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Autecology of *Scoparia dulcis* Linn.

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Scoparia dulcis Linn. (family Scrophulariaceae), a common herbaceous plant, is a widely distributed species found at Varanasi all the year round along the pathways, roadsides, irrigation channels, in wastelands both under open and shade. The plants grow abundantly in rainy season. Seedling appearance takes place in dense patches, but most of them disappear gradually. Flowering starts in October and fruit formation in November. From the beginning of the rainy season onwards new plants keep on appearing as the seeds germinate in flushes. Plants start drying in the last week of December from the apex downwards.

Seeds are light-sensitive and without dormancy.

Freshly collected seeds show 100% germination and require 25°C optimum temperature for germination.

Seed output and reproductive capacity are quite high. Productivity increases with the advancement of the age of the plant and attains the peak at the beginning of fruiting. Biomass attains its peak at the time of fruit maturation.

Energy content of leaf and stem increases till the flowering stage and of root till the fruiting stage. Nitrogen content (%) in leaf and root increases till the flowering stage and in stem till the early flowering stage.

Significant correlationship between nitrogen and energy accumulation in different parts of *S. dulcis* was observed at the two studied sites.

Keywords: *Scoparia dulcis* **Linn., Autecology, Reproductive capacity, Primary production (Biomass and nutrients)**

Introduction

Scoparia dulcis Linn., a member of family Scrophulariaceae, is a widely distributed species. It was first described by Linnaeous in 1953 and is of South American and West Indies origin. It first appeared in India in 1843 (Ridley 1930). It is an erect, branched, herbaceous plant, 30–80 cm in height found growing all the year round along the pathways, roadsides, hedges, irrigation channels and in wastelands and under the shade of trees.

The plants grow abundantly in rainy season or often in wet areas during other seasons of the year at Varanasi.

Autecology of the species was studied to understand its behaviour (which is so successful in its wide occurrence) at various stages of the life cycle.

Materials and Methods

The phenology, seed output, reproductive capacity, dry matter production, nitrogen accumulation and energy content in different parts of *S. dulcis* were determined at the monthly intervals from seedling stage to fully matured stage. Two sites inside the B.H.U. campus, viz. (i) road side near Hindi Department building, and (ii) wasteland between the buildings of Geology and Chemistry departments were selected for the study.

The reproductive capacity of *S. dulcis* was determined by the method outlined by Salisbury (1942). It is the product of the average seed output and the fraction represented by the percentage germination.

To study biomass and productivity of *S. dulcis* in its natural habitats, the plants were sampled from both sites at the monthly intervals from the seedling (30 days age) to the declining phase of the plant. The harvested materials were oven-dried at 80°C for about 48 hrs. The dry weights of plant parts as well as of complete plants were determined. The productivity (g/plant/day) was calculated from the gain in dry weights at monthly intervals.

Energy content (Kcal/g dry weight of the plant material) was determined by Parr Oxygen bomb calorimeter using the following formula:

$$C = \frac{(W_1 \times \triangle t) + (W_2 \times \triangle t)}{W} \text{ Cal/g of oven dry weight}$$

where C is the Energy content of plant material; W—Weight of pellet; W_1—Water equivalent of bomb vessel (532 in present case); W_2—Volume of water taken (1350 ml in present case); and $\triangle t$—rise in temperature.

Total nitrogen content of the plant was determined by using the method described by Piper (1944) and the % nitrogen was calculated by using the following formula:

$$\%nitrogen = \frac{(T - B) \times N \times 1.4}{S}$$

where T is the Volume of HCl used in actual titration; B—Volume of HCl used in blank titration; N—Normality of HCl; S—Weight of material taken (in g).

Observations and Results

Phenology

The description about the nature and life cycle of *S. dulcis* much varies. Hooker (1885) mentioned it as an annual herb; Gamble (1915)—as a glabrous undershrub; and Kanjilal and Das (1939)—as an annual, semiwoody, foetid plant. The present field observations showed it as mostly an annual, but in some moist places some individuals persist and behave as a perennial.

