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## RESEARCH ARTICLE

# ORIGIN, DISTRIBUTION, TAXONOMY, GENETIC DIVERSITY, BREEDING, USES AND PRODUCTION TECHNOLOGY OF IVY GOURD {*Coccinia grandis* (L.) VOIGT.}

***Swamy, K.R.M.**

Former Principal Scientist & Had, Division of Vegetable Crops, ICAR-Indian Institute of Horticultural Research, Bengaluru- 560 089

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****Corresponding Author:***
***Swamy, K.R.M.***

**ABSTRACT**

Ivy gourd (*Cocinia grandis*) is a tropical dioecious perennial plant/vine with a tuberous root stock producing annual stems that grows several metres long. It belongs to the family Cucurbitaceae. This vine has aggressive climbing properties and spreads easily over fences, trees, shrubs, and other supports. The fruits are being used in Indian dishes and their leaves/stem/roots are used in ayurvedic medicines. Various parts of *Coccinia grandis* have specific medicinal values. A monoecious species is cultivated and the species, *C. abyssinica* is grown in Ethiopia for its edible tuberous roots. *Coccinia grandis* is known as ivy gourd, baby watermelon, little gourd, gentleman's toes , scarlet fruited gourd, scarlet gourd, small gourd. Ivy gourd is well known as kundru or tondekai in India. It is cultivated throughout India. It is grown for its immature fruits cooked as vegetables especially in Southern, Eastern and Western India. It is native to Northern and Eastern Africa, Arabia to tropical South and Southeast Asia. The Ivy gourd is widely grown in all tropical regions as that kind of climate enhances it growth. India and Pakistan have massive plantations of this vegetable apart from Thailand, Malaysia and Indonesia. It covers vast tracts of plains in Africa, continuing up to Asia. They are distributed in Hawaii, Australia, Fiji, Vanuatu, Guam, Tonga, Samoa and Marshall Islands as well. In this review article the Origin and Distribution, Taxonomy, Botanical description, Genetic diversity, Breeding, Uses, and Production technology of Ivy gourd are discussed.



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# INTRODUCTION

*Coccinia grandis* or Ivy gourd is an underexploited cucurbitaceous perennial vegetable crop. It is an aggressive climbing vine that spread quickly over, trees, shrubs, fences and other supporting structures. *C. grandis* is believed to be native to central Africa, India and Asia. However, its long history of use, cultivation and transportation by people has obscured its origin (BCC, 2021). The ivy gourd is cultivated in India, tropical Africa, Malaysia and other south east Asian countries, and China. In India it is widely grown in Southern; Eastern and Western regions, mainly in Tamil Nadu, Karnataka, Kerala, Maharastra, Gujarat, Andhra Pradesh and West Bengal. It is distributed in Northern plains and *Terai* regions, extending to peninsular region (TNAU, 2021). But its cultivation is restricted around cities and coastal area. In our country it is being grown in larger areas viz., Bangalore, Kerala, Tamil Nadu, Andhra Pradesh, Maharastra, Bihar and Madhya Pradeh (Dharmatti *et al*., 2008). In India, the Ivy gourd, has been recorded in the Mahabharata period (TNAU, 2021). Ivy gourd plant is dioecious in nature and it is propagated by both seeds and stem cuttings. Young plants require support to keep their young shoots growing upright, since the new shoots are delicate. For commercial crop, plants are trained on a bower system. In the initial stages the plants are supported by stakes branches. Tendrils of this plant are long and elastic with coil like springy characters and they will coil on the G.I. wire of the bower system (Dharmatti *et al*., 2008). In Southern Rajasthan condition clonal variation in this crop is available. However, very little work has been done. It is a cross pollinated, high genetic variation is available in this crop. Genus *Coccinia* deals with 95 names described in the Family Cucurbitaceae, and recognizes 25 species (Holstein, 2015). Genus *Coccinia* is one of the few examples in the plant kingdom, in which at least one species has heteromorphic sex chromosomes (Ming *et al*. 2011). *Coccinia grandis* contains 22 autosomes plus 2 gonosomes. Female individuals have homomorphic XX, whereas male individuals have heteromorphic XY chromosomes. Although Kumar and Deodikar (1940) report males to have two large "X" and females a large X and a smaller Y chromosome, later studies (Chakravorty 1948; Kumar and Vishveshwaraiah 1952) reveal that males are heteromorphic and the Y is 2.5 (Bhaduri and Bose 1947). Aside from research on the sex chromosomes, a few studies on the genome of *C. grandis* have been undertaken. Guha *et al*. (2004) report the 4C nuclear DNA content of female *C. grandis* as 8.37 ± 0.14 pg, whereas that of male *C. grandis* is 10.17 ± 0.24 pg. This means that the difference between X and Y chromosome adds about 20 % to the complete DNA content. It helps to lower blood sugar level, prevents obesity, eliminates long-lasting fatigue, protects the nervous system and

