NOTES ON THE ECOLOGY OF *DESMODIUM GANGETICUM* DC.[1]

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Desmodium gangeticum DC. is a prostrate, diffuse or sub-erect undershrub growing in drier situations, in open or in partial shade. The plant thrives in alkaline soils, rich in exchangeable calcium, but gives better performance in soils with lower exchangeable calcium value. Culture experiments prove that the plants thrive best in moderately calcareous soils. The plant cannot tolerate deep shade. The seeds have no dormancy period. The germination of the seeds is poorer under continuous illumination for 24 hours and maximum in total darkness. The reproductive capacity, stomatal frequency, range of osmotic pressure of the plant sap, phenology, biotic factors, size and weight of seeds, associates, etc., have also been recorded.

INTRODUCTION

A series of papers have been published on the ecology of weed species of Varanasi District (Ramakrishnan 1960*a*, *b*, *c*, 1961; Misra and Ramakrishnan 1959, 1960). The present paper is a further contribution to this aspect of study.

Desmodium gangeticum DC. is a prostrate or sub-erect undershrub growing in waste places, in open or in partially shaded localities during the winter season. The species is distributed throughout India to Ceylon and Burma. It grows on heights up to 1,525 m in the outer Himalayas. The plant is distributed throughout Tropical Asia, Australia, Polynesia and Tropical Africa and introduced in the West Indies.[2]

SIZE AND WEIGHT OF SEEDS

The seed has an average weight of 1·428 mg. The length of the seed varies from 1·718 to 2·333 mm and the breadth from 1·385 to 1·795 mm. The shape index, expressed as length/breadth ratio, varies from 0·96 to 1·68.

ENVIRONMENTAL FACTORS

The plants grow in partial shade, in the open and rarely in deep shade. The soil analysis data for collections from different localities are set in Table I.

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[1] Part of a thesis accepted for the Ph.D. degree of the Banaras Hindu University.

[2] This information was obtained from the Director, Royal Botanic Gardens, Kew.

TABLE I

Soil analysis data for D. gangeticum

Locality	*p*H	Carbonate content (%)	Exchangeable calcium (m.e. %)	Nitrate content (mg/100 g of soil)	Organic matter (%)
Rajghat	7·5	14·025	47·00	2·875	2·46
University area ..	7·5	0·242	20·66	2·520	4·22
Latifshaw	7·2	0·121	11·08	3·050	1·60
Sarnath	7·6	0·132	19·36	4·875	4·10
Akhari	7·4	0·149	27·02	3·500	3·96
Ramnagar	7·2	1·777	40·96	2·875	3·70

*p*H.—The plants grow in alkaline soils with a range of 7·2 to 7·6 *p*H.

Carbonate content.—Soils have a carbonate content range of 0·121 to 14·025 per cent.

Exchangeable calcium.—The plants grow in moderately calcareous to highly calcareous soils and the values for exchangeable calcium range from 11·08 to 47·00 m.e. per cent.

Nitrate content.—This factor has a range of 2·520 to 4·875 mg/100 g of soil.

Organic matter.—This factor varies from 1·60 to 4·22 per cent.

PERFORMANCE OF THE PLANT IN VARIOUS LOCALITIES

The average seed output data for the species from different localities are given in Table II.

TABLE II

Seed output data for D. gangeticum *in different localities*

Locality	Average number of fruits per plant	Average number of seeds per fruit	Seed output
Rajghat	69	6	414
University area ..	235	6	1,410
Latifshaw	283	7	1,981
Sarnath	266	6	1,596
Akhari	123	7	861
Ramnagar	110	6	660

A definite correlation has been obtained between the exchangeable calcium in the soil and the average seed output values. The seed output of the plant decreases with an increase in exchangeable calcium in the soil; best seed output being obtained in soils with about 11 to 20 m.e. per cent, as seen from a comparative study of Tables I and II.

Associates

The associates of *D. gangeticum* in different localities are given in Table III.

Table III

Associates of D. gangeticum *in different localities*

Species	Localities*					
	1	2	3	4	5	6
Desmodium gangeticum	f	f	f	o.f	f	f
Achyranthes aspera	—	o.f	—	—	—	r
Aerua scandens	o.f	—	—	—	—	—
Apluda mutica	l.a	—	—	—	—	—
Biophytum sensitivum	—	—	r	—	o.f	—
Cassia tora	r	—	—	—	o.f	o.f
Crotalaria medicagenia	f	—	—	—	—	—
Croton sparsiflorus	r	—	—	—	—	—
Dactyloctenium aegyptium	—	—	r	—	—	—
Dichanthium annulatum	f	—	—	—	—	r
Eclipta alba	—	—	—	—	r	—
Eleusine indica	—	—	—	f	—	—
Eragrostis indica	—	—	—	f	—	—
Evolvulus alsinoides	—	—	f	f	—	—
Indigofera linifolia	—	—	—	r	—	—
Justicia simplex	o.f	—	—	o.f	—	f
Oplismenus burmannii	—	o.f	f	o.f	v.a	f
Peristrophe bicalyculata	r	o.f	f	—	—	o.f
Phyllanthus niruri	—	r	—	—	—	—
Rhynchosia minima	—	f	—	—	—	—
Rungia perviflora	—	a	o.f	o.f	o.f	—
Sida rhombifolia	—	—	—	—	o.f	—
Tridax procumbens	—	f	—	—	—	—
Triumfetta neglecta	—	—	—	o.f	—	r
Urena lobata	—	—	o.f	—	—	—

