Blooming potential of the detached shoots of *Cephalotaxus griffithii* Hook. f.

Flowering in many temperate plants is either dependent on, or promoted by prior exposure to the prolonged cold of a winter season. The process by which exposure to cold promotes flowering is known as 'vernalization'[1–5]. Several workers have successfully induced flowering in shoots cultured on varied media in the laboratory. Flower formation on shoot tips of bitter melon cultured on Murashige and Tucker medium is known[6]. Regeneration of flower buds in thin tissue layers from the pedicels of photo-induced short-day tobacco has been described[7]. The chilling treatment of rooted cuttings is reported to enhance or delay flowering depending on the species[8]. Shoots of *Murraya paniculata* flowered *in vitro* on half-strength MT basal medium containing 5% sucrose[9]. Branch internodes of mature plants and stem internodes of seedlings of *Fortunella hindsii* flowered *in vitro* and highest percentage of flowering was achieved with explants originating from branch internodes flowering plants close to the apex[10].

The objective of this correspondence is to report atypical flowering (i.e. development of female cones; Figure 1) in detached young branchlets (shoots) of *Cephalotaxus griffithii* Hook. f. (Cephalotaxaceae), which is a dioecious, gymnosperm tree[11] included in the IUCN Red List under LR/nt category as assessed[12] in 2000. *C. griffithii* or plum-yew is found below 2000 m, especially in Mishmi Hills, Arunachal Pradesh[13], Manipur[13], Nagaland[13], Myanmar[14] and West Sichuan Province of China[13]. Gymnosperms differ from angiosperms in bearing naked ovules on female strobili aggregated in the form of cones. The fleshy female cones look like the flowers of angiosperms. The cones of *C. griffithii* are borne in the axil of the lowermost two to four leaves on some newly formed shoots. The flowering or development of female cones on naturally growing trees of *C. griffithii* is observed at the beginning of the spring season in early March in Meghalaya.

In a fortuitous experiment, the development of female cones occurred on pieces of shoot apices of the current year growth, that were collected on 3 October 2005 from four trees of *C. griffithii* in Meghalaya, when mature fleshy seeds were drooping on the trees. The plucked shoot apices were brought to the laboratory, enclosed within polyethylene bags and immediately stored in a refrigerator at a temperature ranging between 8°C and 10°C. A 50–80 lux light could reach the shoot apices occasionally, whenever the door of the refrigerator was opened for transaction. The frequency of opening the door ranged between zero and three, with a mean of 1.5 times per day. The green-coloured young female cones were observed on 12 May 2006, which matured and became fleshy by 18 May 2006. The observed flowering in *C. griffithii* was atypical since it occurred in May, i.e. delayed by nearly two months compared to flowering in naturally growing trees. Also, the flowering was copious, i.e. from the axils of most leaves in a branchlet. A careful examination showed that none of the shoots had developed any roots. Moisture availability was abundant inside the polyethylene bags. Furthermore, the stored shoots that produced flowers were detached, devoid of roots and receiving no nutrient supply and light. The opportunity of gaseous exchange was also negligible. Thus, the storage environment was stressful to the shoots, posing an imminent threat of senescence and death.

Figure 1. Development of female cones in detached young shoots of *Cephalotaxus griffithii* achieved under laboratory conditions. The young branchlets are green; they turn dark brown when dead. A branchlet comprises a leafy stem and the decussate or distichously arranged leaves that are linear, flat, pointed at the tip and rounded at the base (***a***). The leaves are characterized by a silvery abaxial surface and a prominent midrib running from the base to the tip (***b***). The leaves may persist up to three years. The female cones are small (6–8 mm), short-stalked and green when young. A female cone comprises 5–7 pairs of opposite and decussate bracts. Two ovules are borne in the axil of each bract, except the lowest pair. Generally, a single ovule matures into a red-coloured fleshy seed in each cone. The scale shown is in centimetres.

Evidently, the development of female cones occurred on detached shoots under prolonged exposure to darkness coupled with incessant low temperature in the refrigerator. Hence it remains to be ascertained whether the development of female cones in *C. griffithii* was a result of prolonged exposure to cold (vernalization) or a result of absence of light (photoperiod) or an interaction of low temperature and darkness. Genetic analyses have identified three genes that control the vernalization requirement in wheat and barley; *VRN1*, *VRN2* and *FT* (*VRN3*)[15]. *VRN1* is induced by vernalization and accelerates the transition to reproductive development at the shoot apex. *FT* is induced by long days and further accelerates reproductive apex development. *VRN2*, a floral repressor, integrates vernalization and day-length responses by repressing *FT* until plants are vernalized. A planned experiment is required to identify the reason for reproductive development in detached shoots of *C. griffithii*.