Fiber keeps the digestive tract healthy and prevents kidney stones (Indiamart, 2021). Production Technology/Cultivation of Ivy gourd is also discussed. There is a great scope of increasing the production and consumption of vegetable, to ensure balanced diet for the masses.

## ORIGIN AND DISTRIBUTION

*C. grandis* is believed to be native to Central Africa, India and Asia. However, its long history of use, cultivation and transportation by people has obscured its origin (BCC, 2021). In India, the Ivy gourd has been recorded in the Mahabharata period (TNAU, 2021). It is actually native to Northern and Eastern Africa, Arabia to tropical South and Southeast Asia (HBT, 2021). Its native range extends from Africa to Asia, including India, the Philippines, China, Indonesia, Malaysia, Myanmar, Thailand, Vietnam, eastern Papua New Guinea, and the Northern Territories, Australia (Namita, 2015). About 30 species of the genus *Coccinia* occur wild in Africa. The cultivated species, *C. grandis* (L) is found growing in nature in the tropics of India and Southeastern Asia besides Africa. (TNAU, 2021). It was domesticated in India and Southeast Asia (TNAU, 2021). Seeds or fragments of the vine can be relocated and lead to viable offspring. This can occur when humans transport organic debris or equipment containing *C. grandis*. Once the ivy gourd is established, it is presumably spread by birds, rats, and other mammals. In Hawaii, the fruit may be dispersed by pigs. Long-distance dispersal is most commonly carried out by humans due to its culinary uses or by mistake. Regarded as very invasive and on the Hawaii State Noxious Weed List, Ivy gourd can grow up to four inches per day. Its documented introduced range includes the Federated States of Micronesia, Fiji, Guam, Saipan, Hawaii, the Marshall Islands, Samoa, Tonga, and Vanuatu (Namita, 2015).

According to Holstein (2015) Ivy gourd is distributed in Benin, N Cameroon, S Chad, D. R. Congo (in Great African Rift valley), Djibouti, Egypt (along Nile, Elba Mts), Eritrea, Ethiopia, Kenya, Mali (except N), S Mauritania, Niger, Senegal, Somalia, South Sudan, S and E Sudan, N Tanzania (Arusha, Dar es Salaam, Manyara, Morogoro, Mwanza, Pwani, Tanga, Zanzibar), Uganda, mountains and oases of the southern and western Arabian Penin- sula, tropical and subtropical India, subtropical Nepal, Pakistan, Sri Lanka, South East Asia, S China incl. Hainan. Occurrence likely due to recent introduction in: Australia (Northern Territory, Queensland, Western Australia), R. China, Maldives, Mauritius, Mozambique, USA (Florida, Guam, Hawaii, Wake Island), many tropical Pacific islands, Caribbean area, Central and tropical South America. Ivy gourd is native to East Africa and has been spread in different parts of tropical Asia, America and Pacific, but it has become offensive only in Hawaiian and Mariana Islands of the Pacific. Very small populations are distributed throughout Western Australia, the Northern Territory and the Northern coastal parts of Queensland. (HBT, 2021; Chamroeun Keo. 2021; TERI, 2021). It is naturalised in Northern Queensland and in the coastal districts of Northern Western Australia (e.g. Broome, South Hedland and Arnhem Land). Possibly also naturalised, or naturalised beyond its native range, in the Northern Territory. (BCC, 2021)

C. grandis is originally native to north-central East Africa, but also grows wild in the Indo-Malayan region. It has been introduced to Australia, the Pacific region, the Caribbean and southern United States (Muniappan *et al*., 2009. The Ivy gourd/Tindora is cultivated mainly in other countries like in tropical Africa, Malaysia, and other Southeast Asian countries, and China (Agri Farming, 2019). It is distributed in sub-Saharan Africa and with one species, *C. grandis* also in South and Southeast Asia, and it is also introduced into the New World (Wikipedia, 2021). They are widely grown in all tropical regions as that kind of climate enhances it growth. India and Pakistan have massive plantations of this vegetable apart from Thailand, Malaysia and Indonesia. It covers vast tracts of plains in Africa, continuing up to Asia. They are distributed in Hawaii, Australia, Fiji, Vanuatu, Guam, Tonga, Samoa and Marshall Islands as well (TERI, 2021).

