*Trichoderma* grows profusely and also produces millions of conidia. Before extracting cellulase enzyme from the SSF-grown substrate, if the spores are separated and made into a spore suspension, it could be applied directly in the agriculture fields which would serve as a biocontrol agent. The residual straw that is still left after separation of cellulase enzyme and spores of *Trichoderma* sp., could be reused for ethyl alcohol production employing *Saccharomyces cerevisiae* in the subsequent stage. Straw is used for composting and as a feed for cattle. Instead of straw directly being used in composting, various intermediate steps could be undertaken to get several other benefits, as suggested above and schematically represented in Figure 1.

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# Flowering of *Melocanna baccifera* (Bambusaceae) in northeastern India

Flowering of bamboo is a botanical enigma. The factors responsible for this are still not clearly established. Bamboos flower only once and die after flowering to regenerate from seeds[1]. The strange phenomenon of simultaneous flowering in bamboo clumps in vast areas is called gregarious flowering and causes ecological havoc. The bamboo clumps die after flowering and it takes a few years before bamboo plants produce seeds again, leaving bare, exposed soil which could be disastrous in mountainous regions. This would lead to food scarcity, since several animals depend on this plant. The second factor is that rats feed on the flowers and seeds of the dying bamboo tree. This activates a rapid birth rate among the rodents, which leads to the huge rat population feeding on agricultural crops in the fields and granaries, thus leading to famine. This had happened in Mizoram[2] in the late 1950s.

*Melocanna baccifera* is a sympodial bamboo growing to about 20 m height Unlike other sympodial bamboos, the rhizomes are long and so rather than growing as compact clumps, *M. baccifera* produces groves of widely spaced culms, more akin to those of large monopodial bamboos. It is an aggressive colonizer and often forms the dominant vegetation on the tropical and subtropical hill slopes on which it grows. It is naturally distributed in a swathe cutting south to north from southwestern Myanmar through western central and northern Myanmar and the Chittagong hill tracts of the eastern to the northeastern states of India, where it represents between 60 and 95 regional bamboo resources.

The first recorded flowering of *M. baccifera* was in 1863; various periods of vegetative growth prior to flowering have been noted in different locations and there is a wealth of reports that give a reliable picture of the flowering cycle of this species. A study by the Jorhat-based Rain Forest Research Institute (RFRI) has estimated that the 'gregarious flowering' of *M. baccifera* or Muli bamboo will occur in several northeastern states in 2004, over an area of 18,000 km$^2$. The states identified are Mizoram (Figure 1 *a–d*), Tripura, Manipur, Meghalaya and parts of Assam. According to the estimate of INBAR[3], flowering of *M. baccifera* occurred in approximately 1.76 m ha in the northeastern states of India during 2004–08 and about 26 mt of bamboo will flower and die. Millions of people who depend directly or indirectly on Muli bamboo for their livelihood will suffer, and if famine strikes the whole populace of the region could be at risk. The neighbouring regions of Bangladesh and Myanmar could also be equally affected.

The large fruits of Muli bamboo are also eaten by non-human consumers and the sudden enormous increase in their availability will cause a rapid explosion in the rat populations, whose numbers are related to the availability of food

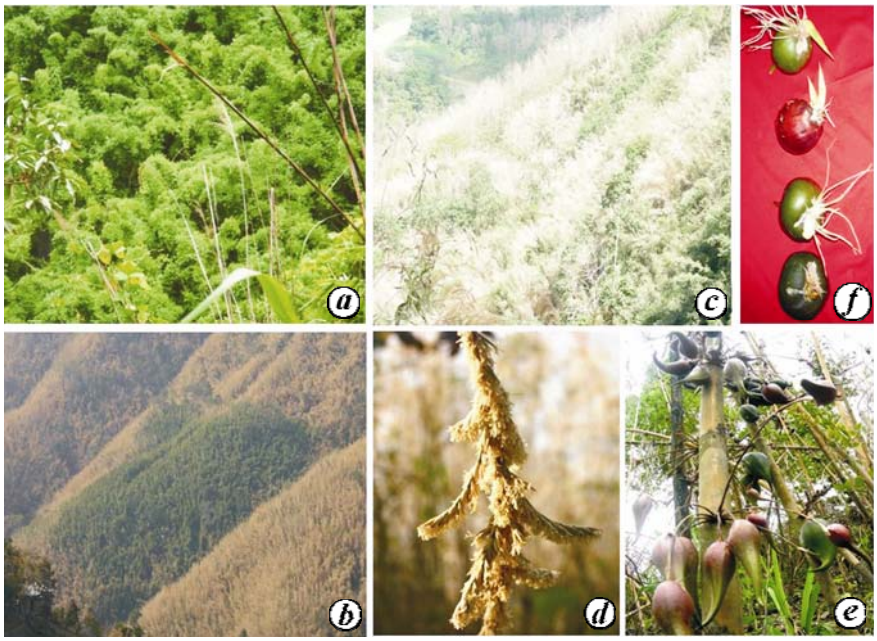


**Figure 1.** ***a***, *Melocanna baccifera* without flowers in Mizoram. ***b***, *M. baccifera* – Green patch without flowers which is sourrounded by flowered plants (in pale colour). ***c***, Profusely flowering *M. baccifera*. ***d***, Enlarged flower of *M. baccifera*. ***e***, Fruits attached to culms. ***f***, Germinating seeds from fruits.

(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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# 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