- N. Bloembergen and A. L. Schawlow for 'the development of laser spectroscopy' (1981).
- E. Ruska for 'the design of first electron microscope' (1986).
- G. Binnig and H. Rohrer for 'the design of the scanning tunneling microscope' (1986).
- G. Charpak for 'the invention and development of particle detector, in particular the multiwire proportional counter' (1992).
- B. N. Brockhouse for 'the development of neutron spectroscopy' with special reference to constant-Q method (1994).
- C. G. Shull for 'the development of neutron diffraction technique' (1994).
- S. Chu, C. Cohen-Tannouji and W. D. Phillips 'for the development of methods to cool and trap atoms with laser light' (1997).
- J. L. Hall and T. W. Haensch for 'laser based precision spectroscopy' (2005).
- S. Haroche and D. J. Wineland for 'ground breaking experimental methods that enable measuring and manipulation of individual quantum systems' (2012).
- I. Akasaki, H. Amano and S. Nakamura for 'the invention of efficient blue LED' (2014).

The award has gone to scientists for developing experimental methods and devices with such monotonous regularity that it hardly seems necessary to cite more examples.

If we wish to innovate and invent at the frontline, we need to build this culture into our system of education. Our students at every level should be mandated to have hands-down experience with simple experiments involving rudimentary construction, gradually increasing in complexity, which, at the tertiary education level, should grow to project work involving some construction of apparatus. This need not involve great expenditure. I learnt my soldering and plating from my 'kalaiwala', who used to do plating for our brass vessels. This helped me in building a methane liquifaction system for my Ph D. In 1930s, when no research fund was available, M Sc students at the Banaras Hindu University, Varanasi built and investigated Geiger–Mueller counters[5] and devised optical silvering methods (for astronomical telescopes) which were of a standard prescribed by the National Bureau of Standards of USA and better than the then prescribed method[6]. Today we have a National Policy for innovation. We need to embed it into our education system. This, of course, requires teachers and guides who themselves think of innovative methods of imparting knowledge. Such teachers need special recognition by the Central and State Governments and our Academies. Recommendations to Governments on innovation, instrumentation and invention will bear fruit only when our scientific community starts respecting and duly recognizing the importance of this type of manpower, rather than overemphasizing paper publication and impact factor. In my opinion such appreciation is lacking. Our senior scientist K. R. Ramanathan, in an IPA meeting discussing ways of attracting students to science, said that this will happen only when society starts respecting scientists.

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B. A. Dasannacharya lives at #4, Beach Resort CHS, Sector 10A, Plot 1, Vashi, Navi Mumbai 400 703, India.
e-mail: adasannacharya@gmail.com

Cultivation of *Saussurea costus* cannot be treated as 'artificially propagated'

Chandra P. Kuniyal, Dharmendra S. Rawat and Rakesh C. Sundriyal

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has resolved that 'the species of fauna and flora that are or may be affected by trade should be included in the appendix I (ref. 1). Appendix I includes the species threatened with extinction and only in exceptional circumstances, trade in specimens of these species is permitted[1]. The fifth and sixth points of a prescribed application format by the Government of India (based on which the trade of particular species – alive or its products – may be permitted) for 'issue of documentation regarding export/import/re-export of CITES listed flora and fauna' asks for (i) source of procurement (collected from wild/bred in captivity/artificially propagated), LPC (legal procurement certificate) number and (ii) country in which the specimen was taken from wild/bred in captivity/artificially propagated[2].

