Gender instability in *Tinospora cordifolia* – an immunomodulator

Tinospora cordifolia (Willd.) Hook f. & Thoms (family Menispermaceae) is an important medicinal plant (Figure 1 *a*) recognized as a good immunomodulator in modern medicine[1]. The species is widely distributed in India, extending from the Himalayas down to the southern part of peninsular India. It is also found in neighbouring countries like Bangladesh, Pakistan and Sri Lanka. The plant is also reported from South East Asian countries such as Malaysia, Indonesia, Thailand, etc. It is reported to bear distinct male and female flowers[2–4] (Figure 1 *b* and *c*). However, our observations on floral biology revealed the gender instability phenomenon in the species and hence a systematic study was conducted at field gene bank of the National Research Centre for Medicinal and Aromatic Plants, Anand (lat. 22.5°N and long. 73°E), from 2002–03 to 2004–05. Average rainfall in the region is about 800 mm, with minimum and maximum temperatures 12.7 and 42.0°C respectively.

There were about 21 female and 31 male accessions in the field gene bank. The species flowers profusely during November to May. Appearance of female phase in staminate flowers was observed for the first time in the population in our germplasm collection. This temporary expression of bisexuality or hermaphrodism in males (Figure 1 *d*) was not reported in the species earlier. In some of the male plants (~24%), development of pistils started from February resulting in hermaphrodite flowers. It was also interesting to note that in February, within the male plants both staminate and hermaphrodite flowers were observed, however, in different frequencies varying between 0 and 10% per inflorescence. All the male plants were converted to hermaphrodites by April and they gradually reverted to males starting from May. In the beginning of the conversion process, small protuberances appeared at the centre of staminate flowers producing no fruit set. However, at a later stage, fully developed pistils were formed and fruits were developed. Although there were three pistils as in the case of pistillate flowers, fruit setting was not successful in all these hermaphrodites, especially in the initial month of the sex conversion (February); later about 12% of the hermaphrodite flowers set seeds. It was observed that only one to two or rarely three fruits were developed normally in these sex-converted flowers. However, in the case of females, the gender expression was highly stable and fruit-setting success was recorded about 100% in the pistils (Figure 1 *e*).

Liability of sexual expression probably has a survival value, where a significant portion of the females must otherwise bear the cost of fruit production in unfavourable environments and this also will enhance an individual's genetic contribution to the next generation[5]. Gender insta-

