

Available light intensity and soil moisture influence the growth behaviour of plant species. Low light intensity stress decreased leaf thickness, photosynthesis and biomass but increased leaf area and chlorophyl[1] concentration in *Glycyrrhiza uralensis* Fisch[1]. In *Centella asiatica* plants, 30 per cent shading exhibited higher biomass, however, the plantlets root system showed higher biomass under full sunlight[2]. Similarly soil moisture stress also affects the growth of plant species[3,4]. Decreasing light intensity caused increase in leaf area with the result that light captured by the leaves increased[5]. Thus phenotypic plasticity is the environmental modification of genotypic expression and an important means by which individual plants respond to changing environment[6].

Evolvulus alsinoides (L.) L. and *E. nummularius* (L.) L. are perennial herbs (Convolvulaceae). The latter is an introduced species from North and South America which is a weed of grassy lawns and road sides in some parts of India. *E. alsinoides* is an indigenous medicinal species spreading upto 60 cm with stout stem and covered with long ferruginous hairs[7]. This species has been reported to grow commonly on gravel hill soil throughout Rajasthan[7] and Delhi area[8]. The review of literature suggests that a few studies have been undertaken to understand the biology of *Evolvulus alsinoides* and *E. nummularius* in general and so far no attempt has been made to study the ecology of these weeds particularly in Rajasthan. Hence, an attempt has been made to evaluate the role of population density, light intensity and soil moisture on the growth of these weedy species.

Material and Methods

Mature seeds of *E. alsinoides* and *E. nummularius* were collected from R.R.College campus and stored in the paper bags in the laboratory. The low light intensity was maintained by covering a net house with muslin cloth from inside while in the other net house the high light intensity conditions were maintained wihtout covering by muslin cloth. Both the net houses were covered by a thin sheet of polythene to protect them against rainfall. The available light intensity was measured in both the net houses by luxmeter (Table 1). Excess seeds were sown in earthen pots (diameter 23cm) filled with thoroughly mixed garden soil. Established seedlings were thinned down to three density levels *i.e.* 2, 4, 6 each for *E. alsinoides* and *E. nummularius*. Nine replicates were maintained for each set of both species. One set of established plants of each

Table 1. Light intensity and soil moisture maintained in pot experiment (±SE).

Observation periods	High light intensity (100 lux)	Low light intensity (100 lux)
August 2009	930.4±39.24	282.±4.23
September 2009	954.2±51.69	28.8±2.58
	High soil moisture	Low soil moisture
August 2009	17.03±3.5	9.3±0.42
September 2009	15.4±0.83	9.42±0.24

Table 2. Growth characteristics of *Evolvulus alsinoides* and *Evolvulus nummularius* in high light intensity and high soil moisture (±SE).

Parameters	III Harvest					
	Evolvulus alsinoides Density per pot			*Evolvulus nummularius* Density per pot		
Vegetative growth	2	4	6	2	4	6
Number of shoot / plant	1.25 ± 0.25	1.25 ± 0.25	1	2.5 ± 0.8	2.5 ± 0.3	2.83 ± 0.2
Length of shoot (cm)	6.25 ± 1.1	7.75 ± 3.4	10.1 ± 0.01	23.5 ± 4.5	21.8 ± 4.6	13.5 ± 1.8
Nuber of leaf/plant	17 ± 2.7	24.7 ± 9.6	37.6 ± 2.09	68.7 ± 28.1	49.7 ± 9.6	44 ± 6.7
Petiole length (mm)	2.25 ± 0.25	2.5 ± 0.5	2.1 ± 0.16	5 ± 0.7	3.75 ± 0.41	3.5 ± 0.2
Leaf area/plant (mm2)	67 ± 15	101 ± 21	103 ± 10	273 ± 27	179 ± 21	179 ± 24
Leaf area/pot (mm2)	135 ± 30	406 ± 85	621 ± 65	547 ± 54	716 ± 86	1076 ± 14
Root length (cm)	3.8 ± 0.7	4.5 ± 0.6	4.8 ± 0.16	627 ± 0.65	6.5 ± 0.01	6.5 ± 0.4
Biomass / plant (gm)	0.15 ± 0.12	0.12 ± 0.07	0.11 ± 0.03	0.56 ± 0.22	0.26 ± 0.0	0.17 ± 0.02
Biomass / pot (gm)	0.3 ± 0.24	0.24 ± 0.14	0.66 ± 0.18	1.12 ± 0.44	1.04 ± 0.0	1.02 ± 0.12
Reproductive growth						
Number of fertile plant/pot	1	1	3	*	*	*
Length of peduncle (cm)	0.7	1.1	1.5	*	*	*
Length of pedicle (cm)	3	4	4	*	*	*
Number of flower/plant	0.5	1.5	2 ± 1.1	*	*	*
Number of fruit / plant	0	2.5 ± 2.5	1.33 ± 1.33	*	*	*
Number of seed / plant	0	9 ± 0	5.33 ± 5.33	*	*	*
Number of seed / pot	0	9 ± 0	15.99 ± 15.9	*	*	*

