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Habitat suitability analysis based on the oil content for the medicinal shrub *Gaultheria fragrantissima* Wallich in the Nilgiris, Western Ghats, India

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Abstract

Influence of genotype and environmental factors on the oil production of four ecological variants of the medicinal shrub, *Gaultheria fragrantissima* was evaluated across four sholas in Nilgiris of Western Ghats, India. The ovate leaf type variant of this species produced significantly higher content of oil (1.13%) than the lanceolate (0.96%), elliptic-lanceolate (0.91%) and oblanceolate (0.92%) leaf type variants. The oil production performance was more influenced by genotype than environmental factors and by the interaction of genotype and environmental factors. Among the four sholas studied the Ebbenadu shola is most suitable for the growth of high oil containing ovate leaf type variant of *G. fragrantissima* with respect to oil production.

Keywords : AMMI analysis, biplot, ecological variants, *Gaultheria fragrantissima*, Nilgiris, oil content

INTRODUCTION

Gaultheria fragrantissima (Ericaceae) is a medicinal shrub distributed in the high hills of Nilgiris, India at shola margins. The oil extracted from the leaves of *G. fragrantissima,* sold in the name of 'oil of Indian Wintergreen' in Ooty markets of Nilgiris, has many medicinal values such as treatment of rheumatic arthritis, sciatica, neuralgia and in the preparation of painbalms and perfumes, due to the presence of the active principle, methyl salycilate in it (Chopra, 1932; Polunin and Stainton, 1984). In Nilgiris, four ecological variants of this species, based on leaf shapes *viz.,* ovate, lanceolate, elliptic-lanceolate and oblanceolate leaf types are recorded (Paulsamy *et al*., 2006). The oil contents in the leaves of these four ecological variants were determined and the most suitable shola habitat for the variant of *G. fragrantissima* that has the highest oil content was ascertained in order to meet the high demand for production of oil from this plant.

STUDY AREA

Four sholas *viz.,* Ebbenadu (elevation 2100 m), Korakundah (elevation 2150 m), Kodappamand (elevation 2360 m) and Kothagiri terrace (elevation 2320 m) in Nilgiris, where the all four variants of *G. fragrantissima* are found, are taken for the present study which was carried out from January to December, 2006. The area of these sholas is *ca*. 140 ha for Ebbenadu, *ca*. 210 ha for Honnathalai, *ca*. 80 ha for Kodappamand and *ca*. 175 ha for Kothagiri terrace. Since the proximity of the 3 sholas viz., Honnathalai, Kodappamand and Kothagiri terrace is very close, the climatic conditions of them are considered to be similar. However for Ebbenadu shola, the climatic conditions are different owing to its considerable spatial separation from the other three sholas.

MATERIALS AND METHODS

Climatic and soil factors

The data on climatic factors are collected from the Government Meteorological Station, Ootacamund. The physical characters of the soils of the study sholas were analysed as per the methods of Piper (1950) and the chemical characters were analysed according to the methods of Jackson (1959) (nitrogen and phosphorous), Peach and Tracey (1956) (potassium), Piper (1944) (organic carbon) and Thomas and Hill (1949) (CO_2 evolution rate).

Oil extraction

Fresh leaves of the four variants of the species, *G. fragrantissima* were collected separately and oil was extracted by distillation in Clevenger's apparatus. The mean values of three samples were expressed on per cent basis.

Statistical analysis

SAS software (1996) was used to perform Additive Main effects and Multiplicative Interaction (AMMI) analysis on the values of leaf oil yield in four variants across the four sholas studied. PROC GLM of SAS was run to calculate genotype by environment interactions. For each genotype and environment, genotypic and environmental scores were obtained by PROC IML of SAS. In addition, principal component axes (PCAs) were extracted and statistically tested by Gollob's (1968) *F*-test procedure (Vargas and Crossa, 2000). These components were used to obtain a biplot by SAS GPLOT procedure (Burgueno *et al*., 2001). To assess fitting AMMI model, predictive and postdictive approaches offered by Zobel *et al*. (1988) were applied to the data.

