

# Snake Gourd and Pointed Gourd: Botany and Horticulture

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## ABSTRACT

*Trichosanthes* is the largest genus of the family Cucurbitaceae. Its center of diversity exists in southern and eastern Asia from India to Taiwan, The Philippines, Japan, and Australia, Fiji, and Pacific Islands. Two species, *T. cucumerina* (snake gourd) and *T. dioica* (pointed gourd), are widely cultivated in tropical regions, mainly for the culinary use of their immature fruit. The fruit of these two species are good sources of minerals and dietary fiber. Despite their economic importance and nutritive values, not much effort has been invested toward genetic improvement of these crops. Only recently efforts have been directed toward systematic improvement strategies of these crops in India.

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*Horticultural Reviews*, Volume 41, First Edition. Edited by Jules Janick.  
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**KEYWORDS:** cucurbits; *Trichosanthes*; *Trichosanthes cucumerina*; *Trichosanthes dioica*

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## I. INTRODUCTION

Snake gourd (*Trichosanthes cucumerina* L. var. *anguina* (L.) Haines) and pointed gourd (*T. dioica* Roxb.) are widely cultivated in tropical regions and used as a vegetable. *Trichosanthes cucumeroides* (Ser.) Maxim. (Japanese snake gourd) is also grown in Japan and China as a source of starch. Snake gourd has high economic importance among vegetables in India and is commonly grown in Southeast Asia, Indo-Malaysia, China, Japan, and northern Australia (Paris and Maynard 2008) as well as parts of Latin America, the Caribbean islands, tropical Africa, and Mauritius (Mini Raj et al. 1993). Pointed gourd is extensively cultivated in the northern and eastern states of India (Uttar Pradesh, West Bengal, Orissa, Bihar, and Assam), Bangladesh, Sri Lanka, and Nepal. Young, tender fruit of snake gourd and pointed gourd are consumed after cooking. Twenty-four species of *Trichosanthes* are found in India, principally along the Malabar Coast of the Western Ghats, in the low and medium elevation zones of the Eastern Ghats, and North Eastern Hills (NEH) region. These gourds also are important in the traditional medicine of China, Thailand, and India.

## II. THE GENUS *TRICHOSANTES*

### A. Origin and Distribution

*Trichosanthes* L. is the largest genus of the Cucurbitaceae with 91 species (Jeffrey 1980, 1990; Yueh and Cheng 1980; Huang et al. 1997,

1998, 2007; Rugayah and de Wilde 1999; de Boer and Thulin 2012). The wild species of *Trichosanthes* are restricted to southern and eastern Asia, tropical Australia, and Fiji, while India or the Indo-Malayan region is considered the center of origin (De Candolle 1882). The genus has its center of diversity in southeast Asia from India eastward to Taiwan, the Philippines, Japan and southeastward to Australia, Fiji, and Pacific islands (de Wilde and Duyfjes 2010). There has been no comprehensive revision for the whole range of its distribution, but there have been regional revisions for India (Chakravarty 1959, 1982); China (Lu et al. 2011); Thailand (Duyfjes and Pruesapan 2004); Cambodia, Laos, and Vietnam (Keraudren-Aymonin 1975); Malaysia, Indonesia, and The Philippines (Rugayah and de Wilde 1997, 1999; de Wilde and Duyfjes 2004, 2010); Australia (Telford 1982; Cooper and de Boer 2011); and Japan (Ohba 1984). Of the 91 species (de Boer and Thulin 2012), 24 have been reported from India (Chakravarty 1959), 17 from Thailand (Duyfjes and Pruesapan 2004), 18 from Malaysia (Backer and Brink 1963), 4 from northern Australia, and 4 from Japan. Pointed gourd is cultivated on a small scale in the United States to supply ethnic farmers' markets and ethnic grocery stores (Singh and Whitehead 1999). *Trichosanthes kirilowii* and *T. rosthornii* are cultivated as medicinal crops. It is difficult to estimate the area and production since these crops are raised mostly for local market use and seldom enter the large commercial channels. Several other wild species of *Trichosanthes* are cultivated locally in India, Pakistan, Nepal, China, and Japan for various purposes (Jeffrey 2001). *Petola* or *patala*, the common name for snake gourd (*T. cucumerina*) in the Malay Peninsula, the Moluccas, and the Philippine Islands, is possibly of Sanskrit origin, indicating that the genus *Trichosanthes* may be indigenous to India (Seshadri 1986).

Because of monoecy and dioecy, the species of *Trichosanthes* are highly cross-pollinated. Pollination is strictly entomophilous; the pollen is sticky and cannot be dispersed by wind. The pyrrillid moth is reported to be the main pollinator.

## B. Taxonomy

*Trichosanthes* pollen studies have been carried out by Erdtman (1952), Ikuse (1956), Marticorena (1963), Keraudren (1968), Keraudren-Aymonin et al. (1969, 1984), Huang (1972), Mandal and Chanda (1981), Yue and Zhang (1986), Beevy and Kuriachan (1996), Huang et al. (1997), Khunwasi (1998), and Pruesapan and Van der Ham (2005). Generally the pollen grains are 3(4)-porate, 3(4)-colporate, psilate, perforate, (micro) retic, rugulate, and verrucate (Jeffrey 1990). Pollen grains of

all the species were starchy and germinated readily in Brewbaker and Kwack's medium.

Revisions have been made to the subgenera and sections within *Trichosanthes*. The genus is in the subtribe Trichosanthinae, tribe Trichosantheae, subfamily Cucurbitoideae of the Cucurbitaceae (Jeffrey 1980; Duyfjes and Pruesapan 2004; Kocyan et al. 2007). The genus has been revised for India by Kundu (1942) and Chakravarty (1959); for Cambodia, Laos, and Vietnam by Keraudren-Aymonin (1975); and for Malaysia by Rugayah and de Wilde (1997, 1999) and Rugayah (1999); taxonomic keys have been provided in some cases. It is a difficult genus to work with, since the herbaria materials are generally insufficient due to dioecious sex expression; also, the fragile corollas that bloom at night are difficult to collect, preserve, and study (Duyfjes and Pruesapan 2004). Rugayah and de Wilde (1999) found that seed characters are useful to characterize species and groups of species. de Wilde and Duyfjes (2004) studied 21 species from Sabah, including 4 new species. Duyfjes and Pruesapan (2004) discovered 7 new species among the 17 already described in Thailand. Huang et al. (2007) described 33 species from China, of which 14 species are endemic. In India, 24 species have been described by Chakravarty (1959). The description of some *Trichosanthes* species is still problematic.

Yueh and Cheng (1974, 1980) have subdivided *Trichosanthes* on the basis of the male bract, fruit pulp, and seed characters into subgenus Cucumeroides (with two sections: Cucumeroides and Tetragonosperma) and subgenus Trichosanthes (with five sections: Foliobracteola, Involucraria, Pedatae, Trichosanthes, and Truncata). Jeffrey (1980) divided the genus into five sections (Cucumeroides, Foliobracteola, Involucraria, Trichosanthes, and Truncata), without any subgenera. He considered Tetragonosperma to be a synonym of Cucumeroides and placed under section Pedatae as a subsection in Involucraria, proposing subsection Bracteatae for the other species in this section. On the basis of pollen morphology, Huang et al. (1997) subdivided section Foliobracteola into the subsections Foliobracteola and Villosa. Huang et al. (1998) revised the genus again, using morphological, cytological, pollen, and anatomical characters, and reinstated the subdivision into the two subgenera: Cucumeroides, with two sections (Cucumeroides and Tetragonosperma), and Trichosanthes, with three sections (Involucraria, Foliobracteola, and Trichosanthes). Later, Rugayah and de Wilde (1999) used the staminate bract, fruit pulp, and seed characters to distinguish five sections (no subgenera) in Malaysia: Cucumeroides (subsections Cucumeroides and Tetragonosperma), Foliobracteola, Involucraria (subsections Involucraria and Pedatae),

*Trichosanthes*, and *Edulis*, a new section from New Guinea. In Sabah, de Wilde and Duyfjes (2004) distinguished five sections (*Cucumeroides*, *Foliobracteola*, *Involucraria*, and *Trichosanthes*) that are more or less the same groups as those of Rugayah and de Wilde (1999), plus the new section *Asterosperma*.