(* No reproductive growth)

species with three density levels was placed in high light intensity conditions and the other set of each species was placed in low light conditions.

Similarly in the high light intensity regime two soil moistures levels were maintained. In high soil moisture level each pot was provided 400ml water daily and in low soil moisture level each pot was provided 400ml water on alternate days. The 400ml of water was found to be enough for watering a pot without any leakage of excess water from the pore of the pot.The soil moisture content of pots was estimated (Table 1). Hence, one set of each species was maintained at high soil moisture level and another set at low soil moisture level. Three harvests were taken, first harvest was taken in the end of August 2009, second harvest in the end of September and third harvest in the end of October. The vegetative and reproductive characters of harvested plants were measured. Then the entire plant was dried at 80°C for 48 hours in a hot air oven for estimating dry biomass following Misra[9].

Results and Discussion

Effect of light intensity: The leaf area per plant of *Evolvulus alsinoides* was 67, 101 and 103 cm^2 at high light intensity level whereas it was 98, 55 and 98 cm^2 at low light intensity at density levels 2, 4 and 6 plants per pot respectively (Table 2). The corresponding values for *E. alsinoides* for biomass per plant were 0.15, 0.12 and 0.11 gm at high light intensity and 0.06, 0.03 and 0.05

gm at low light intensity (Table 3). These observations suggest that this species exhibited higher vegetative growth at high light intensity. Incase of *E. nummularius,* the leaf area per plant was 273, 179 and 179 cm^2 at high light intensity whereas it was 188, 155 and 159 cm^2 at low light intensity at dnesity levels 2, 4 and 6 plants per pot respectively. The corresponding values for this species for biomass per plant were 0.56, 0.26 and 17 gm at high light intensity and 0.11, 0.07 and 0.05 gm at low light intensity regimes. Similar trend was observed with respect to other growth parameters (Table 2,3). These observations indicate that *E. nummularius* showed higher vegetative growth than that of *E. alsinoides* at both the light intensity levels. Both species exhibited higher growth under highlight intensity conditions, however, their response response to density stress was different. *E. alsinoides* exhibited increased growth with increase in density whereas *E. nummularius* showed decrease in growth with increase in population density.The growth of roots seems to be not affected by the light intensity level in both the species. The root length of *E. alsinoides* was 3.8, 4.5 and 4.8 cm at high light intensity whereas it was 6.12, 3 and 4.8 cm at low light intensity at density levels 2, 4 and 6 plants per pot. Incase of *E. nummularius,* the corresponding values for root length were 6.3, 6.5 and 6.5 cm at high light intensity and 6.1, 7.6 and 6.9 cm at low light intensity. Contrary to vegetative growth E. alsinoides exhibited higher reproductive growth than that of *E. nummularius* (Table 2,3). A few plants of the former species produced flowers and fruits at all density levels whereas none of the latter species produced flowers in the experimental pots.