* Localities: 1, Rajghat; 2, University area; 3, Latifshaw; 4, Sarnath; 5, Akhari; 6, Ramnagar. f = frequent, o.f = occasionally found, l.a = locally abundant, v.a = very abundant, r = rare.

Cultural Experiments

From field observations, it has been found that the seed output of the plant decreases with an increase in exchangeable calcium in the soil. To study this field observation, culture experiment was undertaken.

Four culture pots were filled with unmanured garden soil. One of the pots was kept as a control and to others various doses of lime were added. The soil analysed at the end of the culture experiment (after about five months) gave the following levels of exchangeable calcium in the soils:

Pot No. 1—Control (soil with 8·6 m.e. % of exchangeable calcium)
„ 2—Soil with 13·6 m.e. % of exchangeable calcium
„ 3— „ 24·0 „ „ „
„ 4— „ 32·8 „ „ „

The detailed soil analysis data are set in Table IV.

TABLE IV

Analysis of soils in pots after culturing D. gangeticum

Observations	Pot number			
	1	2	3	4
*p*H	7·2	7·4	7·4	7·7
Carbonate content (%) ..	0·328	1·200	1·630	1·802
Exchangeable calcium (m.e. %)	8·6	13·6	24·0	32·8

The growth performance of the plant at the end of the culture experiment is given in Table V.

TABLE V

Growth performance of D. gangeticum *in soils with different levels of exchangeable calcium*

Observations	Pot number*			
	1	2	3	4
Height of plant (cm) ..	168·0	180·0	178·0	178·0
Number of fruits/plant ..	245	272	256	232
Average number of seeds/fruit	7	7	7	6
Seed output	1,715	1,904	1,792	1,392
Fresh weight of shoot (g) ..	50·0	79·0	95·5	72·5
Dry weight of shoot (g) ..	28·7	37·5	43·7	31·8

* Pot contents:
No. 1—Control (with 8·6 m.e. % of exchangeable calcium)
No. 2—Soil with 13·6 m.e. % of exchangeable calcium
No. 3— „ 24·0 „ „ „
No. 4— „ 32·8 „ „ „

It is found that the best seed output is obtained in moderately calcareous soil with 13·6 m.e. per cent of exchangeable calcium. In highly calcareous soils and in calcium poor soils, the seed output tends to decrease. This is in accordance with the field observations (Tables I and II). Good vegetative growth is obtained in all the culture pots, best growth being obtained in soils with 13·6 and 24·0 m.e. per cent of exchangeable calcium.

Culture experiments were undertaken to investigate whether the species grows in a clayey or clayey loam soil, either in the open or in partial shade.

Two pots each filled with clayey and clayey loam soils were set up in the open, partial shade and deep shade. In each of the pots two plants were allowed to grow for about five months. At the end of the culture experiment, best performance on the basis of fresh and dry weight of the shoot and seed output is obtained in the open. In deep shade, the growth is very poor and the plants failed to flower and fruit. Moreover, it has been found that best growth is obtained in clayey loam soil under all the light conditions. In deep shade, the plant failed to survive in a clayey soil and died after stunted growth, after about two months (Table VI).

TABLE VI

Growth performance of D. gangeticum *in the open, partial shade and deep shade*

Observations	Open		Partial shade		Deep shade	
	Clay	Clayey loam	Clay	Clayey loam	Clay	Clayey loam
Height of plant (cm) ..	200·0	195·0	112·0	168·0	—	18·0
Number of fruits/plant ..	525	575	163	245	—	Nil
Average number of seeds/ fruit ..	7	7	7	7	—	,,
Seed output	3,675	4,025	1,141	1,715	—	,,
Fresh weight of shoot (g) ..	141·3	127·0	47·5	50·0	—	2·9
Dry weight of shoot (g) ..	73·5	74·0	23·0	28·7	—	1·1

BIOTIC FACTORS

The plant is frequently grazed by cattle and cut by man and hence very often exhibits arrested growth. Only one fungal parasite has been reported on this species from India, viz. *Synchytrium desmodiicola* (Index of Fungi, C.M.I., Vol. II, pt. 15, 1957).

PHENOLOGY

Most of the seedlings come up, in nature, in July, after the first few showers. A few of them may arise in winter also after showers. In the former, flowering and fruiting take place from October to February. The seedlings which come up in winter remain stunted and exhibit poor growth. These may, however, flower and fruit from February to April.