One reason for the difficulty of *Trichosanthes* classification is the lack of a recent monographic revision. So far, the sections are largely based on regional studies with little coordination of the classification of the widely distributed species. However, all authors distinguish several sections, usually grouped into two subgenera: *Cucumeroides* and *Trichosanthes*. Recently, de Boer and Thulin (2012) revised the infrageneric classification of the genus, merging *Gymnopetalum* and *Trichosanthes*. The genus has 2 subgenera with 11 sections, which are as follows: *Asterospermae*, *Cucumeroides*, *Edulis*, *Foliobracteola*, *Gymnopetalum*, *Involucraria*, *Pseudovarrifera*, *Villosae*, *Trichosanthes*, *Tripodanthera*, and *Truncata*.

The genus is endemic in Asia and Australia, except for *T. amara*, a species from the Caribbean island of Hispaniola in the Greater Antilles. However, Schaefer et al. (2008) placed this species in a new genus, *Linnaeosicyos*, using molecular and morphological data. *Trichosanthes* has long been seen as closest to the Asian genera *Hodgsonia* (Muller and Pax 1889) or *Gymnopetalum* (Jeffrey 1962; de Wilde and Duyfjes 2006), and also close to African/Madagascan groups such as *Peponium* (Jeffrey 1962). The different species of *Trichosanthes* have similar protein patterns. However, a few high-molecular-weight proteins are detected only in *T. dioica* and absent in other *Trichosanthes* species and also in *Gymnopetalum*, which belongs to the same tribe. The protein pattern of *Gymnopetalum cochinchinense* has considerable similarity with that of *T. cucumerina* (Pasha and Sen 1998).

### C. Cytogenetics

The basic chromosome number of *Trichosanthes* is  $x = 11$  with many diploid and some polyploid species (Table 9.1). Unlike the majority of taxa of the Cucurbitaceae, the chromosomes of *Trichosanthes* are large enough to allow karyotypic analysis. The metacentric to submetacentric chromosomes range from 5.74 to 1.48  $\mu\text{m}$ . The sporophytic chromosome number of *T. cucumerina* and *T. dioica* is  $2n = 22$  (Singh and Roy 1979a) with 11 bivalents at meiosis (McKay 1931; Banerji and Das 1937; Sen 1976; Datta and Basu 1978). Giemsa C-banding patterns for intraspecific differentiation have been carried out in *T. dioica* (Sarkar and Datta 1987). The great similarity observed

**Table 9.1.** Gametophytic and sporophytic chromosome number of *Trichosanthes* species.

Species	Chromosome number		References
	Gametic	Sporophytic	
<i>T. anamalaiensis</i>	11	22	Beevy and Kuriachan (1996)
<i>T. anguina</i> <sup>z</sup>	11	22	Mckay (1931), Sen (1976), Datta and Basu (1978), Beevy and Kuriachan (1996)
<i>T. bracteata</i>	22	44	Thakur (1973), Thakur and Sinha (1976)
<i>T. bracteata</i> var. <i>bracteata</i>	11	22, 44	Beevy and Kuriachan (1996)
<i>T. cucumerina</i>	–	22	Roy and Misra (1982), Huang et al. (1994), Beevy and Kuriachan (1996)
	11	22	Sen (1976), Datta and Basu (1978)
<i>T. dioica</i>	11	44	Banerji and Das (1937)
	11	22	Bhaduri and Bose (1947), Sen and Datta (1975), Sen (1976)
	–	33	Singh (1979)
<i>T. japonica</i> <sup>y</sup>	11	22	Nakajima (1937), Sinoto (1929)
<i>T. kirilowii</i>	44	88	Huang et al. (1994)
<i>T. lepiniana</i>	22	44	Huang et al. (1994)
<i>T. lobata</i>	11	22	Singh and Roy (1979a)
<i>T. multiloba</i>	11	22	Kurita (1939)
<i>T. nervifolia</i>	11	22	Beevy and Kuriachan (1996)
<i>T. truncata</i>	11	22	Huang et al. (1994)

<sup>z</sup>*T. anguina* is a var. of *T. cucumerina*.

<sup>y</sup>*T. japonica* is a synonym of *T. kirilowii*.

between the plant morphology of *T. cucumerina*, *T. lobata*, and *T. anguina* is reflected in the chromosomes since they have the same frequency of chiasmata and the same terminalization coefficient per PMC (Singh and Roy 1979a). These species are cross-compatible, with high pollen fertility in the three interspecific hybrids (Singh and Roy 1979b).

It has been suggested that the cultivated snake gourd (*T. cucumerina* var. *anguina*) might have arisen directly from *T. cucumerina* var. *cucumerina* (Singh 1990). Pointed gourd (*T. dioica*) is a dioecious perennial species with karyomorphology different from snake gourd. A heteromorphic pair of chromosomes associated with dioecy has been reported in *T. japonica* (Sinoto 1929; Nakajima 1937) and *T. dioica* (Patel 1952; Sarkar and Datta 1988), but the heteromorphic pair in *T. dioica* was not confirmed in later studies (Singh 1990). Polyploids were also induced in *T. anguina* but have not been commercially successful

so far (Singh and Roy 1975). A natural autotriploid from *T. dioica* was also reported (Singh 1990).

#### D. Medicinal Use

*Trichosanthes* species in southeast Asia are traditionally used to treat skin diseases, intestinal disorders, coughs, ulcers, and malaria (Sivarajan and Balachandran 1994). They are considered to be abortifacient, vermifuge, stomachic, refrigerant, purgative, laxative, hydragogue, hemagglutinant, emetic, cathartic, and anthelmintic (Nadkani 2002). The species and plant parts used to treat various diseases are listed in Table 9.2.

*Trichosanthes* species are also used in Chinese herbal medicine (Dou and Li 2004) and Thai traditional medicine (Kanchanapoom et al. 2002). Species such as *T. dioica* Roxb., *T. nervifolia* L., *T. tricuspidata* Lour., and *T. cucumerina* were known from the earlier times (Monier-Williams 1899; Sivarajan and Balachandran 1994; Decker-Walters 1998) as herbal medicine. *T. cucumerina* has a prominent place in alternative systems of Indian medicine (Ayurveda and Siddha) due to its various pharmacological activities involving antidiabetic, hepatoprotective, hypoglycemic, cytotoxic, antiinflammatory, antifertility, and larvicidal effects (Sandhya et al. 2010). *T. kirilowii* is commonly used in Chinese herbalism, where it is considered to be one of the 50 fundamental herbs (Duke and Ayensu 1985). The tubers and fruit of *T. kirilowii* have been a traditional herbal resource due to its novel pharmaceutical components (Oh et al. 2002; Fei et al. 2004; Kondo et al. 2004). Its tuber traditionally has been prescribed for patients with diabetes, rigorous coughing, breast abscesses, and cancer-related symptoms (Shin et al. 2008). *T. kirilowii* roots are used in Japan for pyretolysis, diuresis, and as an antitussive and antiinflammatory drug. In China the fruit, peel, and seeds are used to treat pneumonia, pleurisy, intercostal neuralgia, tonsillar pharyngitis, and angina pectoris (Ozaki et al. 1996). The seeds are used as an antiinflammatory and expectorant, and to treat coughs (Akihisa et al. 1994). It is purported that *T. dioica* possesses the medicinal property of lowering total cholesterol and blood sugar. These claims were supported by preliminary clinical trials with rats (Chandrasekar et al. 1988) and rabbits (Sharma and Pant 1988; Sharma et al. 1988). Roots of *T. dioica* are traditionally used in India as a hydrogogue, anthelmintic, cathartic, tonic, and febrifuge, and in the treatment of jaundice, anasarca, and ascites (Bhattacharya et al. 2010). The aqueous extract of its leaves has hypoglycemic potential along with a high antidiabetic profile (Rai et al. 2008b).