Saussurea costus (Falc.) Lipsch., also known by several other synonyms in the scientific literature like *Saussurea lappa* (Decne) Sch. Bip., *Aplotaxis lappa* Decne., *Aucklandia costus* Falc., *Aucklandia lappa* Decne., *Theodorea costus* Kuntze (Sanskrit – Kushtha, Kashmiri – Postkhi, Tibetan – Puchuk or Putchok, Hindi – Kuth or Kooth, and English and trade name – Costus, family Asteraceae), is an ancient medicinal herb. Its roots are used in ayurvedic formulations, cosmetics and various other herbal formulations[3]. *S. costus* is listed in appendix I of CITES[4] and specified plants in the Schedule VI of the Wildlife (Protection)

Act, 1972 (India). The Kuth Act, 1978 (AD 1921), enacted by the Government of Jammu and Kashmir (J&K) provides conservation, preservation and protection to the plant and its produce, and guards against illicit cultivation, extraction, possession and export thereof, from J&K[5]. Further, the Act was repealed and enacted in 2002 and 2005 respectively, for imposing complete ban on harvesting from the wild. Moreover, according to the Wildlife (Protection) Act 1972, no person shall cultivate a specified plant except under, or in accordance with a license granted by the Chief Wildlife Warden or any other officer authorized by the State Government in this behalf (Chapter IIIA, 17C – Chapter IIIA, inserted by Act 44 of 1991, sec. 13).

The earliest floristic record of *S. costus* mentions that this is an endemic plant of Kashmir – India, and supposed to be the Costus of ancient times[6,7]. In earlier times large quantities of Kuth roots were extracted from wild populations for commercial use, resulting in its depletion. Consequently, its collection from the wild was banned and the species was listed in CITES. More recent floristic literature describes it as a native of J&K and also found between 3200 and 3800 m in subalpine and alpine regions of the western Himalaya, including northeast Pakistan (viz. along the India–Pakistan border), Himachal Pradesh (HP) and Uttarakhand[8,9]. It has been reported that *S. costus* is cultivated and also occurs as an escape around habitations in Khoksar–Lahaul, HP[10,11]. In Uttarakhand, occurrence of Kuth in the wild is reported from north of Bampa village (3800 m) in Joshimath (Chamoli), which is situated along the former Indo-Tibet/China trade route[12]. A more recent study of this region, where Costus was mentioned as wild, clearly indicates it as cultivated[13]. Duthie's catalogue of plants (published in 1906; prior to the introduction of *S. costus* in Uttarakhand), which lists almost all wild plants of that region, does not mention Kuth[14]. Therefore, Kuth cannot be authentically considered as a wild plant in Uttarakhand hills.

Cultivation of Kuth by missionaries was initiated during 1920s in Lahaul, HP[11] and introductory cultivation of Kuth in the present Uttarakhand was started during 1929 at Bhuna or Bhoona in a experimental farm developed by the Department of Forest in Chamoli, (~3150 m asl, located along Roopkund trail)[15]. At present, Kuth occurs at random in this location. Also, within 25–30 km of this region about 150 farmers in Kanol, Sutol, Wan and Kuling villages are cultivating Kuth (Figure 1). The inhabitants of these villages along the former Indo-Tibet/China trade route also reiterate that cultivation–trade of Costus was common in all high-altitude villages, until the Indo-Tibet/China trade was postponed after the World War II, and it was exported to China under the name 'Puchuk or Putchok'. Migrant villagers in these locations are still upholding cultivation of Kuth as a traditional practice in Malari, Bampa, Gamshali, Dronagiri and Niti villages. In Uttarakhand, from 2005–06 to 2012–13, around 490 farmers of the Chamoli and Pithoragarh districts are registered as Kuth cultivators with the Herbal Research and Development Institute (HRDI), Chamoli although the area under cultivation of Kuth by such farmers on individual basis is around 0.02–0.06 ha (database of HRDI; the institute is the designated agency for registration of medicinal plant growers and authorized for registration of Kuth growers in Uttarakhand). In Uttarakhand, procurement price of Rs 150.00/kg is fixed for the dried roots of Kuth.