## TAXONOMY

The scientific classification of the genus *Coccinia* is as follows (Candolle, 2007; Wikipedia, 2021; Wikimedia. 2021):

Family: *Cucurbitaceae;*
Subfamily: *Cucurbitoideae;*
Tribe: *Benincaseae;*
Genus: *Coccinia;*
Species: *grandis*

Synonyms of genus *Coccinia* are *Cephalandra*, *Physedra* and *Staphylosyce* (Wikimedia. 2021; Wikipedia, 2021). However, Wunderlin *et al*. (2022) reported only two synonyms viz., Cephalandra and Cephalopentandra.

According to Holstein (2015) the monograph of *Coccinia* (Cucurbitaceae) deals with all 95 names described in the Family Cucurbitaceae, genus *Coccinia* and recognizes 25 species (Table 1).

**Table 1. Recognised species of genus Coccinia**

| |
|---|
| 1. Coccinia abyssinica (Lam.) Cogn. |
| 2a. Coccinia adoensis (Hochst. ex A.Rich.) Cogn. var. adoensis |
| 2b. Coccinia adoensis var. aurantiaca (C.Jeffrey) Holstein |
| 2c. Coccinia adoensis var. jeffreyana Holstein |
| 3. Coccinia barteri (Hook.f.) Keay |
| 4. Coccinia grandiflora Cogn. |
| 5. Coccinia grandis (L.) Voigt |
| 6. Coccinia heterophylla (Hook.f.) Holstein |
| 7. Coccinia hirtella Cogn. |
| 8. Coccinia intermedia Holstein |
| 9. Coccinia keayana R.Fern. |
| 10. Coccinia longicarpa Jongkind |
| 11. Coccinia mackenii Naudin ex C.Huber |
| 12. Coccinia megarthiza C.Jeffrey |
| 13. Coccinia microphylla Gilg |
| 14. Coccinia mildbraedii Gilg |
| 15. Coccinia ogadensis Thulin |
| 16. Coccinia pwaniensis Holstein |
| 17. Coccinia quinqueloba (Thunb.) Cogn. |
| 18. Coccinia racemiflora Keraudren |
| 19. Coccinia rehmannii Cogn. |
| 20. Coccinia samburuensis Holstein |
| 21. Coccinia schliebenii Harms |
| 22. Coccinia senensis (Klotzsch) Cogn. |
| 23a. Coccinia sessilifolia (Sond.) Cogn. var. sessilifolia |
| 23b. Coccinia sessilifolia var. variifolia (A.Meeuse) Holstein |
| 24. Coccinia subsessiliflora Cogn. |
| 25. Coccinia trilobata (Cogn.) C.Jeffrey |

**However, it was reported that the genus *Cocainia* includes 33 accepted species as given below (TPL, 2021):**

- Coccinia abyssinica (Lam.) Cogn.,
- Coccinia adoensis (A.Rich.) Cogn.,
- Coccinia aurantiaca C.Jeffrey,
- Coccinia barteri (Hook.f.) Keay,
- Coccinia buettneriana Cogn.
- Coccinia decipiens (Hook.f) Cogn.
- Coccinia fernandesiana C.Jeffrey
- Coccinia gabonensis Keraudren
- Coccinia grandiflora Cogn. ex Engl.
- Coccinia grandis (L.) Voigt
- Coccinia hirtella Cogn.
- Coccinia keayana R.Fern.
- Coccinia lalambensis Penz.

- Coccinia longicarpa Jongkind
- Coccinia longipetiolata Chiov.
- Coccinia mackenii Naudin ex C.Huber
- Coccinia megarrhiza C.Jeffey
- Coccinia microphylla Gilg
- Coccinia mildbraedii Gilg ex Harms
- Coccinia palmata (E.Mey. ex Sond.) Cogn.
- Coccinia quinqueloba (Thunb.) Cogn.
- Coccinia racemiflora Keraudren
- Coccinia rehmannii Cogn.
- Coccinia schliebenii Harms
- Coccinia senensis (Klotzsch) Cogn.
- Coccinia sessilifolia (Sond.) Cogn.
- Coccinia stolzii Harms
- Coccinia subglabra C.Jeffrey
- Coccinia subhastata Keraudren
- Coccinia subsessiliflora Cogn.
- Coccinia trilobata (Cogn.) C.Jeffrey
- Coccinia ulugurensis Harms and
- Coccinia variifolia A.Meeuse.