**Table 9.2.** Traditional medicinal uses attributed to *Trichosanthes* species.

Species	Use (part used)	References
<i>T. cucumeroides</i>	Abortifacient (plant)	Yeung and Li (1987)
<i>T. anguina</i>	Anthelmintic (fruit), cooling (seed), emetic (fruit), purgative (fruit) Blood sugar lowering principle (plant)	Chopra et al. (1956) Chandrasekar et al. (1988)
<i>T. cucumerina</i>	Anthelmintic and vermifuge (seed, plant), bilious disorder (leaf, stem, seed), boils and carbuncles (plant), cardiac tonic (plant), cathartic (root juice), emetic (leaf juice), emmenagogue (leaf, stem), febrifuge (plant), labor women laxative (fruit), skin eruption (leaf, stem) Abortifacient, vermifuge, refrigerant, purgative malaria, laxative, hemagglutinant, emetic, cathartic, bronchitis, anthelmintic Tonic (plant) Diabetes, inflammatory (stem, leaf decoction)	Chopra et al. (1956) Chopra et al. (1956) Nadkani (2002) Chopra et al. (1956) Kar et al. (2003)
<i>T. bracteata</i>	Asthma (fruit-smoked), cathartic (fruit), headache (root-boiling with mustard oil), hydragogue (fruit) Boils and carbuncles (root)	Chopra et al. (1956) Kirtikar and Basu (1988), Chopra et al. (1956) Chopra et al. (1956)
<i>T. dioica</i>	Bilious fever (leaf), cooling (fresh juice, unripe fruit), febrifuge (leaf with equal part of coriander), labor women laxative (leaf, juice from unripe fruit), hydragogue (root), spermatorrhoea (fruit) Blood sugar lowering principle (plant)	Chandrasekar et al. (1988)
<i>T. cordata</i>	Tonic (bitter) Enlargement of spleen and liver (root dried and powdered), leprosy and leprous ulcers (root mixed with oil), stimulant (dried powder)	Chopra et al. (1956) Chopra et al. (1956)
<i>T. nervifolia</i>	Tonic (bitter) Febrifuge (plant), purgative (root) Tonic (bitter)	Chopra et al. (1956) Chopra et al. (1956) Chopra et al. (1956)
<i>T. kirilowii</i>	Hypoglycemic activity	Hikino et al. (1989)

(continued)

**Table 9.2.** (Continued)

Species	Use (part used)	References
<i>T. tricuspadata</i>	Asthma, ear ache, ozoena, carminative, purgative, abortifacient, to lessen inflammation, cure migraines, and reduce heat of the brain; as a treatment for ophthalmia, leprosy, epilepsy, and rheumatism (fruit); emetic and purgative (seeds)	Bhandari et al. (2008)
	Antifever remedy, a laxative, an anthelmintic as well as in migraine treatments	Kanchanapoom et al. (2002)
<i>T. lobata</i>	Bronchitis	Gaur (1999)
	Leprosy (whole plant)	Jeeva et al. (2007)

Species of *Trichosanthes* are well known for their production of biologically active triterpenes (Kanchanapoom et al. 2002) that have been isolated from the highly polar fraction of the nonsaponifiable lipids of saponified *T. kirilowii* seed extracts (Homberg and Seher 1977; Kimura et al. 1997). Multiflorane-type triterpenes such as (3*a*)-multiflora-7,9(11)-diene-3,29-diol, known as karounidiol and its 3-*O*-benzoate were identified as major components of the saponified extract of *T. kirilowii* seeds (Akihisa et al. 1988). The former compound was found to suppress tumor production in mice, as induced by 12-*O*-tetradecanoylphorbol-13-acetate (Yasukawak et al. 1994), and it showed cytotoxic activities against human cancer cell lines, especially renal-cancer cells (Akihisa et al. 2001). The abortifacient proteins trichosanthin (from *T. kirilowii*), and  $\beta$ -trichosanthin (from *T. cucumeroides*) have been isolated. Trichosanthin (TCS) is a type I ribosome-inactivating protein (RIP) isolated from root tuber of *T. kirilowii*. Trichosanthin is of particular interest because of its multiple pharmacological properties such as abortifacient, anti-HIV, immunoregulatory, antiviral, and anti-tumor activities (Leung et al. 1986; McGrath et al. 1989; Zheng et al. 1995, 2000; Lu et al. 2001; Zhao et al. 2006). These trichosanthin-derived pharmaceutical activities, including antitumor effects, were assumed to be connected to its biochemical activities, disrupting the binding of elongation factors to the P-complex as well as *N*-glycosidase activity for ribosome inactivation (Zhang and Liu 1992; Chan et al. 2001; Shaw et al. 2005). The drug trichosanthin is obtained from *T. kirilowii*, which was used locally in China to induce abortion and for the treatment of cancer (Heiser 1979). Anticancer mechanisms of *T. kirilowii* tuber linked to the inhibition of tubulin polymerization, through which it exerts cell cycle arrest at the G<sub>2</sub>/M phase in the HepG2

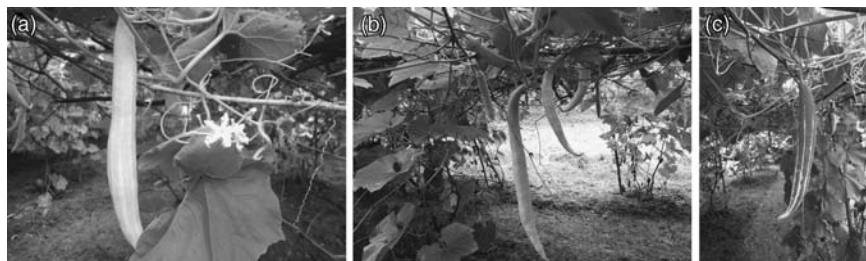
cell line (Shin et al. 2008). An antihuman immunodeficiency virus (anti-HIV) protein (TAP 29) has also been isolated and purified to homogeneity from *T. krilowii* (Huang et al. 1991).

*In vitro* and *in vivo* studies in animals have shown that aqueous extract of *T. cucumerina* has improved glucose tolerance in noninsulin-dependent diabetes mellitus (NIDDM) animals (Kirana and Srinivasan 2008; Arawwawala et al. 2009), and decreased the sugar level in streptozotocin-induced diabetic rats (Rai et al. 2008a). Hot aqueous extract of root tubers of *T. cucumerina* has been investigated against carrageenin-induced mouse's hind paw edema and it exhibited significant antiinflammatory activity (Kolte et al. 1997). Root extract of *T. cucumerina* L. inhibited human breast cancer cell lines and lung cancer cell lines and one colon cancer cell line (Kongtun et al. 1999). Methanolic extract of the whole plant of *T. cucumerina* showed good hepatoprotective activity against carbon tetrachloride-induced hepatotoxicity (Sathesh et al. 2009). Ethanol extract of whole plant of *T. cucumerina* L. var. *cucumerina* showed antioviulatory activity in female albino rats (Devendra et al. 2009). Hot water extract of *T. cucumerina* showed a significant protection against ethanol-or indomethacin-induced gastric damage, increasing the protective mucus layer, and decreasing the acidity of the gastric juice and antihistamine activity (Arawwawala et al. 2010).

### III. SNAKE GOURD

#### A. Quality Attributes and Human Nutrition

Immature fruit of snake gourd (Fig. 9.1) are used as a vegetable in southeast Asian countries, while in the eastern part of Nigeria, the ripe pulp is consumed. The red pulp can be used to improve food appearance as it can be blended and used to produce a paste for stew, which tastes like and serves the role of tomato (Enwere 1998). The use of snake gourd as a replacement for tomato is reported from Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Benin, and Nigeria (Soladoye and Adebisi 2004). The fruit have poor nutrient content when compared to other common vegetables but do have vitamins C and A (Ojiako and Igwe 2008) as well as proteins, fat, fiber, carbohydrates, and vitamin E. The total phenolic and flavonoid contents are 46.8% and 78.0%, respectively (Adebooye 2008). The predominant mineral elements per 100 g are potassium (122 mg) and phosphorus (135 mg). Other elements found in fairly high amounts are sodium, magnesium, and zinc. The nutritive value of snake gourd is presented in Table 9.3.



