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Effect of seasonal and altitudinal variations on growth performance of *Acalypha indica* Linn. in Alagar Hill (Eastern Ghats), South India

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Abstract: A study was carried out on a medicinal herb *Acalypha indica* Linn. (Family : Euphorbiaceae) in deciduous forest of Alagar hill, South India (12°18 N and 76°42 E) to assess the effect of season (summer and monsoon) and altitude (275, 350 and 550 m above mean sea level) on six morphological parameters. Growth performance of *A. indica* in terms of number of leaves per plant and shoot height was better during monsoon than the summer season. Similarly its best growth was recorded on hill top (550 m) than at mid hill (350 m) and foot hill (275 m). One way ANOVA revealed significant effect of altitude on all growth parameters.

Resumen: Se realizó un estudio con la hierba medicinal *Acalypha indica* Linn. (Familia: Euphorbiaceae) en bosques deciduos de la colina Algar al sur de la India (12° 18 N y 76° 42 E), para determinar el efecto de la estación (verano y monzón) y la altitud (275, 350 y 550 msnm) en seis parámetros morfológicos. El crecimiento de *A. indica* en terminos del número de hojas por planta y altura del tallo fue major durante el monzón que durante el verano. Similarmente, se registró su mayor crecimiento en la cima de la colina (550 m), que a la mitad (350 m) o al pie (275 m) de la misma. Un ANOVA de una vía reveló un efecto significativo de la altitud en todos los parámetros de crecimiento.

Resumo: Para avaliar o efeito da estação (verão e monção) e altitude (275, 350 e 550 m acima do nível do mar) sobre a erva medicinal *Acalypha indica* Linn. (Família: Euphorbiaceae) foi efectuado um estudo numa floresta decidua do monte Alagar, Sul da Índia (12° 18 N e 76° 42 E) e que incidiu sobre seis parâmetros morfológicos. A performance do crescimento da *A. indica* em termos do número de folhas por planta e altura dos lançamentos foi melhor durante a monção do que no verão. Do mesmo modo, o seu melhor crescimento foi registado no topo do monte (550 m) do que ao nível médio (350 m) ou na base (275 m). Uma ANOVA revelou efeitos significativos da altitude em todos os parametros de crescimento.

Key words : *Acalyapha indica*, Alagar hill, altitudinal variation, growth performance, quantitative morphology, seasonal variation.

Introduction

With the renewed interest in biodiversity, the knowledge pertaining to medicinal flora has assumed economic importance. Investigations on growth performance of medicinal plants have gained adequate attention in India. Quantitative information on the growth performance of medicinal plants under experimental field conditions (Bargali 1997; Karikanthimath *et al.* 1997; Pandey *et al.* 1998; Sangai 1995; Shylaja *et al.* 1996; Singh & Singh 1998) as well as natural ecosystem conditions (Chauhan *et al.* 1997; Jamwel & Kaul 1997; Marian & Gopalakrishnan 1997) are plenty in literature. However, when considering the richness of Indian flora (Jain & De Fillipps 1991), the availa-

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ble information on medicinal plants is meagre. Thus, in the present paper, growth performance of a medicinal herb, *Acalypha indica* Linn. (Family : Euphorbiaceae), studied under natural ecosystem conditions in the deciduous forests of Alagar hill (Eastern Ghats), South India during two seasons at three altitudes have been discussed.

Materials and methods

Alagar hill forms a discontinuous minor range in the Deccan plain and appears as an extension of Eastern Ghats. It is located 22 kms north east of Madurai city (Lat. 12°18 N; Long. 76°42 E; Alti. 275 m above mean sea level). The deciduous forests of Alagar hill is composed of both disturbed and protected vegetation, which varies due to change in topography of the area (Sriganesan 1984, 1987).

Growth performance of *A. indica* was studied along an altitudinal gradient during summer (March - April) and monsoon (October - November) seasons of 1989. Plants growing at three different altitudes *viz.*, 275 m (foot hill - Silambar valley), 350 m (mid hill - Palamutheer solai - middle of Silambar valley) and 550 m (top hill - above Nupuragangi towards Bisan valley) were considered for growth study.

Six morphological parameters *viz.*, leaf length (excluding petiole), maximum breadth of leaf, number of leaves and branches per plant, plant height and length of the tap root system of randomly selected plants were measured at field during each sampling. For the measurement of the length of tap root, the plants were carefully dug out to avoid major damage to the root system and then measured.

In each season (60 days), fifteen samples were analysed for each parameter at four days interval, including five sample from each altitude. In altitudinal study at each altitude, ten samples were studied for each parameter at six days interval, representing equally five samples per season. In both studies, each sample refers to the mean value of three replicates. However, these mean values of each parameter (*i.e.*, n = 15 and 10 for seasonal and altitudinal analysis respectively) were only considered for further statistical analysis.