The seeds lying on the soil surface start germinating after a few showers of rain in June/July when a vigorous sprouting of *S. dulcis* also takes place from the old stumps. After a month or so the shoots start flowering and fruiting. The seeds produced by these sproutings, germinate and produce seedlings. The new plants flower in October and fruit in November. From the beginning of the rainy season onwards new plants keep on appearing as the seeds germinate in flushes. Thus in a population of individuals of various ages, some plants can also be found in flowering and fruiting stages in rainy and winter seasons. Those plants which do not succumb in summer and behave as perennials, continue to flower in several flushes. Seeds are dispersed by bursting of capsule. Plants start drying from apex downwards in the last week of December. But the field observations and experimental studies show that where the moisture supply is maintained, the new branches arise from the green stem base while the older branches dry.

Vegetative propagation

In moist places the root system of *S. dulcis* remains functional throughout the year. Due to this feature even if the aerial parts of this plant are clipped completely, it is capable of regenerating new leafy branches from the base of clipped stem. Plants developed in this way grow vigorously soon after rains. In this process the lower part of the stem becomes brown woody and gives an appearance of a perennial herb.

Seedling mortality

Seedlings appear in dense patches, though most of them disappear gradually. Mortality is much greater in the seedling stage (table 1) but if once established, it continues to thrive on even comparatively drier soil. Seedling mortality was observed at three spots of the 50×50 cm area in the wasteland between the buildings of Geology and Chemistry departments.

Table 1 *Seedling mortality in* S. dulcis *(Data based on 3 replicates of field study)*

Date of observation	No. of new seedlings appeared	No. of seedlings disappeared	Seedling mortality
15.8.73	135±13.22	—	—
30.8.73	40±4.35	102±7.54	75.5%
15.9.73	32±6.24	55±6.24	68.4%
30.9.73	15±5.56	25±6.55	50.0%
15.10.73	—	5±1.73	12.5%
30.10.73	—	—	—

Reproductive capacity

The seed output and reproductive capacity determined in the month of December, 1973, were very high and varied from site to site (table 2).

Germination of seeds

Seeds are light-sensitive and without any dormancy. Germination is 100% in freshly collected seeds and requires an optimal temperature of 25°C (Lal 1977). Germination is not possible in a light intensity below 500 lux.

Table 2 *Seed output and reproductive capacity of* S. dulcis *(on the basis of fresh seed germination)*

Sites	Germination %	Average seed output	Reproductive capacity
I. Roadside near Hindi Department building	92±3.46	43840±1375.7	40332.8
II. Wasteland between Geology & Chemistry Department buildings	100± 0.0	69933±4366.1	69933.0

Biomass

Dry biomass of *S. dulcis* increased at each site with the increase in the plant age (figure 1). Up to 60 days the leaf biomass

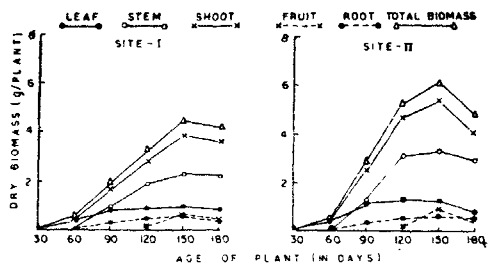

Figure 1 Dry Biomass of *Scoparia dulcis* at various sites

was greater than that of the stem or root but afterwards the stem biomass exceeded the leaf biomass (table 3). The stem remained very small up to 60 days and thereafter it started elongating rapidly.

The first harvesting was done at the age of 30 days when dry biomass was 0.052 and 0.065 g/plant for sites I and II respectively. Maximum values of plant biomass were 4.48 and 6.10 g/plant at 150 days age at sites I and II respectively, after which biomass started decreasing (figure 1).