**Fig. 9.1.** Snake gourd (a) inflorescence and immature fruit of snake gourd; (b) immature fruit; and (c) marketable fruit.

**Table 9.3.** Proximate analysis and nutritive value of snake gourd and pointed gourd.

Nutrient component	Snake gourd <sup>a</sup>		Pointed gourd <sup>b</sup>
	Tender fruit	Ripe fruit	
Moisture (g)	94.60	93.15	92.00
Protein (g)	0.50	1.85	2.00
Fat (g)	0.30	0.23	0.30
Minerals (g)	0.50	–	0.50
Fiber (g)	0.80	0.81	3.00
Carbohydrates (g)	3.30	3.48	4.20
Energy (kcal)	18.00	–	20.00
Calcium (mg)	50.00	–	30.00
Magnesium (mg)	53.00	–	9.00
Phosphorus (mg)	20.00	–	40.00
Iron (mg)	1.10	–	1.70
Sodium (mg)	25.40	–	2.60
Potassium (mg)	34.00	–	83.00
Copper (mg)	0.11	–	1.11
Sulfur (mg)	35.00	–	17.00
Chlorine (mg)	21.00	–	4.00
Vitamin A	160.00 (IU)	347 (µg 100 mL)	255.00 (IU)
Thiamine (mg)	0.04	–	0.05
Riboflavin (mg)	0.06	–	0.06
Nicotinic acid (mg)	0.30	–	0.50
Vitamin C (mg)	5.00	18.90 (mg 100 mL)	29.00
Oxalic acid (mg)	34.00	–	7.00

<sup>a</sup>Source: Ojiako and Igwe (2008).

<sup>b</sup>Source: Gopalan et al. (1989).

## B. Reproductive Biology

Snake gourd is a monoecious annual with nontuberous roots. Perfect (hermaphroditic) flowers have been observed but were nonfunctional (Singh 1953). Flowers open from bud stage in 8–16 days, with anthesis starting in early evening, that is, between 5 and 7 pm. The stigma remains receptive from 12 h before anthesis to 12 h after anthesis, but maximum receptivity remains at the time of anthesis (Deshpande et al. 1980; Singh et al. 1989). The sex ratio (ratio of staminate to pistillate flowers) in the monoecious species of snake gourd varies from 25:1 to 225:1 (Singh 1953). The major pollinators are bees (*Apis florea* and *A. dorsata*) and beetles (*Conpophilus* sp.)

## C. Ecology

Wild snake gourd grows in scrub vegetation, along forest edges and in open forest, from sea level to 1,500 m altitude. Snake gourd performs well in warm and humid climate and is best suited to places where rains are abundant. High humidity favors growth and fruit development. Temperatures between 30 and 35 °C are considered optimum for growth and fruiting, and temperatures below 20 °C restrict growth. Plants are susceptible to frost. Loamy to sandy loam soils rich in organic matter and having pH range of 6.0–7.0 are best suited. Plants do not tolerate dry soil and require a good moisture reserve in the soil. However, plants are sensitive to waterlogged soils, and heavy soils are unsuitable for cultivation.

## D. Culture

**1. Propagation.** Snake gourd is grown in Kharif (rainy) as well as summer seasons. In northern India, snake gourd seeds are sown from the end of the winter season, that is, late February (Paul 1959) for summer crop and in June and July for the rainy season crop. Various methods of sowing are adopted, depending on season and system of cultivation. In the rainy season, plants are supported on trellises (Bastin and Khader 1985; Seshadri 1986). Seeds (5–6 kg seed per ha) are sown in the hills near the edges of raised beds or pits. Between-row spacings are 1.5–2.5 m, and within-row spacings are 0.6–1.2 m (Nath et al. 1987). For rapid germination, the seeds may be soaked in water for 1 day before sowing (Paul 1959). Normally, the seeds will germinate and emerge in 1 week, unless the soil is too dry or the weather is too cold. Seedlings can be raised in the nursery and transplanted to the field

at the two-true-leaf stage. However, direct seeding is often preferred due to the delicate nature of transplants. Zhang et al. (2000) tested different cytokinins for bud induction *in vitro* and reported that a mixture of benzyladenine and IAA was the best combination.

**2. Nutrient Management.** Snake gourd responds well to manuring and fertilizer application, but too much nitrogenous fertilizer leads to excessive stem production at the expense of fruit production. In Asia, 20–25 t ha<sup>-1</sup> farmyard manure incorporated into the soil, supplemented with N (35 kg), P (11 kg), and K (21 kg) per ha, provided good plant growth. N should be applied in several split doses at 2-week intervals for optimum fruiting and yield. Syriac and Pillai (2001) reported maximum fruit yield using 105 kg N ha<sup>-1</sup>, 200 ppm ethephon, and drip irrigation at 5 mm cumulative pan evaporation.

**3. Water Management.** For the initial stages of growth, irrigation at an interval of 3–4 days is essential. In the dry season, plants should be irrigated on alternate days during flowering and fruiting periods. Flooding and soil waterlogging should be avoided to reduce the incidence of *Fusarium* wilt and root rots.

**4. Training.** The bower system of training is most commonly used in growing of snake gourd in India. When seedlings start producing tendrils, they are staked to thin bamboo poles using string or banana fibers to enable the vines to spread on the trellis. In long-fruited types, a small stone is tied to the tip of the developing fruit 5 days after fruit set to prevent coiling; short-fruited types do not require such training. Maximum fruit length and diameter, number of fruit/plant, and yield have been obtained by training to a single stake followed by the bower system (Prakash et al. 2003). However, vines that are allowed to spread over the ground are more vigorous, bear more fruit, and are less damaged by fruit fly. The vines dry up at the cessation of fruiting during October and November. Vines can then be pruned to leave 30–35 cm of stem above the soil.

**5. Weed Management.** Weed control is important, particularly during the initial stages of plant growth. Use of paddy straw or black polyethylene as a mulch will reduce heat and moisture stress, as well as weed incidence. Two weedings by hand or machine, supplemented with fluchloralin (1.0 kg ha<sup>-1</sup>) or paraquat (0.5 kg ha<sup>-1</sup>), effectively controls weeds (refer to the chemical handbook for your area for registered treatments).

**6. Use of Growth Regulators.** In snake gourd, application of ethephon to seedlings at the two- and four-true-leaf stage reduces the days to first pistillate flowering, and increases the number of pistillate flowers (Kohinoor and Mian 2005).

### **E. Harvest and Postharvest Management**

The harvest of snake gourd starts 78–80 days after sowing and about 2 weeks after fruit set when they are 30–100 cm in length depending on the cultivar. Fruit may weigh up to 1 kg. Harvesting should be done at an interval of 5–6 days with a total of 6–8 harvests per cropping season. Fruit are usually picked when immature. When fruit pulp production is the objective of cultivation, the harvest of the fruit takes place at full maturity. The same ripe fruit may be used for seed extraction. The average plant yields 50 fruit. Yield ranges from 18 to 25 t ha<sup>-1</sup>.

### **F. Pests and Diseases**

**1. Melon Fly (*Dacus cucurbitae*).** The female adult punctures the young ovary and lays eggs below the epidermis. The maggots bore deeply into the fruit and feed, making the fruit unmarketable. The fruit become distorted, begin to rot, and fall from the vine. Control is through registered pesticides such as methyl eugenol and malathion.

**2. 28-Spotted Potato Beetle (*Epilachna vigintioctopunctata*).** Grubs and adult cause severe damage to leaves by feeding on the green tissue between the veins, giving a lace-like appearance. Control is through registered pesticides such as Sevin 50 WP.

**3. Red Pumpkin Beetle (*Aulacophora foveicollis*).** The insect feeds on seedlings. Adults feed on the cotyledons. Control is through registered pesticides such as Sevin 50 WP.