At each altitude six randomly marked plots were studied for three soil parameters *viz.*, width of the top layer (A-horizon), soil moisture and soil penetrability. In each parameter, six samples (n = 6) were analysed including three representative samples for each season. Soil moisture (%) was estimated by routine method. The width of the top layer of soil was measured by digging a trench with clean sides and measuring with a meter scale. Soil penetrability was estimated recently in 1998 after Sutherland (1997) by inserting down a calibrated stick into the soil and recording the distance of penetration. A separate analysis of all parameters (n = 6) was made for each season, including two samples from each altitude.

Comparison of the mean values of each growth as well as soil parameters between seasons were done by using t-test while oneway ANOVA was employed to test the effect significance of altitude on both growth as well as soil parameters (Zar 1984).

Results and discussion

Table 1 presents data on growth parameters of *A. indica* and soil parameters at Alagar hill measured during summer and monsoon seasons of 1989. The cause of better performance during monsoon may be the increased soil moisture and availability of nutrients from decomposing leaf litter. The higher soil moisture during monsoon is also indirectly supported by maximum soil penetrability. In general, plants subjected to water stress exhibit a reduction in size and growth (Kramer 1983). Studies on medicinal plants under experimental field conditions were also reported that higher soil moisture enhances the growth performance in terms of leaf number, plant height (in *Quercus leucotrichophora* : Bargali 1997), shoot height, leaf weight (in *Aloe barbadensis* : Van Schaik *et al.* 1997) and leaf width (in *Cymbopogon* sps : Pandey *et al.* 1998).

The maximum width of the top soil during monsoon suggests that it may provide a rich supply of nutrients through decomposing leaf litter to *A. indica*. According to Chauhan *et al.* (1997), leaf litter produced by *Populus deltoides* and *Eucalyptus* sps. has added significant quantity of NPK to soil, which in turn enhances the growth performance of medicinal intercrops like lemongrass, palmarosa and mint. Similarly, exogenous supply of nutrients like NPK under experimental field conditions also improved the growth performance like root and shoot yield (in *Catharanthus rseus*: Shylaja *et al.* 1996), plant height, leaf area index

Table 1. Quantitative morphology of *A. indica* and soil parameters at Alagar Hill in relation to two seasons of 1989 (n = 15).

Parameters	Monsoon	Summer	Pooled variance	t	p
Leaf Length (cm)	6.6 ± 1.10	5.4 ± 0.50	0.8957	3.668	<0.01
Leaf Breadth (cm)	4.8 ± 0.42	4.2 ± 0.55	0.7003	2.345	<0.05
No. of Leaves	31.6 ± 6.06	22.7 ± 4.41	2.289	10.765	<0.001
No. of Branches	18.7 ± 1.80	13.8 ± 2.47	1.653	8.281	<0.001
Height (cm)	39.2 ± 4.69	27.2 ± 6.01	2.311	14.217	<0.001
Length of Tap root (cm)	10.6 ± 1.80	8.1 ± 1.71	1.325	4.132	<0.001
Width of Top layer (cm)	2.8 ± 0.32	2.2 ± 0.45	0.3924	2.685	<0.05
Penetrability (cm)	4.10 ± 0.42	2.10 ± 0.23	0.3391	10.296	<0.001
Moisture (%)	78.5 ± 1.95	51.0 ± 2.45	2.214	21.131	<0.001

Table t at df 28 for P <0.01 is 2.76; P <0.05 is 2.05; P <0.001 is 3.67 for growth parameters.
Table t at df 18 for P <0.01 is 2.88; P <0.05 is 2.10; P <0.001 is 3.92 for soil parameters.
Values are expressed as means ± SD.

Table 2. Quantitative morphology of *A. indica* and soil parameters at Alagar Hill in relation to three different altitudes (n = 10).

Parameters	Foot-hill (275 m)	Mid-hill (350 m)	Top-hill (550 m)
Leaf Length (cm)	4.9 ± 0.7	5.6 ± 0.5	6.4 ± 0.6
Leaf Breadth (cm)	2.7 ± 0.4	3.9 ± 0.5	5.0 ± 0.3
No. of Leaves	14.5 ± 3.2	24.0 ± 2.6	28.5 ± 2.8
Height (cm)	16.3 ± 1.4	23.2 ± 1.6	28.3 ± 1.5
Length of Tap root (cm)	8.5 ± 1.0	11.6 ± 2.0	13.5 ± 1.0
No. of Branches	8.0 ± 1.3	11.7 ± 1.5	14.5 ± 1.5
Width of Top layer (cm)	1.9 ± 0.3	2.4 ± 0.2	3.3 ± 0.2
Penetrability (cm)	1.6 ± 0.2	2.2 ± 0.2	3.7 ± 0.1
Moisture (%)	41.3 ± 4.7	57.8 ± 5.1	76.6 ± 2.7

Values are expressed as means ± SD.