A total 304.05 metric tonnes (MT; 1.00 MT = 1000.00 kg) Kuth (@ Rs 20.40 to 56.00/kg; Rs 61.42 = US$ 1.00, as on 6 November 2014) from cultivated sources were traded from Lahaul, HP during 1988–89 to 2000–2001 (ref. 11). On the other hand, 11.04 MT Kuth from cultivated sources (@ Rs 53.00 to 120.00/kg) are also marketed from Uttarakhand during 2007–2010 (ref. 16). India has exported nearly 278,444.00 kg Kuth from 1983 to 2009 (ref. 5). However, during 2003–04 and 2004–05, India imported around 398,480.00 and 216,460.00 kg Kuth from neighbouring countries, having an economic value of Rs 4,919,567.00 and Rs 2,759,775.00 respectively[17]. Also, recently, the Director General of Foreign Trade, India, has approved an application for the import of 500.00 MT Kuth for stock and sale purpose (minutes of the Policy Relaxation Committee meeting No. 11/AM 09 held on 24 March 2009 at 4.30 p.m.). In general, requirement of Kuth roots in Indian herbal market is estimated to be around 100–200 MT and even larger quantities are required in the international market. China is also cultivating this herb in many of its provinces (http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=2500 97338) and may outcompete India in production.

Figure 1. Cultivation of *Saussurea costus* in a temperate village of Chamoli, Uttarakhand, India.

In fact, *S. costus* is neither a narcotic nor a hazardous or invasive species; it has a demonstrated potential to take the status of an economically viable medicinal plant crop in Western Himalaya[11,16]. If a species is in cultivation for about 85–94 years, to include it in appendix I of CITES may not be justified. Its inclusion in appendix I of CITES and specified plants in Schedule VI of the Wildlife (Protection) Act 1972, is hampering cultivation and trade of Kuth. Therefore, cultivated Costus must not be treated as artificial breeding. Legal barriers and other associated factors are detrimental for production of low-cost raw materials of Costus in the Himalayan region for Indian industries, earning foreign exchange by export, and undoubtedly favour its import from neighbouring countries. Once adopted, cultivation of this crop having relatively longer shelf-life will directly benefit the hill farmers, where perishable crops like potatoes and temperate fruits are difficult to transport due to lack of year-round road connectivity.

Practically, it is still difficult to resolve how cultivated Costus can be categorized as artificially propagated. Because cultivation itself is from seed to seed and this fact is fulfiled in the cultivation of Costus. Almost a century-old cultivation of this species (from 1920 and 1929 onwards in HP and Uttarakhand respectively) in the Indian Himalayan region cannot be categorized now as 'wild harvesting, bred in captivity or artificially propagated', as it has to be furnished for issue of documentation for international trade. India is among the signatories of CITES agreements and it is desirable that

the government needs to act as a facilitator rather than to create barriers[18]. Occurrence of Costus around villages or along the old Indo-Tibet/China trade routes must be an escape from cultivated sources. Mere evidence is available on its natural occurrence in Uttarakhand; therefore, the Conservation Assessment and Management Prioritization (CAMP) has not assessed it for Uttarakhand[19]. Scientifically, avoiding its misidentification with the morphologically somewhat similar plant, *Arctium lappa* and developing effective post-harvest technology are also important.

Considering Pakistan's request[20] for exempting Kuth from CITES and China's strategy of its multilocational cultivation, the future of Kuth cultivation in India is in peril. Therefore, an immediate policy shift is required for exclusion of cultivated Kuth from appendix I of CITES and also relaxation has to be granted for cultivation of this species via revisions in Schedule VI of the Wildlife (Protection) Act 1972. As a legal alternative, geographical indication (GI) registration and providing a specific GI number for cultivated Costus (Kuth) will help in protecting the rights of the cultivators, large-scale production and economically viable trade.

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Chandra P. Kuniyal is in Herbal Research and Development Institute, Mandal, Chamoli 246 401, India; Dharmendra S. Rawat is in Department of Biological Sciences, G.B. Pant University of Agriculture and Technology, Pantnagar 263 145, India; Rakesh C. Sundriyal is in G. B. Pant Institute of Himalayan Environment and Development Kosi-Katarmal, Almora 263 643, India.*
**e-mail: cpkuniyal@rediffmail.com*