Productivity

The productivity of shoot, root and of complete plant increased with the age of the plant till the early fruiting (90–120 days age) and then decreased although there was still increase in plant biomass. The maximum values of shoot productivity were 43.63 (Site I) and 73.33 mg/plant/day (Site II) at 90 and 120 days of plant age respectively (table 4).

Energy content

Monthly reading of energy content of various plant parts varied within certain range on the two sites. The energy content/g of leaf and stem dry biomass increased up to the age of 120 days and decreased later in the plants harvested from both the sites (figure 2). The energy content of leaf (3.24

Table 3 *Monthly variation in dry biomass (g/plant) of* Scoparia dulcis *at the two study sites*

Age of plant (in days)	Dry biomass (g/plant)									
	Site I					Site II				
	Leaf	Stem	Fruit	Root	Total plant biomass	Leaf	Stem	Fruit	Root	Total plant biomass
30	0.030 ±0.002	0.012 ±0.002	— —	0.010 ±0.002	0.052	0.040 ±0.007	0.014 ±0.003	—	0.011 ±0.002	0.065
60	0.245 ±0.01	0.068 ±0.02	—	0.047 ±0.002	0.360	0.290 ±0.01	0.090 ±0.01	—	0.070 ±0.005	0.450
90	0.750 ±0.03	0.870 ±0.07	—	0.250 ±0.02	1.870	1.150 ±0.17	1.250 ±0.10	—	0.330 ±0.04	2.830
120	0.820 ±0.03	1.850 ±0.08	0.091 ±0.01	0.480 ±0.04	3.241	1.320 ±0.09	3.100 ±0.36	0.280 ±0.03	0.550 ±0.07	5.250
150	0.940 ±0.05	2.320 ±0.23	0.640 ±0.05	0.580 ±0.05	4.480	1.200 ±0.19	3.325 ±0.18	0.900 ±0.11	0.675 ±0.05	6.100
180	0.800 ±0.10	2.280 ±0.52	0.570 ±0.05	0.550 ±0.02	4.200	0.850 ±0.03	2.900 ±0.17	0.410 ±0.03	0.640 ±0.02	4.800

Table 4 *Productivity (mg/plant/day) of* Scoparia dulcis *at two studied sites (Data based on average biomass of shoot and root)*

Age of the plant (in days)	Productivity					
	Site I			Site II		
	Shoot	Root	Total shoot + root	Shoot	Root	Total shoot + root
30	1.40	0.33	1.73	1.80	0.36	2.16
60	9.03	1.23	10.26	10.86	1.96	12.82
90	43.63	6.76	50.29	70.66	8.66	79.32
120	38.03	7.66	45.69	73.33	7.33	80.66
150	37.96	3.33	41.29	24.16	4.16	28.32
180	—8.33	—1.00	—9.33	—42.16	—1.16	—43.32

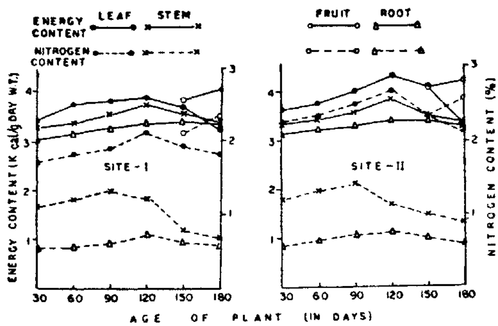

Figure 2 Energy content (Kcal/g Dry weight) and Nitrogen content (%) of *Scoparia dulcis* at various sites.

to 4.33 Kcal/g dry weight of plant) was highest among the vegetative parts followed by those of stem and root at each site while that of fruit ranged between 3.82 and 4.24 Kcal/g dry weight at different sites and growth stages of this species.

Nitrogen content of the plant

The nitrogen percentage increased till 120 days (flowering stage) in leaf and root and 90 days (early flowering stage) in stem (figure 2). Leaves contained maximum nitrogen followed by fruit, stem and root. Figure 3 also reveals that plants growing at site II were richer in nitrogen content than the plants growing at site I.