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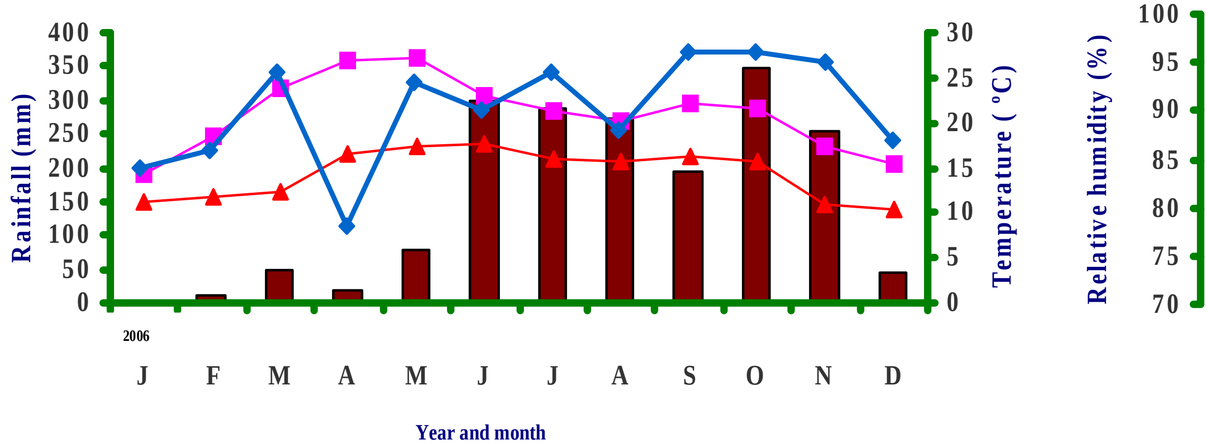

Figure 1. Monthly variations in the climatic factors Ebbenadu shola for the year 2006 (Bars represent rainfall, lines with traingles represent minimum temperature, lines with squares represent maximum temperature and lines with diamond symbols represent relative humidity)

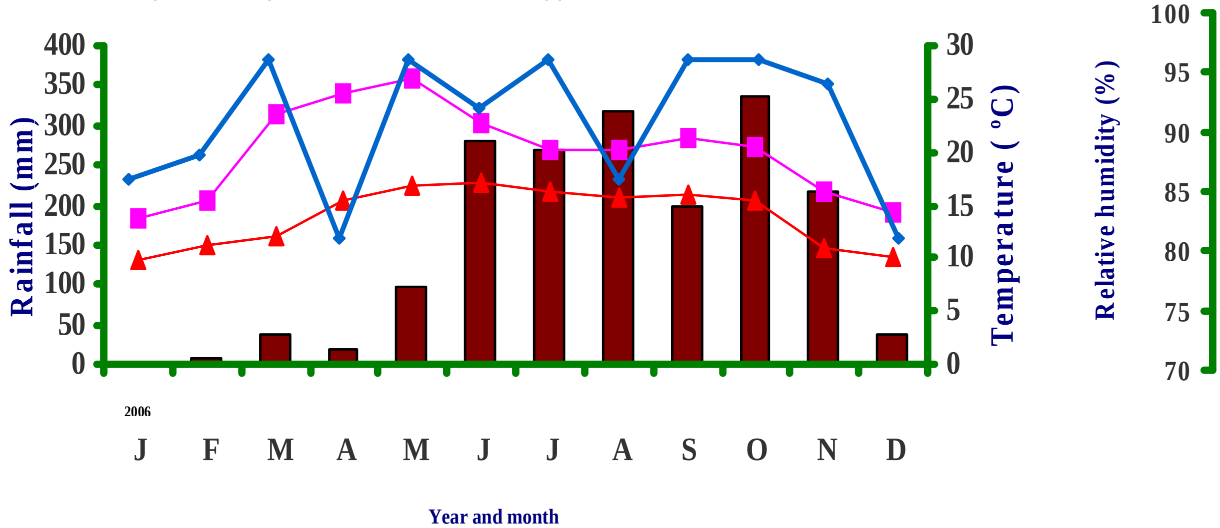

Figure 2. Monthly variations in the climatic factors at the sholas at Honnathalai, Kodappamand and Kothagiri terrace for the year 2006 (Bars represent rainfall, lines with traingles represent minimum temperature, lines with squares represent maximum temperature and lines with diamond symbols represent relative humidity)

Table 1. Physical and chemical characteristics of soil in the four sholas of Nilgiris taken for the present study

Parameter	Shola			
	Ebbenadu	Honnathalai	Kodappamand	Kothagiri terrace
Physical factors				
Water holding capacity (%)	42.5	40.6	41.0	40.5
Bulk density (g/ccs)	1.24	1.10	1.08	1.09
Soil texture	Sandy loam	Sandy loam	Sandy loam	Sandy loam
Chemical factors				
pH	6.1	6.4	6.5	6.4
Nitrogen (%)	1.15	1.03	1.05	0.99
Phosphorus (%)	0.06	0.07	0.07	0.06
Potassium (%)	0.28	0.33	0.30	0.31
Organic carbon (%)	4.20	4.13	4.10	4.17
CO_2 evolution (mg/100g soil/h)	0.92	0.85	0.86	0.88

RESULTS AND DISCUSSION

The data on climatic factors of the study forests (Figs. 1 and 2) showed that the temperature varied between 9.8 and 27.2°C and the annual rainfall was 1860 mm in Ebbenadu shola and 1820 mm in the other three sholas. The relative humidity was above 80% in all the four sholas. The physical and chemical characters of soils vary across the sholas studied (Table 1) and it was reported that they are most suited for the plant growth (Alexander, 1967).