**4. Mite (*Tetranychus kanzawai*).** Spider mites colonize the undersurface of the leaves. Both nymphs and adults feed on the sap, which results in yellowish specks on the upper surface of the leaves in pointed gourd. The leaves gradually turn pale and dry up. Control is through registered pesticides such as Dicofol (0.05%).

**5. Anthracnose (*Colletotrichum lagenarium*).** Leaf spots that are round, reddish-brown, and dry form on the young infected leaves, starting near the veins. The spots may coalesce and leaves become

blighted. The center of leaf spots falls off giving a shot-hole appearance. In advanced stages, there is shriveling and death of the leaf. Affected fruit have brown to black water-soaked round spots with ash-colored centers. High humidity and moist weather are favorable for spread of this disease. The pathogen is both soil- and seedborne. Destruction of the plant debris after harvest is recommended. Crop rotation with nonhost crops helps in minimizing the incidence of disease. Control is through registered pesticides for seed treatment and foliar application. Seed treatment chemicals include Dithane M-45 or Thiram ( $2 \text{ g kg}^{-1}$  seed). Foliar control pesticides include Dithane M-45 (0.2%) at 5–7 days interval controls the disease.

**6. Alternaria Blight (*Alternaria cucumerina*).** Initially, small spots appear on the leaves, rapidly increasing in number and size. The adjoining spots on severely affected leaves coalesce and have a burned appearance. Use of disease-free seed, seed treatment before sowing, and crop rotation help in minimizing disease incidence. Control is through registered pesticides such as captan (0.2–0.3%) or mancozeb (0.3%) at 10–15-day intervals. Destruction of plant debris after harvest is recommended.

**7. Downy Mildew (*Pseudoperonospora cubensis*).** Symptoms appear as yellow to brown angular spots on the leaves with purplish growth on the lower surface, causing significant defoliation. High rainfall and moderate temperature ( $20\text{--}22^\circ\text{C}$ ) are favorable for spread of this disease. Control is through registered pesticides such as Ridomil MZ 72 ( $2.5 \text{ g L}^{-1}$ ) or Dithane M-45 ( $3 \text{ g L}^{-1}$ ). Destruction of the plant debris after harvest is recommended.

**8. Fruit Rots (*Pythium aphanidermatum*, *P. butleri*, *P. debaryanum*, and *P. ultimum*).** Soft, water-soaked lesions appear on the fruit surface, becoming extensive fruit rot. Training of the vines should be done on a trellis or bower to avoid contact of fruit with the soil. Removal and destruction of all affected plant parts including the fruit is required. Control is through registered pesticides such as a soil drench using copper oxychloride (0.2%).

**9. Cucumber Green Mottle Mosaic Virus.** Cucumber green mottle mosaic virus causes leaf mosaic, leaf distortion, reduction of internode length, and fruit distortion. The virus is mechanically transmitted to several cucurbit hosts, and is seedborne. Infected plants should be removed and destroyed as soon as they are observed.



**10. Cucumber Mosaic Virus.** Cucumber mosaic virus (CMV) causes plants to have stunted growth with fewer flowers and fruit, resulting in yield reduction. Chlorosis, vein banding, blistering, and deformation of the leaves are the other symptoms of the disease. The virus spreads by mechanical inoculation and by aphid vectors (*Aphis gossypii*, *Myzus persicae*). Infected plants should be removed and destroyed as soon as they are observed.

## G. Crop Improvement

**1. Genetics.** A multiple allelic series controls fruit skin color, which segregated in a monohybrid ratio in the  $F_2$  generation. Deep green was dominant over green, yellow, and white; green was dominant over yellow and white; and yellow was dominant over white (Sardar and Mukherjee 1987). Mini Raj et al. (1993) reported the monogenic inheritance of fruit color [white (WW) dominant over green-white stripes (ww)], fruit size (partial dominance), and fruit pericarp color (deep green dominant over green, yellow, and white; green dominant over yellow and white; and yellow dominant over white). Characters such as node of first pistillate flower, fruit length, fruit weight, fruit diameter, number of pistillate flowers per plant, and fruit per plant are polygenic and positively correlated with yield.

Kumaresan et al. (2006b) reported that days to first staminate flower opening, days to first pistillate flower opening, main vine length, number of fruit per vine, fruit length, fruit diameter, fruit weight, and yield per vine were controlled by both additive and nonadditive gene action with predominance of additive gene action.

Snake gourd has high broad-sense heritability and high genetic gain for plant growth and yield components such as mean fruit weight, fruit length, days to first staminate flower, fruit per plant, and fruit yield so substantial improvement can be made (Joseph 1978; Varghese 1991; Varghese and Rajan 1993; Mathew and Abdul Khader 1999; Rajkumar and Karuppaiah 2007; Banik et al. 2009). Rajkumar and Karuppaiah (2007) observed high heritability for ascorbic acid content of the fruit, crude fiber content, and node number of first pistillate flower. Fruit yield was strongly correlated with fruit weight, fruit per plant, fruit diameter, fruit length, days to first harvest, flesh thickness, and days to first pistillate flower opening (Narayanankutty et al. 2006). Fruit yield was also correlated with vine length, number of seeds per fruit, seed weight per fruit, and ascorbic acid content of the fruit (Kumaresan et al. 2006a).

Path coefficient analysis showed that individual fruit weight, fruit diameter, number of fruit per plant, and node of first pistillate flower are

the most important characteristics contributing to yield due to high direct effects (Pynadath 1978; Kumaresan et al. 2006a; Narayanankutty et al. 2006). On the basis of correlation and path coefficient analysis, proper weight must be given to pistillate flowers per plant, number of fruit per plant, and fruit weight by virtue of their high contribution to yield (Kondalraj et al. 1984). Analysis of combining ability showed significance of general and specific combining ability variances for all characters except sex ratio, number of fruit per plant, and crop duration, indicating the role of both additive and nonadditive gene action (Varghese 1991).

**2. Plant Genetic Resources.** The southern peninsular tract of India was identified as the first priority region for collection of *T. cucumerina* var. *anguina* based on germplasm distribution, variability, extent of gene erosion, and a survey of existing collections (Toll and Vausloten 1982). Wide variability of snake gourd exists in South India, and institutions such as Tamil Nadu Agricultural University, Coimbatore and Kerala Agricultural University, have made a diverse collection of germplasm. A wide range of variability exists in Bangladesh (Ahmed et al. 2000; Rahman 2004; Khatun et al. 2010) and in India (Pynadath 1978; Mathew 1996; Ashok 2000). N.I. Vavilov Research Institute of Plant Industry (VIR), St. Petersburg, Russian Federation collected 15 genotypes of *T. cucumerina* var. *anguina*.

**3. Breeding.** There are various goals for plant breeding programs. These include vigorous and highly branched plants, earliness (lower node of appearance of first pistillate flower), high pistillate to staminate flower ratio, high fruit quality and appearance including green or white color depending on consumer preference, and a range of fruit sizes such as short (30–35 cm), medium long (60–70 cm), long (160–180 cm), or extra long (180–200 cm). Fruit should be thick, heavy, as well as non-fibrous and tender at marketable stage. There is a need for resistance to insects (fruit fly) and diseases (fruit rot and mosaic virus).

Variability exists for earliness, size of fruit, fruit/plant, and yield. Local strains have been selected by several institutions and many cultivars have been developed using pure line selection, including CO-1, CO-2, TA-19, and 'Baby' (Table 9.4). Prakash (1953) reported that  $F_1$  hybrids of snake gourd are superior to their parents in plant vigor, fruit number, and fruit size. Natarajan et al. (1985) reported a hybrid snake gourd 'MDU 1' (Panni Pudal  $\times$  Sel.1).