Table 3. Matrix of "t" values for comparison between the selected altitudes. Code : Top, 550 m; Mid, 350 m and Foot, 275 m).

Parameters	TOP vs MID		TOP vs FOOT		MID vs FOOT	
	t	p	t	p	t	P
Leaf Length (cm)	2.349	<0.05	4.052	<0.001	2.014	<0.001
Leaf Breadth (cm)	3.819	<0.01	10.107	<0.001	3.978	<0.001
No. of Leaves	6.079	<0.001	17.949	<0.001	12.386	<0.001
Height (cm)	9.050	<0.001	21.957	<0.001	12.584	<0.001
Length of Tap root (cm)	3.409	<0.01	11.025	<0.001	5.580	<0.001
No. of Branches	5.131	<0.001	12.422	<0.001	7.047	<0.001
Width of Top layer (cm)	6.699	<0.001	7.968	<0.001	2.835	<0.001
Penetrability (cm)	9.909	<0.001	13.775	<0.001	5.203	<0.001
Moisture (%)	7.935	<0.001	15.803	<0.001	5.797	<0.001

Table t at df 18 for P <0.01 is 2.88; P <0.05 is 2.10; P <0.001 is 3.92 for growth parameters.
Table t at df 10 for P <0.01 is 3.70; P <0.05 is 2.23; P <0.001 is 4.59 for soil parameters.

Table 4. ANOVA matrix for comparison between the selected altitudes code : SV, sources of variation; BS, between samples; WS, within samples; SS, sum of squares; MS, mean squares.

Parameters	SV	SS	df	MS	F*/P
Leaf Breadth (cm)	BS	29	9	3.222	7.908
	WS	11	27	0.407	P<0.001
No. of Leaves	BS	1012	9	112.442	108.381
	WS	28	27	1.037	P<0.001
Leaf Length (cm)	BS	10	9	1.111	2.314
	WS	12.966	27	0.480	NS
Height (cm)	BS	724	9	80.444	30.240
	WS	72	27	2.666	P<0.001
Length of Tap root (cm)	BS	126	9	14	6.517
	WS	58	27	2.148	P<0.05
No. of Branches	BS	212	9	23.551	15.161
	WS	42	27	1.553	P<0.001
Width of Top layer (cm)	BS	6.99	5	1.398	20.361
	WS	1.03	15	0.068	P<0.001
Penetrability (cm)	BS	14.16	5	2.832	77.377
	WS	0.55	15	0.037	P<0.001
Moisture (%)	BS	4029	5	805.8	43.279
	WS	279	15	18.6	P<0.001

* Table F at df 2 and 27 for P<0.05 is 3.4, P<0.01 is 7.7; and P<0.001 is 13.6; NS, non significant for growth parameters.
* Table F at df 2 and 15 for P <0.05 is 3.7, P <0.01 is 8.7 and P <0.001 is 16.6 for soil parameters.

(in *Cymbopogan flexuosus*: Singh & Singh 1998), and root length (in *Coriandrum sativum* : Subramanian & Vijayakumar 1998) of medicinal flora.

Table 2 contains data on quantitative morphology of *A. indica* and soil parameters with reference to three altitudes at Alagar hill. Comparison of data by t-test revealed that growth performance of *A. indica* was better on hill top than those growing at lower altitudes (Table 3). The higher width of the top soil as natural reserve of nutrients as well as higher soil moisture at hill top when compared to lower altitudes support this conclusion. As stated earlier, studies under experimental field conditions have also revealed that higher soil moisture (Bargali 1997; Pandey *et al.* 1998; Van Schaik *et al.* 1997) as well as exogenous supply of NPK (Shylaja *et al.* 1996; Singh & Singh 1998; Subramanian & Vijayakumar 1998) were found to enhance the growth parameters of medicinal plants. ANOVA expressed significant difference in all growth as well as soil parameters except leaf length as a function of altitude (Table 4). According to Manian & Gopalakrishnan (1997), variations in growth performance of *Eucalyptus globulus* in terms of diameter of wood and oil yield correspond the variations in availability of total P and N at different altitudes. Similarly, variation in morphological parameters like plant height and leaf area as a function of altitude have been reported for non-medicinal plants (in *Eupatorium adenophorum* and *E. riparium*: Papiya Dev & Ramakrishnan 1987). In conclusion, it may be said that the growth performance of *A. indica* in the deciduous forests of Alagar hill was determined by soil and climatic factors those vary in relation to seasons and altitudes.

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