Relationship between energy and nitrogen accumulation

Energy and nitrogen accumulation values have been obtained by multiplying the respective biomass and energy or nitrogen concentrations as shown. On comparing the energy accumulation in different parts of *S. dulcis* with the nitrogen accumulation (figures 1 and 2), a significant correlation between them is found (table 5).

Culture experiments

S. dulcis shows excellent growth in open sunlight and in soil containing higher organic matter in culture studies (Lal 1976). It survives in a wide range of soil moisture from mesophytic to waterlogged conditions. The growth is better in the soil watered on alternate days (Lal 1978).

Table 5 *Correlation coefficient value* (r) *of energy and nitrogen accumulation in plant components of* Scoparia dulcis *at two studied sites*

Plant parts	Correlation coefficient (r)	Degree of freedom	Level of significance
Leaf	0.828	11	0.001
Stem	0.884	11	0.001
Fruit	0.981	3	0.01
Root	0.984	11	0.001

Discussion

Mason (1936) has stressed the role of tolerance limits of species which determine climatic and edaphic ranges in which it is distributed. *Scoparia dulcis* got introduced in India in 1843 (Ridley 1930). Its wide distribution at many parts clearly indicates that climatic conditions are well suited for this species.

S. dulcis is mostly found along the pathway and along the water channel where there is greater chance of wastage of seeds due to biotic disturbances. Hence there is much possibility of elimination of its population. This possibility is minimised by a large seed output and high reproductive capacity. Salisbury (1942) considers that more the special requirements of a species the larger will be the proportion of seeds that will reach unsuitable habitats and greater will be consequent wastage. He correlates the reproductive capacity with the risk of mortality.

The high mortality rate during seedling stage may be accounted mainly due to grazing, trampling and other biotic disturbances, which are so common on grounds when the plants grow. Seeds of *S. dulcis* are very light in weight which means that only a limited amount of food is available for the developing seedlings. Since the young seedlings are very delicate and small, the slightest soil moisture stress and competition results into heavy mortality. But once the plants establish themselves well, they are capable of survival in dry conditions. This is confirmed from the culture experiments done with respect to water relations (Lal 1978). The capacity to colonise in the face of competition appears to be associated with the amount of food reserves which the seed contains (Salisbury 1942). Due to absence of dormancy, seeds have the capacity to germinate at any time if the favourable conditions for germination are available.

The productivity is maximum just before the maturation of fruits. The period just preceding the peak biomass is found to be most efficient in productivity. After attaining the peak value, there is a decrease in the rate of production of the plant, although the biomass of the plant continues to increase up to fruit maturity stage. At mature stage the rate of production declines due to the reduced rate of photosynthesis since chlorophyll and water contents decrease at this stage.

The decrease in energy contents of leaf, stem and root of *S. dulcis* after 120 days of the age (early fruiting) is probably due to the utilization of stored energy of these plant components in the formation of fruits. It is evident from the higher value of energy in fruits of *S. dulcis*.

The decrease in the values of percentage nitrogen content in plant parts after flowering stage is due to the translocation of nitrogen from older leaves and stem tissues to newly formed flowers and fruits. Bowsen et al. (1969) and Davy and Taylor (1975) have also observed an increase in percentage of nitrogen in younger and newly formed tissues of plants. The difference in nitrogen content in plants at various study sites may also be due to the variation in nitrogen content of the soil of the study sites. The highest accumulation of nitrogen in leaves is due to its active metabolic state.

Thus it is evident from the foregoing discussion that *S. dulcis* makes its existence in nature due to its high seed output and reproductive capacity and having the capacity to grow well in a varieties of habitats ranging from extremely dry to waterlogged conditions, open to deep shades and in different soil types with varying organic content. Its capacity to propagate vegetatively also helps in the survival of its population if all the seeds produced are destroyed due to natural calamities.

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