Mutation breeding holds promise in snake gourd improvement. Datta (1987) isolated a mutant with yellow striped fruit in  $M_2$ , following

**Table 9.4.** Important cultivars of snake gourd (*T. cucumerina* var. *anguina*) from India and their characters.

Cultivar name	Characteristics	Yield (t ha <sup>-1</sup> )
APAU Swetha	Fruit long with whitish background and green stripes	28–30 in 125–130 days
CO-1	Fruit long (160–180 cm), dark green with white stripes	18 in 135 days
CO-2	Fruit short (30 cm long), stout, pale greenish white with ashy bloom on surface; vines less spreading	25
CO-4	Early maturing; fruit long (160–190 cm), dark green with white stripes	25 q ha <sup>-1</sup>
MDU-1	F <sub>1</sub> hybrid; fruit medium in length (50–60 cm) with white stripes over a green background	35
PKM-1	Fruit extra long (200 cm), dark green with white stripes outside and light green inside, 700 g	25 in 135–140 days
TA 19	Fruit 60 cm long and average fruit weight is 600 g; ready for harvest in 63–70 days from sowing	25
Konkan Sweta	Fruit medium long (90–100 cm) and white	15–20 in 120–130 days
Baby	Fruit small, 22 cm diam., 30–40 cm long, 474 g, elongated and uniformly white	56 (potential)
Manushri	Medium long, white fruited	25–30
Kaumudi	Fruit white, long (100 cm); suited to acid alluvial soils.	500 q ha <sup>-1</sup>

treatments with 18 KR X-rays of seeds from a white striped cultivar and the mutant was superior to its parent for yield and puniolic acid in the seed oil. Datta (1994) induced a short thick fruit with 30 KR X-rays which proved to be a monogenic recessive mutant. The cultivar PKM-1 was developed through induced mutation (Pillai et al. 1979).

#### IV. POINTED GOURD

##### A. Quality Attributes and Human Nutrition

The immature fruit, leaves, and new tender shoots of pointed gourd (Fig. 9.2) are used as vegetables in Asia. The fruit are also used in the preparation of pickles and confectionary products. Singh (1989) reported that pointed gourd is rich in vitamins and minerals (Table 9.3).

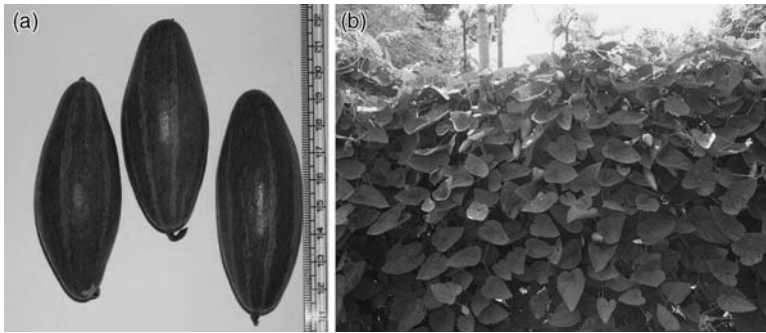


Fig. 9.2. Pointed gourd (a) fruit of 'CHPG 22'; and (b) plant of 'Swarna Alaukik'.

## B. Reproductive Biology

*T. dioica* is a dioecious, tuberous perennial. Occasional perfect flowers are nonfunctional (Singh 1953). A gynodioecious intersex variant with fertile anthers in *T. dioica* was reported by Baillon (1922). Three types of perfect flowers have been reported in *T. dioica*: (1) long style with stigma protruding out of corolla tube with rudimentary stamens; (2) shorter style with stigma lying at the mouth of corolla tube with fully developed anthers, and (3) short style that did not reach up to the mouth of corolla tube with stamens extending slightly above the stigma (Singh et al. 1992).

In the production areas of southern Asia such as India, flowering generally starts in February and continues until November. The opening of a flower from the time of its appearance as a bud takes 16–19 days in staminate flowers and 10–14 days in pistillate flowers. Anthesis begins in the evening, that is, between 7 and 8 pm. The stigma remains receptive from 12 h before anthesis to 12 h after anthesis but maximum receptivity remains at the time of anthesis (Deshpande et al. 1980; Singh et al. 1989). Because of dioecy the pointed gourd is highly cross-pollinated and pollinizers are essential. Pollination is strictly entomophilous; pollen is sticky and therefore unsuitable for wind pollination. There are four insect species visiting the staminate and pistillate flowers of pointed gourd; the red brown beetle (*Carpophilus dimidiatus*) contributes appreciably to pollination (Sachan et al. 1990) as do small ants (*Componotus compressus*).

Natural parthenocarpy has been observed in pointed gourd, and a parthenocarpic line (IIVRPG-105) was developed at the Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh, India. The percentages

of parthenocarpic fruit set in *T. dioica* following natural pollination and pollination with the pollen of *Lagenaria leucantha*, *Momordica charantia*, and *L. leucantha* + *M. charantia* were 58%, 67%, 71%, and 85%, respectively (Singh 1978). Parthenocarpy can be induced with 100–1,000 mg L<sup>-1</sup> of AgNO<sub>3</sub> (Houqe et al. 2002) or 100–500 ppm naphthalacetic (NAA) (Dubey and Nair 1972).

### C. Ecology (Climate and Soil)

Pointed gourd performs best in a warm and humid climate where rains are abundant. High humidity favors growth and fruit development. Temperatures between 30 and 35 °C are considered optimum for growth and fruiting, while temperatures below 20 °C restrict growth. Pointed gourd is susceptible to frost. Sandy loam to loam soils rich in organic matter and having a pH of 6–7 with good moisture reserves are best. The crop is sensitive to waterlogging, so heavy soils are unsuitable. Pointed gourd becomes dormant during winter but will sprout and begin growing from the perennial base in the summer.

### D. Culture

**1. Propagation.** Pointed gourd is usually propagated through vine cuttings, root suckers, layered plants, and tissue culture. Seeds are generally not used for commercial propagation owing to poor germination and unpredictable sex expression. Plants raised from seeds are weak, have small leaves, and require 1 year to produce fruit. In the root sucker method, the small roots at the nodes of stems growing along the soil surface are uprooted in October and set in single-plant hills (Seshadri 1986). Pointed gourd can also be multiplied through layering (Singh 1989). Cuttings from the basal portion of mature vines are collected in October when fruiting is nearly complete. The vine cuttings can be planted October to November or February to March in any one of the following methods: (1) vine cuttings of 1–1.5 m having 8–10 nodes are folded in the shape of an 8 and planted in pits filled with farmyard manure and soil; (2) vine cuttings are made into a ring shape and planted in pits keeping the ends above the ground; (3) straight vine cuttings are planted in furrows filled with farmyard manure and soil, keeping the ends of the cutting above the ground; (4) vine cuttings 60–90 cm long are wrapped in moist soil and planted 10 cm deep in furrows.

In areas where there is risk of frost damage during the winter, 20 cm long cuttings taken from mature vines are planted in a protected nursery

in October to November, and the rooted cuttings are transplanted to the field in February to March. Dipping the vine cuttings in  $100 \text{ mg L}^{-1}$  indole-3-butyric acid (IBA) increases rooting (Pandey and Ram 2000).

Pointed gourd should be planted at  $1.5 \times 1.5 \text{ m}$  or  $2 \times 2 \text{ m}$  spacing in the well-prepared pits. A spacing of  $1.5 \times 1.5 \text{ m}$  is optimum when the vines are trained on trellis (Yadav 1985; Singh 1989). Since pointed gourd is dioecious, sufficient pollinizers must be planted. One staminate plant for every 10 pistillate plants should be planted for proper pollination and high yield.

Houqe et al. (1998) achieved shoot formation in seedling explants on Murashige and Skoog (MS) medium supplemented with  $4.44 \mu\text{M}$  BA. Debnath et al. (2000) developed an efficient *in vitro* protocol for direct plant regeneration, multiplication, and rooting. Efficient rooting was obtained on half strength of MS +  $0.5 \text{ mg L}^{-1}$  NAA. Kumar et al. (2003) reported that a low concentration of IBA ( $0.49 \mu\text{M}$ ) produced a significantly higher number of roots per shoot, whereas higher concentrations of IBA favored formation of malformed and thick roots. They reported the highest number of shoots per explant (5.78), highest number of nodes/shoot (6.11), and longest shoots (3.57 cm) on a medium containing  $8.88 \mu\text{M}$  BA, a five- to sixfold multiplication rate compared with earlier studies. Mythili and Thomas (1999) successfully multiplied pointed gourd by culturing of shoot tip and node explants on MS medium containing indole-3-acetic acid ( $1.0 \mu\text{M}$ ) and indole-3-butyric acid ( $0.2 \mu\text{M}$ ). Abdul-Awal et al. (2005) micropropagated pointed gourd on MS media supplemented with different concentrations of cytokinins (BA and 2ip) under various combinations of NAA,  $\text{GA}_3$ , and coconut water. In order to reduce the cost and time of *in vitro* raised plants of pointed gourd, Komal (2011) formulated a minimal medium by substituting costly growth regulators from the MS medium with coconut water. A semisolid MS medium supplemented exclusively with 15% coconut water showed the highest percentage of plantlet regeneration (99%) in the explants.

