(Figure 1 *e* and *f*). The rats not only devastate the naturally regenerating seeds and seedlings, and thereby reduce the regeneration rate, but also destroy other crops and stored grains. Such famines have occurred in the Lushai hills of Assam (as Mizoram was known before its independence)[4], in 1815, 1863, 1911 and 1959. Throughout the North East, the flowering-induced famine in 1959 claimed 10,000 to 15,000 lives, and flowering in 1881 also claimed a similar number[5].

During December 2005, we observed the flowering of *M. baccifera* in Nongpoh (91°52′E, 25°53′N) in the East Khasi Hills, Meghalaya.

Recent reports about the flowering of *M. baccifera* are not from Mizoram alone, but in the huge forested areas across the other northeastern states of Tripura, Manipur and southern Assam, which has attracted national and international attention. In Mizoram, the phenomenon is known as 'Mautam', literally meaning 'bamboo dying' ('mau' meaning bamboo and 'tam' meaning to die)[5–8].

As most bamboo flowering is unpredictable, for no species is sufficient information available to state unequivocally that flowering at such long, fixed intervals is the norm for that species. Only for *M. baccifera* there is reasonable evidence to suggest that the patterns observed are likely to be representative of the species[3]. The present observation confirms that the said prediction can be true in case of bamboo flowering for the above-mentioned species.

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S. JEEVA[1]
S. KIRUBA[2]
H. LALHRUAITLUANGA[3]
M. N. V. PRASAD[3,*]
R. R. RAO[4]

[1]*Department of Botany, Nesamony Memorial Christian College, Marthandam 629 165, India*
[2]*Centre for Biological Research, 2/77, Kamaraj Street, East Puthalam, Puthalam 629 602, India*
[3]*Department of Plant Sciences, University of Hyderabad, Hyderabad 500 046, India*
[4]*Central Institute of Medicinal and Aromatic Plants Allalasandra, GKVK Post, Bangalore 560 065, India*
**e-mail: prasad_mnv@yahoo.com*

Essential oils from leaves of micropropagated turmeric

Turmeric (*Curcuma longa* L.) is known worldwide for its multipurpose use in medicine, cosmetics, food flavouring and textile industries. Several pharmacological activities of turmeric like anti-inflammatory, hepato-protective, antimicrobial, wound healing, anticancer, anti-tumour and antiviral properties are due to the presence of curcumin present in the rhizome and essential oil found both in the rhizomes and leaves[1]. There is ever increasing demand for leaf oil of turmeric due to its use in medicine, perfume and aromatherapy[2]. The price of leaf oil of turmeric is approximately US$ 1 per 10 ml in the international market. The yield of the aromatic leaf oil is not up to the desired level due to the huge wastage of leaves during post-harvest processing of the rhizomes, high occurrence of diseases like rhizome rot, leaf spot and leaf blotch accounting for nearly 60% crop loss, and due to unavailability of requisite high oil-yielding planting material. An effort was therefore made to explore the possibility of an alternative method of essential oil production from leaves of *in vitro*-grown turmeric plants through biotechnological intervention, as reported in other species[3].

An elite cultivar of *C. longa* L. (cv. Suroma) having high rhizome-yielding potential (44.9 t/ha) was collected from the High Altitude Research Station, Orissa University of Agriculture and Technology, Potangi, Orissa, and was micropropagated from dormant axillary buds of unsprouted rhizomes on MS basal medium[4] containing various combinations of benzyladenine (BA), indoleacetic acid (IAA) and adenine sulphate (ADS). The medium containing 3 mg/l BA, 1 mg/l IAA and 50 mg/l ADS was optimum for shoot multiplication, producing 5–7 shoots of about 3–4 cm long per culture within every 30 days. Shoots rooted on the same medium and micrpropagated plantlets were maintained with regular subculturing at 60 days interval.

Leaves were excised aseptically from micropropagated turmeric plant (10–12 cm long) from a culture tube (Borosil, 150 mm × 2.5 cm) and used for extraction of essential oil in a Clevenger's Apparatus. After harvesting of leaves from the culture tube, the basal region of the plant stock was maintained with supply of fresh nutrient medium, which could produce extractable leaf biomass after another 2 months of culture. GLC analysis of essential oil was carried out in Perkin–Elmer auto-system fitted with a capillary column Carbowax 20 m of 50 m length flux ionization detector, Okidata 320 recorded digital computer DEC station fed with turbochrom-3 software and nitrogen as carrier gas. Samples of essential oil were analysed by temperature programming of GC (60°C for 10 min followed

by increase of 3°C/min to 200°C and kept at 200°C for 13 min). Major volatile constituents were identified on the chromatogram by comparing their retention times with authentic compounds.

Hydro-distillation of tissue-cultured turmeric leaves yielded 0.2% essential oil possessing characteristic aroma of turmeric leaf oil. GLC analysis of essential oil extracted from *in vitro*-grown leaves revealed the presence of major compounds similar to that of the source plant, i.e. alpha-phellandrene (38.5%), (1,8-cineole (8.2%), alphapinene (2.4%), myrcene (1.0%), linalool (0.4%), geraniol (1.5%)). Alpha-phellandrene which was present in large amount (38.5%) in the leaf oil of micropropagated plants of *C. longa* (cv. Suroma) was also reported to occur as a major component in the leaf oil of *C. longa* of different origin[5]. Oil content of *in vitro*-grown plants was relatively less (0.2%) in comparison to that of conventional grown source plant (0.5%), which could be attributed to juvenile state of *in vitro*-grown leaves.

An effort was made to increase the oil production by increasing the leaf biomass implementing two different methods: (a) change in combination of plant growth regulators, like addition of IAA (1 mg/l) and ADS (100 mg/l) along with BA (3 mg/l) could enhance the biomass yield from 3–4 g per culture tube to 7–8 g and (b) change in the volume of the container from 15 ml test tube to 250 ml conical flask resulted in an increase of leaf biomass to 15 g within a period of 2 months. The enhancement in leaf biomass production by changing the physiological parameters, in turn, resulted in an increase in the total oil production within a culture period of 2 months. Work on refinement of the technique is in progress for increase in leaf biomass yield, and quality as well as quantity of oil using various culture conditions and media components.

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ANANYA KUANAR
SUJATA MOHANTY
MANOJ KUMAR PANDA
SANGHAMITRA NAYAK*

Centre of Biotechnology,
School of Pharmaceutical Sciences,
Siksha 'O' Anusandhan University,
Kalinga Nagar, Ghatikia,
Bhubaneswar 751 003, India
**For correspondence.*
e-mail: sanghamitran@yahoo.com