The oil content of ovate leaf type variant of *G. fragrantissima* was significantly higher than that of the other 3 variants (Table 2). According to Paulsamy *et al*. (2006) such variations may be due to genetic factors. However, Barua and Bardoli (1987) pointed out that high content of chlorophyll in the leaves may induce the production of secondary metabolites like oil at higher rate. To support this concept our previous study reports that the ovate leaf contained higher chlorophyll pigments than the other 3 variants (Vijayakumar, 2006). Further, the present study revealed that the oil content was significantly higher in all variants of Ebbenadu shola when compared to other sholas, which may be attributed to the suitable microsites available in Ebbenadu shola for oil production by *G. fragrantissima*. However, this assumption could not be confirmed as the microclimatic conditions of the study sholas were not analysed in the present study.

When the data on oil content of four ecological variants of *G. fragrantissima* were subjected to Additive Main effects and Multiplicative Interaction (AMMI), it was found that 7.27% of the variations due to environmental effects, 85.23% due to genotypic effects and 7.49% due to interactive effects of genotype and environmental (Table 3). Hence, it is obvious that oil content of *G. fragrantissima* is mainly due to genetic factors rather than environmental factors. However, environmental factors i.e. microclimatic conditions, existing in the study sholas might also have had significant influence over oil content as 7.27% of the variations was contributed by environmental factors (Table 3).

Biplot analysis is the most powerful interpretive tool for AMMI model (Mahalingam *et al.,* 2006). In the AMMI 2 model biplot used in the present study, the scores of

Table 2. Per cent oil content of the four ecological variants of *Gaultheria fragrantissima* in the four study sholas at Nilgiris

S. No.	Shola	Oil yield by the ecological variant (%)			
		Ovate	Lanceolate	Elliptic- lanceolate	Oblanceolate
1	Ebbenadu	1.13 [a]	0.96 [b]	0.91 [b]	0.92 [b]
2	Honnathalai	1.06 [a]	0.92 [b]	0.85 [b]	0.85 [b]
3	Kodappamand	1.10 [a]	0.92 [b]	0.79 [c]	0.80 [c]
4	Kothagiri terrace	1.07 [a]	0.91 [b]	0.72 [c]	0.91 [b]
	Mean oil yield (%)	1.09	0.92	0.82	0.87

In a row, means followed by different letter are significantly different at at 5% level (Duncan's Multiple Range Test)

Table 3. Additive Main effects and Multiplicative Interaction (AMMI) analysis of variance for oil content (%) by the variants of *G. fragrantissima* across the four study sholas

Sources of variation	df	Sum of squares	Mean squares	Variants explained (%)
Trials	15	0.36694	0.02446**	
Genotypes (G)	3	0.31275	0.10425**	85.23
Environments (E)	3	0.02668	0.00889*	7.27
GxE interaction	9	0.02752	0.00306	7.49
PCA I	5	0.02025	0.00405	73.58
PCA II	3	0.00711	0.00237	25.83
PCA III	1	0.00015	0.00015	0.54

* and **- significant at 0.05 and 0.01 probability levels, respectively.

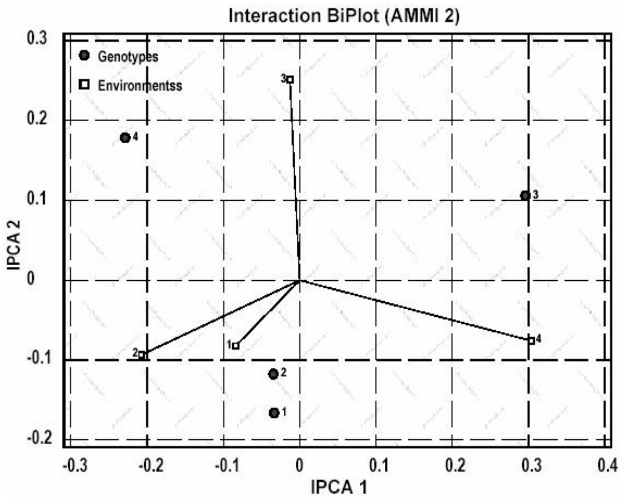

Figure 3. AMMI 2 model biplot for oil content in leaves of the four variants in four environments (sholas).
●- 1. Ovate; 2. Lanceolate; 3. Elliptic-lanceolate; 4. Oblanceolate
▫- 1. Ebbenadu; 2. Honnathalai; 3. Kodappamand; 4. Kothagiri terrace

IPCA1 and IPCA2 are plotted (Fig. 3). From figure 3, it is inferred that in the Ebbenadu site, the microclimate is more suited for the oil production by ovate leaf variant. So, it is suggested that the areas with microclimatic conditions similar to the Ebbenadu shola in the high hills of Nilgiris may be suitable for the cultivation of ovate leaf type variant of *G. fragrantissima* to meet the growing demand for its oil and also to decrease the pressure upon the wild plants.

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