**2. Nutrient Management.** Basal application of farmyard manure at  $20\text{--}25 \text{ t ha}^{-1}$  in pits is essential for better growth and fruiting in pointed gourd. In West Bengal,  $90 \text{ kg N}$ ,  $26 \text{ kg P}$ , and  $33 \text{ kg K ha}^{-1}$  was found to be optimum (Das et al. 1987). Another study reported that application of  $150 \text{ kg N}$ ,  $35 \text{ kg P}$ , and  $67 \text{ kg K ha}^{-1}$  gave the highest yield and high fruit quality (Misra et al. 1994). In river bed production areas, application of  $20\text{--}25 \text{ t}$  farmyard manure,  $40\text{--}45 \text{ kg N}$ ,  $17 \text{ kg P}$ , and  $33 \text{ kg K ha}^{-1}$  is recommended (Nath and Subramaniyam 1972). Singandhupe et al. (2006) reported that fertigation with 75% of recommended dose of fertilizers

on the basis of 80% potential evapotranspiration (PE) produced the maximum fruit yield of  $5.46 \text{ t ha}^{-1}$ , which was similar to the yield obtained when 100% of the recommended dose of fertilizer was applied using soil application. Prakash et al. (2003) reported that the use of organic mulch (paddy straw) produced higher number of fruit per plant, maximum fruit length, and yield.

**3. Water Management.** Irrigation (or rainfall) at an interval of 3–4 days is essential during initial stages of growth. Irrigation on alternate days is carried out during flowering and fruiting periods; no irrigation is required during rainy season when waterlogging may increase the incidence of *Fusarium* wilt. Singandhupe et al. (2006) reported that irrigation at 80% PE saves water and checks weed growth.

**4. Training.** Pointed gourd vines require training onto an aerial support system (borders, arches, trellis) to achieve maximum fruit production (Prasad and Singh 1987; Yadav et al. 1989) and facilitate effective pollination. In the border system, horizontal netted galvanized iron wire is supported above 2.5 m from ground on iron or wood stakes or concrete pillars. Yield was increased 14% when vines were trained on border system compared with production on the ground (Singh 1989).

**5. Weed Management.** Weed control is essential during early stages of growth. Control is through registered herbicides such as Fluchloralin  $1.0 \text{ kg ha}^{-1}$ . Herbicide treatment plus one hand weeding was the most economical weed control method resulting in the highest cost benefit ratio of 1:2 (Gogoi and Gogoi 1997). Dwivedi et al. (1999) obtained high profit with the use of paddy straw mulch instead of herbicides.

**6. Pollination Problems.** Drying of flowers 1–2 days after anthesis, or yellowing and drying of fruit 5–7 days after anthesis is a common problem during summer. This has been attributed to the lack of pollination and subsequent ovule fertilization during summer months. Both problems underscore the importance of maintaining a ratio of 1 staminate to 10 pistillate plants (Maurya et al. 1985; Mehta et al. 1999).

**7. Growth Regulators.** Foliar application of gibberellic acid ( $\text{GA}_3$ ) at  $40 \text{ mg L}^{-1}$  increased the number of pistillate flowers by 230% and decreased flower abortion by 20%, resulting in increased fruit set (by 18.7%). It also increased the length, diameter, and weight of the fruit and also the amount of carbohydrate and ascorbic acid in the fruit (Basu et al. 1999). Application of 30 ppm kinetin increased the protein

content, total soluble carbohydrates, and ascorbic acid content in fruit. Singh et al. (2005) reported an increase in total fruit per plant with the application of 1,000 ppm Alar.

### E. Harvest and Postharvest Management

Pointed gourd has uneven fruit maturation due to nonsynchronous fruit set. Fruit become ready for first harvest in 80–90 days after planting (DAP). The full-grown, physiologically mature green fruit are harvested once or twice per week. The average yield of 12–15 t ha<sup>-1</sup> can be obtained from well-managed plantings. Pointed gourd produces maximum yields for 3–4 years, after which yield gradually declines (Samal and Parida 1983).

As fruit become mature, the exterior turns orange. Harvested fruit have a short shelf-life: only 3–4 days. During long-distance transportation, fruit turn yellow and shrivel, and the seeds harden. The shelf life of pointed gourd increases by 4 days when stored in a zero energy cool chamber [90% relative humidity (RH) and temperature 10–15 °C less than ambient conditions; Chakraborty et al. 1991]. Storability of pointed gourd fruit can be increased to 8 days by coating with waxol (wax emulsion containing 12% solids) + maleic hydrazide (1,000 mg L<sup>-1</sup>) (Singh 1989) and for 5 days by coating with carnauba wax + sodium hypochlorite (100 mg L<sup>-1</sup>) + potassium metabisulphite (500 mg L<sup>-1</sup>) (Koley et al. 2009).

### F. Pests and Diseases

**1. Melon Fly (*D. cucurbitae*).** The female adult punctures the young ovary and lays eggs below the epidermis. The maggots bore deeply into the fruit and feed, making the fruit unmarketable. The fruit become distorted, begin to rot, and fall from the vine. Control is through registered pesticides such as methyl eugenol and malathion.

**2. White Fly (*Bemisia tabaci*).** The adult flies suck the sap from tender leaves, stunting plant growth. This pest can be controlled by spraying dimethoate 1.5 mL L<sup>-1</sup> (before flowering) and malathion (2 mL L<sup>-1</sup>) after flowering).

**3. Red Pumpkin Beetle (*A. foveicollis*).** The insect feeds on seedlings. Adults feed on the cotyledons. Control is through registered pesticides such as Sevin 50 WP.



**4. Node Borer (*Apomecyna saltator*).** Borers initially damage the nodal region, and then larvae cause stem swelling and sap oozing by boring into the main stem; their tunnels are filled with glutinous waste material (Singh et al. 2008). Yellow gum exudes from infected nodes, and the stem above the infected node dries. A spray with malathion ( $2 \text{ mL L}^{-1}$ ) controls the insect. Experiments conducted at the Regional Research Station, Chiplima, India showed that 25–30% of the planting material (roots) contained grubs of the vine borer, which causes significant yield loss at later stage. Control is by soaking of ‘seed’ (planting stock) in 0.05% Ekalux, Dimecron or 0.067% Thiodan for 15 min before planting.

**5. Root Knot Nematode (*Meloidogyne incognita*).** Pointed gourd is highly susceptible to root knot nematode. Infected roots are short and stubby, and covered with galls. Application of carbofuran 3 g/plant during August to September and 200 g/plant of neem cake with farmyard manure during January and February reduces nematode incidence. Khan et al. (2009) reported a reduction of root galling by dipping vines in monocrotophos 36SL at 1,000 ppm followed by soil inoculation of *Trichoderma viride* at 10 g/pit once at planting and a second dose 40 DAP. Mukhopadhyay et al. (2006) reported effective control of *M. incognita* by dipping vines in carbosulfan 25 EC at 500 ppm for 6 h followed by application of carbofuran 3G at 2.5 g/pit 45 DAP. Biological control can be done using *Paecilomyces lilacinus* (50 g) along with *Trichoderma harzianum* (100 g), neem cake (250 g), and marigold (*Tagetes erecta*) (3 plants per pit) to control *M. incognita* (Verma et al. 2005).