The plant is a perennial and due to the biotic disturbances, remains stunted and more or less prostrate. By summer, the shoots dry up. New shoots arise in July from rootstocks that remain in the soil. However,

under cultural conditions, the plants attain a height of a few metres and the same vegetative shoot continues growth year after year.

Germination

Seeds collected in November, 1958, were used in the germination studies.

Fresh seeds give a germination of 36 per cent and after about three months' storage give 44 per cent germination.

Seeds were put for germination under different light conditions on 26th April, 1959, and the results are shown in Table VII.

Table VII

Germination of seeds of D. gangeticum *under different light conditions*

Date	Number of seeds germinated out of 50		
	Diffused daylight	Continuous light	Continuous darkness
28-4-59	2	0	0
1-5-59	10	0	0
2-5-59	4	0	0
3-5-59	4	0	0
4-5-59	6	0	0
6-5-59	0	13	19
7-5-59	0	2	4
9-5-59	1	1	4
11-5-59	0	0	2
19-5-59	0	0	1
23-5-59	1	0	0
Percentage of germination	56	32	60

Maximum germination was obtained in continuous darkness and minimum in continuous light.

Reproductive Capacity

Seeds give a germination of 56 per cent. The plants have an average seed output of 1,154. Hence, the reproductive capacity of the species works out to 646.

Epidermal Structure and Stomatal Frequency of Leaves

In surface view, the epidermal cells of the leaves are wavy in outline, more so on the lower side. Stomata are strictly confined to the lower epidermis. The frequency of epidermal cells and stomata is higher in the open than in the shade (Table VIII).

TABLE VIII

Stomatal frequency and stomatal index in 'sun' and 'shade' leaves of D. gangeticum

	Upper epidermis		Lower epidermis		Stomatal index	
	Stomata per mm²	Epidermal cells per mm²	Stomata per mm²	Epidermal cells per mm²	Upper surface	Lower surface
Open I	0	1,019	259	1,157	—	18·3
II	0	898	259	1,130	—	18·6
III	0	972	269	1,213	—	18·2
Shade I	0	806	241	972	—	19·9
II	0	704	204	880	—	18·8
III	0	750	222	935	—	19·2

OSMOTIC PRESSURE OF THE PLANT SAP

The osmotic pressure of the plant sap decreases with an increase in the moisture content of the substratum. The range of values obtained is given in Table IX.

TABLE IX

Osmotic pressure of the plant sap of D. gangeticum

Locality	Moisture content of substratum (%)	Osmotic pressure of plant sap (atmos.)
I	4·9	17·806
II	5·8	16·000
III	6·2	14·430

DISPERSAL OF SEEDS

The pod is jointed and breaks up into segments, each containing one seed. They are generally hairy, at least, on the outer edges and frequently covered on the faces with very short viscous hairs, so that they readily adhere to clothes or fur or plumage. The hooked hairs clothing the pod are helpful in adhesion.

SEEDLING MORPHOLOGY

Seeds are flat and rounded with a concavity on one side. The germination of the seeds is epigeal. The radicle comes out as a protuberance from just below the concavity. When the radicle is a few mm long, the hypocotyl elongates in the form of a hook carrying with it the two cotyledonary leaves enclosed within the testa. The cotyledonary leaves expand and turn green.

Not infrequently, the hypocotyl elongates rapidly, before the radicle protrudes out, so that the cotyledonary leaves come out of the testa, while the radicle still remains inside it.

Discussion

Daubenmire (1947) states that there is a gradation of tolerance and/or requirement of calcium among plants. Thus, in *Euphorbia thymifolia* Linn., two distinct ecotypes are recognizable, the red form and the green form, each with different tolerance ranges for exchangeable calcium (Ramakrishnan 1961). In *Echinochloa colonum* Link. and *Eclipta alba* no such differentiation in populations is noticeable. The former is a strict calcifuge, while the latter has a wide range of tolerance for exchangeable calcium. On the other hand, *Desmodium gangeticum* DC. thrives in moderate to highly calcareous soils and within the range in which it grows in nature, the seed output of the plant decreases with an increase in the exchangeable calcium in the soil. Culture experiments show that the best seed output is obtained in moderately calcareous soil.

Reproductive capacity represents the intrinsic capacity of the species to reproduce in time, provided the excizing factors are favourable (Salisbury 1932). A high reproductive capacity is an asset to the species inasmuch as it shows its capacity to spread over wide if the means of dispersal are efficient and proper conditions are available for the establishment of seedlings. The reproductive capacity of *D. gangeticum* works out to 646 which is a low value.

The frequency of stomata in the leaves is higher in the open than in the shade though the stomatal index is not appreciably different. Salisbury (1932) states that the differences in the stomatal frequency is due to their spacing which is due mainly, if not entirely, to the moisture relations of the leaves. The difference in moisture relations may be internal as is shown in the two ecotypes of *Euphorbia hirta* (Ramakrishnan 1960*c*) or external as in the 'open' and 'shade' forms of *D. gangeticum*.

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