Effect of soil moisture level: The leaf area per plant of *E. alsinoides* was 67, 101 and 103 cm^2 at high soil moisture level whereas it was 128, 156 and 222 cm^2 at low soil moisture level at density levels 2, 4 and 6 plants per pot respectively (Table 2,4). The corresponding values for biomass per plant of *E. alsinoides* were 0.15, 0.12 and 0.11 gm at high soil moisture level and 0.07, 0.3 and 0.74 gm at low moisture level. Incase of *E. nummularius,* the leaf area per plant was 273, 179 and 179 cm^2 at high soil moisture level and 551, 236 and 230 cm^2 at low soil moisture level at density levels 2, 4 and 6 plants per pot respectively . The corresponding values for biomass per plant in *E. nummularius* were 0.56, 0.26 and 0.17 gm at high soil moisture level and 3.44, 0.28 and 0.32 gm at low soil moisture level. At low soil moisture level, the root length was 4.12, 5.75 and 6.3 cm in *E. alsinoides* and 8, 8.87 and 7.0 cm in *E.nummularius* at density level 2, 4 and 6 plants per pot respectively. Both species exhibited increase in root length at low soil moisture level, however, their response to density stress was different at low soil moisture level. The root length increased in *E. alsinoides* whereas it decreased in *E. nummularius* with increase in density stress. These observations suggest that both the species exhibited higher vegetative growth at low soil moisture level.

Unlike vegetative growth, the reproductive growth of *E. alsinoides* was more than that of *E. nummularius.* The former species produced flowers and fruits at all density levels whereas the latter produced fruits only at low soil moisture level at population density 2 plants per pot (Table 2,4). The fruit production was higher in *E. alsinoides* at low soil moisture level as compared to that at high soil moisture level .

The results obtained suggest that *Evolvulus alsinoides* and *E. nummularius* exhibited higher growth rate at high light intensity. *E. nummularius* showed higher vegetative growth than *E. alsinoides* under both light intensity regimes, however, the former exhibited more reduction in leaf area and biomass per plant than that of the latter when grown under low light intensity. This indicates that *E. alsinoides* is better adapted to shade conditions than *E. nummularius.* This is in agreement with Lio *et al.*[10] who reported that shade intolerant species have greater plasticity than shade tolerant species. Similar observations were also made by other workers[11,12]. The leaf area per plant in *E. alsinoides* showed a tendency to increase under low light intensity which is in conformity with Hou *et al.*[1] who suggested that low light intensity stress decreased biomass and increased leaf area. However, incase of *E. nummularius* leaf area per plant also decreased under low light intensity which indicates that it is a sun loving species. Both the species exhibited higher vegetative growth at low soil moisture level, however, the increase in leaf area and biomass per plant was higher in *E. nummularius* than that of *E. alsinoides* at low soil moisture level. Although both the species showed higher vegetative growth at low soil moisture level under highlight intensity, the increase in leaf area and biomass per plant in *E. nummularius* was almost threefold. This further suggets that this species exhibits more plasticity than *E. alsinoides* under similar situations.

In contrast to vegetative growth, *E. alsinoides* exhibited higher reproductive growth than *E. nummularius* under high light intensity and low soil moisture regimes. The latter species did not produce flowers and fruits in experimental pots except at low density level under low soil moisture regime while the former produced seeds in all treatments with higher seed production at low soil

Table 3. Growth characteristics of *Evolvulus alsinoides* and *Evolvulus nummularius* in low light intensity and high soil moisture (±SE).

Parameters	III Harvest					
	Evolvulus alsinoides			*Evolvulus nummularius*		
Vegetative growth	Density per pot			Density per pot		
	2	4	6	2	4	6
Number of shoot / plant	1	1	1	2.75 ± 0.47	2.25 ± 0.2	1.91 ± 0.31
Length of shoot (cm)	8.63 ± 4.17	5.43 ± 0.01	6.5 ± 1.08	9.25 ± 1.3	6.25 ± 10	8.54 ± 0.97
Nuber of leaf/plant	14 ± 8.3	9.12 ± 2.24	13.5 ± 1.94	22 ± 2.6	17.8 ± 2.7	16.4 ± 1.9
Petiole length (mm)	2.5 ± 0.28	2 ± 0	2.4 ± 0.14	3 ± 0.4	2.75 ± 0.16	2.6 ± 0.18
Leaf area/plant (mm2)	98 ± 32	55 ± 15	98 ± 17	188 ± 39	155 ± 18	159 ± 21
Leaf area/pot (mm2)	196 ± 65	221 ± 60	586 ± 102	375 ± 77	619 ± 71	954 ± 126
Root length (cm)	6.12 ± 1.6	3 ± 0	4.8 ± 1.3	6.1 ± 0.8	7.6 ± 0.8	6.9 ± 0.5
Biomass / plant (gm)	0.06 ± 0.04	0.03 ± 0.01	0.05 ± 0.01	0.11 ± 0.01	0.07 ± 0.81	0.05 ± 0.006
Biomass / pot (gm)	0.24 ± 0.16	0.13 ± 0.04	0.31 ± 0.06	0.22 ± 0.02	0.29 ± 3.24	0.3 ± 0.03
Reproductive growth						
Number of fertile plant/pot	1	*	0.5±-0.5	*	*	*
Length of peduncle (cm)	*	*	0.1±0.9	*	*	*
Length of pedicle (cm)	*	*	0.5±0.5	*	*	*
Number of flower/plant	*	*	0.16±0.16	*	*	*
Number of fruit / plant	1±0.05	*	0.08±0.08	*	*	*
Number of seed / plant	4±2.02	*	0.33±0.33	*	*	*
Number of seed / pot	4±4.0	*	0.165±0.165	*	*	*