**6. Fusarium Wilt.** The causal organism is *Fusarium oxysporum* f. sp. *niveum* (Smith) Snyder and Hansen. Symptoms include leaves wilting suddenly and vascular bundles in the collar region becoming yellow or brown. The fungus persists in the soil, making it difficult to control this disease. Use of disease-free planting material and drenching with Captan ( $1.5 \text{ g L}^{-1}$ ) and Bavistin ( $2 \text{ g L}^{-1}$ ) around the root zone, followed by application of *Trichoderma* at the rate of 100 g/pit, are recommended for disease control. Soil treatment with 0.5 g Bavistin/pit is also effective.

**7. Stem and Fruit Rot.** This soilborne disease is associated with *Phytophthora malonis* and *P. cinnamomi*, *Pythium* spp. (*P. aphanidermatum* and *P. cucurbitacearum*), and *Rhizoctonia solani*. This disease is severe during rainy season. Water-soaked lesions appear on the fruit

skin, resulting in fruit rot. Fine mycelial growth is observed on the fruit surface in advanced stages. Vine rotting also occurs. Vines should be trained onto a trellis or bower to avoid contact of fruit with the soil. Removal and destruction of all affected plant parts and fruit is advised. It is important to prevent injury of the fruit skin. Soil drenching with copper oxychloride (0.2%) is recommended. Three sprays of metalaxyl 8% + mancozeb 64% wettable powder both at 0.25% at 8–10 days interval can control this disease effectively (Naskar et al. 2006).

**8. Powdery Mildew.** Symptoms of powdery mildew caused by *Sphaerotheca fuliginea* appear as nearly white or powdery growth, somewhat circular patches or spots on the lower surface of leaves. More advanced symptoms include leaves becoming brown and shriveled, and plants becoming defoliated. Application of Carbendazim (0.1%) at 2-week intervals and removal of plant debris after harvest are recommended.

**9. Watermelon Mosaic Virus (WMV).** Affected plants have fewer flowers and fruit resulting in yield reduction. Mild mottling of the leaves as well as vein banding may be observed. The virus spreads by mechanical sap inoculation and vectored by aphids (*A. gossypii* and *M. persicae*). Rapid removal and destruction of infected plants is recommended.

## G. Crop Improvement

**1. Genetics.** A RAPD band OPC 07<sub>567</sub> was reported as a molecular marker for sex expression (Singh et al. 2002). Isozymatic patterns make it possible to identify sex expression before flowering (Sardar et al. 1994). Kumar et al. (2008) studied the inheritance of stem and leaf morphological traits, and reported that stem shape (angular vs. round), stem pubescence, tendril coiling, tendril branching, and leaf pubescence are governed by a single genes.

Characters such as fruit weight, length and diameter, fruit pulp content, fruit number per plant, fruit volume, number of primary branches per plant, number of leaves per plant, and leaf length are the major yield contributing factors in pointed gourd (Singh et al. 1993, 2007; Sarkar et al. 1999; Hazra et al. 2003). High heritability was reported for fruit length, fruit volume, yield per plant, primary branches per plant, number of fruit per plant, and skin thickness, suggesting that these characters are governed by additive gene action (Singh et al. 1985, 1986, 1992; Sarkar 1989). Significant positive correlations exist between

fruit yield per plant and late flowering (Sarkar and Datta 1987; Prasad and Singh 1990); number of fruit (Singh et al. 1986, 1993; Sarkar 1989; Singh and Prasad 1989; Dora et al. 2003); fruit volume and fruit weight (Singh et al. 1986; Sarkar 1989; Singh and Prasad 1989; Sarkar et al. 1999); fruit diameter (Singh et al. 1987; Sarkar et al. 1999); and fruit length (Singh et al. 1987). However, there was a significant negative correlation between fruit diameter and yield (Singh and Prasad 1989). Yadav et al. (1998) suggested selecting high yielding pistillate clones bearing more fruit per plant in combination with early maturity.

**2. Plant Genetic Resources.** Extensive collections of pointed gourd germplasm are maintained at multiple locations in India. These include Narendra Dev University of Agriculture & Technology, Faizabad, Uttar Pradesh; Rajendra Agricultural University, Sabour, Bihar; Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal; National Bureau of Plant Genetic Resources (NBPGR), New Delhi; Krishna Chandra Mishra Research Institute of Wild Vegetable Crops, Bandanwar, Godda, Bihar; and Central Horticultural Experiment Station, Bhubaneswar.

RAPD (Goswami et al. 2009; Khan et al. 2009; Goswami and Tripathi 2010) and ISSR markers (Goswami and Tripathi 2010) have been used to estimate genetic diversity of pointed gourd germplasm (Hazra et al. 1998; Dora et al. 2001; Ram 2001; Ram et al. 2001; Bharathi and Nath 2010–2011). Kabir et al. (2009) studied the genetic diversity of pointed gourd in Bangladesh and grouped the germplasm based on nine characters.

**3. Breeding.** The goals for cultivar development in pointed gourd include increased productivity (increased branching, earlier maturity, and more fruit per plant), high fruit quality (proper size, darker color, reduced seed content, longer shelf life), and high insect and disease resistance. Variability exists for earliness, fruit size, number of fruit/plant, and yield. Efficient breeding methods should take advantage of the fact that pointed gourd is cross-pollinated and clonally propagated. Thus, clonal selection is an important part of developing high yielding cultivars. The existing clones of pointed gourd are highly heterozygous, and biparental crosses produce segregating populations for the selection of improved clones. Cultivars such as 'Arka Neelachal Kirti', 'Swarna Rekha', 'Swarna Alaukik', 'FP 1', 'FP 3', and 'FP 4' have been developed through clonal selection (Table 9.5). Induced polyploidy has not been promising because of lack of fertility (Hazra and Ghosh 2001).

**Table 9.5.** Important cultivars of pointed gourd (*Trichosanthes dioica*) from India and their characters.

Cultivar	Characteristics	Yield (q ha <sup>-1</sup> )
CHES Hybrid 1	First hybrid developed, resistant to fruit fly. The solid, green striped fruit each weigh 30–35 g	280–320
CHES Hybrid 2	Dark green striped fruit with average fruit weight of 25–30 g	300–400
Faizabad Parwal 1	Fruit round, green, and attractive	150–170
Faizabad Parwal 3	Fruit are spindle shaped, green, and less striped	125–150
Faizabad Parwal 4	Fruit are light green, spindle shaped with tapering ends. Recommended for reclaimed sodic soils	125–150
Rajendra Parwal 1	Highly suitable for <i>diara</i> land cultivation. Fruit are big-sized striped and green	140–150
Rajendra Parwal 2	Highly suitable for <i>diara</i> land cultivation. Fruit are large, dark green with whitish stripes	150–170
Swarna Alaukik	Fruit light green with blunt ends, 5–8 cm long, solid, thin skinned, and good for vegetable as well as sweets	230–280
Swarna Rekha	Fruit greenish white, striped, 8–10 cm long and tapering on both sides	200–230
Shankolia	Fruit are medium long (7.56 cm × 2.94 cm), resembling those of shell; greenish with white stripes, slightly beaked toward distal end and bulged toward stalk	125–150
Konkan Harita	Fruit dark green with white stripes, thin skinned, and good for vegetable	140–170
Arka Neelachal Kirti	Fruit dark green with 3–4 fragmented stripes of cream color; long, elongated spindle shaped with solid core, approximately 45–50 g	250–260

## V. FUTURE PROSPECTS

Most of the genetic improvement in snake gourd and pointed gourd has been the result of selection within landraces by farmers in local habitats. However, over the last two decades, increasing emphasis has been placed on more systematic improvement strategies in India. This has resulted in the release of many improved open-pollinated cultivars in these crops by state agricultural universities and the Indian Council of Agricultural Research.

Hybridization programs are expected to create improved recombinants and transgressive segregants. The early identification of staminate and pistillate plants in pointed gourd would be advantageous to help farmers to obtain desirable ratios for optimum yield. Future efforts in snake gourd and pointed gourd breeding should emphasize the development of nutritious, high-yielding cultivars with superior resistance to major diseases and exceptional fruit quality for both domestic and foreign markets.

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