1. Chouard, P., *Annu. Rev. Plant Physiol.*, 1960, **11**, 191–238.
2. Lang, A., In *Encyclopedia of Plant Physiology* (ed. Ruhland, W.), Springer-Verlag, Berlin, 1965, pp. 1371–1536.
3. Bernier, G., Kinet, J.-M. and Sachs, R. M., *The Physiology of Flowering*, CRC Press, Boca Raton, Florida, 1981.
4. Sung, S. and Amasino, R. M., *Annu. Rev. Plant Biol.*, 2005, **56**, 491–508.
5. Amasino, R. M., *Curr. Opin. Biotechnol.*, 2005, **16**, 154–158.
6. Wang, S., Tang, L. and Chen, F., *Plant Cell Rep.*, 2001, **20**, 393–397.
7. Rajeevan, M. S. and Lang, A., *Planta*, 1987, **171**, 560–564.
8. Fukai, S. and Goi, M., ISHS Acta Horticulturae: XXV International Horticultural Congress, Part 5: Culture Techniques with Special Emphasis on Environmental Implications – Chemical, Physical and Biological Means of Regulating Crop Growth in Ornamentals and other Crops, Brussels, Belgium (on-line publication only, ISSN 0567-7572), 2000.
9. Jumin, H. B. and Ahmad, M., *Plant Cell Rep.*, 1999, **18**, 764–768.
10. Jumin, H. B. and Nito, N., *Plant Cell Rep.*, 1996, **15**, 484–488.
11. Hooker, J. D., *Flora of British India*, L. Reeve and Co., London, 1885, vol. 5, pp. 647–648.
12. IUCN Red List of threatened species (Conifer Specialist Group 2000), 2006; www.iucnredlist.org
13. Tripp, K. E., *Arnoldia*, 1995, **55**, 24–39.
14. Farjon, A., *World Checklist and Bibliography of Conifers*, Royal Botanical Gardens at Kew, Richmond, UK, 1998.
15. Trevaskis, B., Hemming, M. N., Dennis, E. S. and Peacock, W. J., *Trends Plant Sci.*, 2007, **12**, 352–357.

Received 18 May 2007; revised accepted 24 June 2008

UMA SHANKAR

Department of Botany,
North-Eastern Hill University,
Shillong 793 022, India
e-mail: arshuma@yahoo.com

Occurrence of vivipary in *Jatropha curcas* L.

Jatropha curcas L. (Euphorbiaceae), a drought-resistant, photo-insensitive perennial plant, is a potential source of non-edible biodiesel-producing energy crop[1,2]. *Jatropha* is a multipurpose tree with a long history of cultivation in the tropical and subtropical regions of the world[3]. It is a native to Central America and occurs mainly at lower altitudes (0–500 m) in areas with an annual temperature of well above 20°C. Two species of *Jatropha* that are grown include *J. curcas* and *J. glandulifera*. *J. curcas* is mainly promoted for bio-diesel because of higher oil content (up to 48%), whereas *J. glandulifera* is known for its beautiful flowers and oil content (up to 27%). The plant can tolerate extremes in temperature, but not frost and water stagnation. It grows almost everywhere – even on gravely, sandy, acidic and alkaline soils, with pH ranging from 5.5 to 8.5. It can thrive in the poorest stony soils.

Vivipary is the process by which seeds germinate within the fruit, followed by subsequent embryo development before the seeds are dispersed from the parent plant. The germination of viviparous seeds usually occurs while they are still on the parent plant (precocious germination), a relatively unusual phenomenon in angiosperms[4]. Vivipary has been reported in fewer than 100 flowering plant families[4], representing less than 0.1% of angiosperms. The best known cases of vivipary in angiosperms are documented in mangroves of Rhizophoraceae and Avicenniaceae[5]. To our knowledge, there is no report of vivipary in *J. curcas*. The objective of this correspondence is to document the occurrence of viviparous seeds in *J. curcas*, and leave clues for further research on understanding the viviparous nature in *J. curcas* and its ecological and evolutionary significance.

The Plant Metabolic Engineering Group at Dhirubhai Ambani Life Sciences Centre (DALC), Navi Mumbai, has initiated work on mass propagation[2] and development of transgenic *Jatropha*. To support regular explant collection, we have planted around 250 plants (Figure 1 *a*) inside the DALC Campus situated at Rabale (lat. 19°15′N, long. 72°99′E). The rainy season in this area is mostly confined to the south-west monsoon, with 80% of the rainfall during June–October (60–70 days). On an average, the area receives 2500–3500 mm of rainfall. The area has marine humid–pre-humid climate with more humidity and less diurnal variations. Relative humidity varies from 41 to 97%, the driest days being in winter and wettest ones in July.

The first finding of peculiar phenomenon of vivipary was observed in the above populations (Figure 1 *a*) during heavy monsoon, from late June through early August 2007. The mother plants were two years old and they had fully developed mature fruits. It was observed that during continuous rainfall, the inflorescence head gets wet and the seeds begin to germinate. A well-developed, white root system first emerged from the posterior portion of the dry fruit (Figure 1 *b*). The seeds in several stages of germination, viz. tiny embryos emerging from the seed coat to young, healthy seedlings with small cotyledons, elongated hypocotyls and radicals, including fully grown seedlings were found in mature fruits (Figure 1 *c–f*), while they were still attached to the mother plant. Some of the seedlings finally got detached and fell on the ground due to their own weight, when the radicle embedded into the soil got established into a plant. This type of seedling establishment through germination on the plant is extremely uncommon in this environment. Thus, it is an example of true vivipary which was favoured by excessive atmospheric moisture or wet condition experienced by the plant after seed ripening.

Although we do not have a conclusive explanation for this phenomenon in *J. curcas*, we presume that various intrinsic and extrinsic factors of the plant may be involved, namely physiology, soil condition, temperature and dry spell followed by high humidity induced by heavy rainfall. Vivipary, a phenomenon characterized by lack of dormancy, is important because, in addition to being a relatively unusual event in nature, it has been interpreted as a specialized trait of evolutionary and biological significance,