(* No reproductive growth)

Table 4. Growth characteristics of *Evolvulus alsinoides* and *Evolvulus nummularius* in high light intensity and low soil moisture (±SE).

Parameters	III Harvest					
	Evolvulus alsinoides			Evolvulus nummularius		
Vegetative growth	Density per pot			Density per pot		
	2	4	6	2	4	6
Number of shoot / plant	1	2.12 ± 0.58	2.75 ± 0.41	4.25 ± 0.25	3.25 ± 0.16	2.91 ± 0.28
Length of shoot (cm)	6.8 ± 2.2	12.2 ± 3.5	33.2 ± 6.5	70.5 ± 4.7	31.7 ± 5.2	31.5 ± 4.5
Nuber of leaf/plant	10.7 ± 2.8	23.5 ± 5.7	69.0 ± 15.65	349.7 ± 213.8	49 ± 0.88	51.7 ± 7.7
Petiole length (mm)	2 ± 0	2.5 ± 0.18	2.91 ± 0.19	8.75 ± 1.10	3.62 ± 0.32	4.16 ± 0.24
Leaf area/plant (mm2)	128 ± 24	156 ± 34	223 ± 21	551 ± 275	236 ± 22	230±16
Leaf area/pot (mm2)	256 ± 48	624 ± 136	1336 ± 126	1103±551	946 ± 87	1384±100
Root length (cm)	4.12 ± 0.59	5.75 ± 0.81	6.3 ± 0.43	8±0.7	8.87 ± 0.7	7.0±0.54
Biomass / plant (gm)	0.07 ± 0.02	0.30 ± 0.14	0.74 ± 0.18	3.44 ± 6.8	0.28 ± 0.06	0.32±0.06
Biomass / pot (gm)	0.14 ± 0.04	1.2 ± 0.56	4.44 ± 1.08	6.88 ± 13.6	1.12 ± 0.24	1.92±0.36
Reproductive growth						
Number of fertile plant/pot	0.5	0.3	6	2	*	*
Length of peduncle (cm)	0.5±0.5	1.02±0.5	2.66±0.33	0	*	*
Length of pedicle (cm)	0.5±0.5	0.33±0.16	0.82±0.06	3.5±0.25	*	*
Number of flower/plant	1.5±1.5	3.25±2.67	38.25±21.7	8±2.4	*	*
Number of fruit / plant	0	2.75±0.01	19±6.51	11±3.0	*	*
Number of seed / plant	0	11±7.8	60±25.5	40.2±11	*	*
Number of seed / pot	0	3.3±2.34	360±153	80.4±22	*	*

(* No reproductive growth)

moisture regime. Hence it may be suggested that *E. alsinoides* makes more reproductive effect than *E. nummularius* in varying environmental situations. The latter species produced seeds only when they were large enough with more than 500 mm leaf area per plant while the former produced seeds when leaf area per plant was very low. The amount of minimum biomass accumulated during vegetative growth seems to have no effect on initiation of flowering in these species.

Although both species showed similar pattern of growth under varying light and soil moistures regimes, their response to density stress was quite distinct. *E. alsinoides* exhibited the ability to absorb density stress whereas *E. nummularius* was very sensitive to density stress. This characteristic feature of the former species enables it to tolerate the stress caused by the presence of associated herbacious species. It may be infered that the tolerance of low light intensity and low soil moisture level, higher reproductive effort under stressed situations and ability to absorb density stress may be attributed to the more wide spread distribution of *E. alsinoides* than *E. nummularius* in various habitats in the Alwar district of Rajasthan.

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