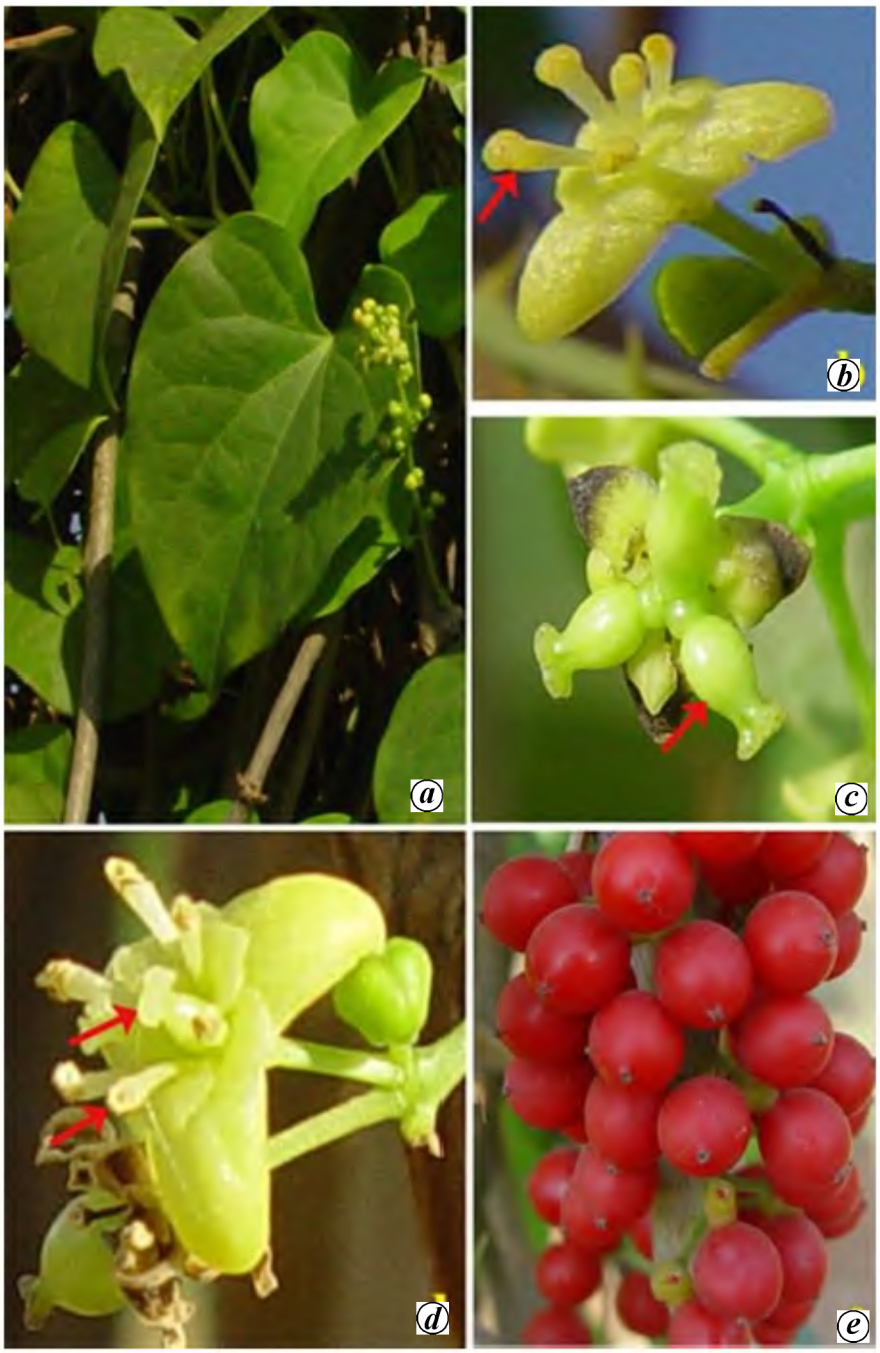

Figure 1. *Tinospora cordifolia*. ***a***, Plant habit; ***b***, Staminate flower; ***c***, Pistillate flower; ***d***, Hermaphrodite flower with both stamen and pistil and ***e***, Fruiting in female plant.

bility is reported in a number of species such as *Cannabis sativa*, *Cucurbita peppo*, *Curcumis sativa*, *Ricinus communis*, *Kalenchoe integra*, *Catasetum* spp., *Zea mays*, *Carica papaya*, *Cleome spinosa*, *Morus alba*, *Citrullus lanatus*, etc.[6]. *Piper nigrum* L., which is dioecious under wild condition, turned hermaphrodite under cultivated condition. It was also observed in the species that under intense shade condition, the bisexual types produce more of pistillate flowers and less of hermaphrodites[7]. In *P. thomsoni* Hook also, sex conversion was noticed by Saji *et al.*[8].

Unisexual individual is considered evolutionarily superior to hermaphrodites[9]. In *T. cordifolia*, evolution of gender expression is in its way of advancement towards unisexuality, where a portion of the population has reached a stable sex expression, i.e. females and remaining population are yet to be fully stabilized.

Thus *T. cordifolia* is an example of a species which is in its evolutionary way and earlier reports of its dioecious nature might have been due to incomplete observations taken at a time when hermaphrodite plants showed male expression. The species is in 'unstable stage' passing through different sex forms, viz. dioecious (male and female plants), subdioecious (female plant exists with plants of male as well as hermaphrodite flowers), gynodioecious (female plants along with plants of hermaphrodites) or polygamous (females, males and hermaphrodites) condition.

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Occurrence of uraninite and brannerite in the Samarkiya area, Bhilwara District, Rajasthan

The Pur-Banera basin is one amongst the eight pull-apart[1] metasedimentary basins of Lower Proterozoic age present as linear belts in the Banded Gneissic Complex (BGC) terrain of Rajasthan. It has a length of 50 km and width ranging from 4 to 7 km. The metasedimentary sequences of Pur-Banera Group unconformably overlie the Archaean basement[2] comprising gneisses, migmatites and garnetiferous biotite schist of the Manglawar Group. The Pur-Banera basin hosts a number of Cu, Pb, Zn and minor silver occurrences, prospected by the Geological Survey of India[3]. Gurla-Rewara tract constitutes the southern part of the Pur-Banera basin. Radioactivity due to uranium is reported at Samarkiya, located at 8 km SSW of Gurla (Figure 1).

The Atomic Minerals Directorate for Exploration and Research (AMD), Hyderabad has identified the Pur-Banera basin as a potential target for uranium exploration. The lowermost member of the Pur-Banera Group is massive and micaceous quartzite with thin polymictic conglomerate, designated as Pur Formation[3]. It is overlain by the Rewara Formation constituting calc-schist/gneiss and calc-silicate rock. The banded magnetite quartzite, referred to as BIF, occupies the central part of the belt and forms an important marker horizon for base-metal exploration. The uppermost Samodi Formation includes quartzite and mica schist with intercalations of marble and calc-silicate bands.

Pur quartzite exposed at Samarkiya, Sethuriya forms an antiform structure overturned toward west (Figure 1). The closure of this antiform is located at 1 km north of Samarkiya, where the quartzite has a width of 200–500 m. Quartzite is exposed intermittently as three isolated outcrops along the axial region. Uranium mineralization occurs along the axial region where it is highly silicified, brecciated and sheared, and at a few places slickensides were also observed indicating movement towards northeast. Apart from these, adjoining fault (Figure 1) and sulphide mineralization in the basement are also noteworthy – these features point towards structural control of mineralization. Quartzite is greyish to light pink in colour. Outcrop pattern of Pur quartzite is controlled by F2 folding with steep axial plane, trending NNE, with moderate to steep plunge towards NE. Three sets of fracture have developed trending N30°E–S30°W, dips 55°–70° due SE, E–W and N60°W–S60°E with sub-vertical dips.

Systematic radiometric checking led to the identification of uranium mineralization associated with fractured, sheared and brecciated quartzite of the Pur Formation at Samarkiya, close to the contact of quartzite and garnetiferous biotite schist (Figure 1). Detailed field studies of closely spaced radiometric checking, trenching, pitting and shielded probe logging have revealed four sub-parallel mineralized bands ranging in length from 50 to 320 m, with width ranging from 0.5 to 2 m.

Band I has an explored length of 320 m; band II has a length of 90 m and assayed the highest value of grab sample of 6.6%