It was also reported by TNAU (2021 ) that the genus *Coccinia* has about 30 species, occurring mostly in Africa. Only one species- *Coccinia grandis* (L.) Voigt. - is cultivated (TNAU, 2021). Synonyms of Ivy Gourd *(Coccinia grandis)* are *Bryonia grandis*, *Coccinia cordifolia, Coccinia indica,* and *Cephalandra indica* (Holstein, 2015; Namita, 2015; HBT, 2021).

**However, it was reported that the synonyms of *Cocinia grandis* consists of the following 30 names (NBP, 2021):**

- *Bryonia alceifolia* Willd.,
- *Bryonia acerifolia* D. Dietr.,
- *Bryonia barbata* Buch.-Ham. ex Cogn.,
- *Bryonia glabra* Roxb.,
- *Bryonia grandis* L.,
- *Bryonia palmata* Wall.,
- *Bryonia sinuata* Wall.,
- *Bryonia sinuosa* Wall.,
- *Cephalandra grandis* (L.) Kurz,
- *Cephalandra indica* (Wight & Arn.) Naudin,
- *Cephalandra moghadd* (Aschers.) Broun & Massey,
- *Cephalandra schimperi* Naud.,
- *Coccinia grandis* var. *wightiana* (Roem.) I. Grebenscikov,
- *Coccinia helenae* Busc. & Muschl.,
- *Coccinia indica* var. *palmata* Wight & Arn.,
- *Coccinia loureiriana* M. Roem.,
- *Coccinia moghadd* (Forssk.) Aschers,
- *Coccinia moimoi* M. Roem,
- *Coccinia palmatisecta* Kotschy,
- *Coccinia schimperi* Naud.,
- *Coccinia wightiana* M. Roem.,
- *Cucumis rheedii* Kostel.,
- *Cucurbita dioica* Roxb. ex Wight & Arn.,
- *Cucurbita schimperiana* Hochst. ex Cogn.,
- *Cucurbita triangulata* Hochst. ex Cogn.,
- *Momordica bicolor* Bl.,
- *Momordica covei* Dennst.,
- *Momordica monadelpha* Roxb.,
- *Physedra gracilis* A. Chev. and
- *Turia moghadd* Forssk.

**Common English Names:** *Cocinia grandis* is known as ivy gourd, baby watermelon, little gourd, gentleman's toes , scarlet fruited gourd, scarlet gourd, small gourd (Namita, 2015; BCC, 2021; HBT, 2021)

**Common Names in some of the countries** (HBT, 2021)

**Bangladesh:** Telakucha,
**Chinese:** Hong gua
**Danish:** Skariagenagurk.
**French:** Gourde écarlate del' Inde.
**German:** Tindola, Scharlachranke
**Japanese:** Yasai karasu uri.
**Malay:** Pepasan, Papasan (Indonesia), Bolu teke (Java).
**Marshallese:** Kiuri awia
**Micronesia:** Aipikohrd (Pohnpei)
**Nepalese:** Akhu pami, Gol kankri, Kundaruu (Kundaru), Van kirii (Van kiri).
**Peninsular Malaysia:** Pepasan
**Pohnpeian:** Aipikohrd
**Spanish:** Pepino cimarrón
**Swedish:** Scharlakansgurka
**Thai:** Tảlụng, Tam luen g, P̄hạk tảlụng , Phak tamlueng.
**Tongan:** Kiukamapa 'ae 'initia
Vietnamese: Bát

**Common Names in Indian Languages (Holstein, 2015; Agri.Farming, 2019; HBT, 2021)**

**Bengali:** Telakucha
**Hindi:** Bimb, Bimba, Kanduri, Kanturi, Kundree, Kundru, Kunduru, tindora, tindori
**Kannada:** Kaagethonde , Konde ball , Theekkuduru, Thonde balli, Thundike, Tondikay
**Malayalam:** Kova, Koval.
**Marathi:** Tondili, Tondalī, Tondli
**Oriya:** Kunduri, Ban-kundri
**Sanskrit:** Bimbi, Bimbika, Jivaka, Patupami, Vimba, Vira.
**Tamil:** Covay, Kotturukanni, Kovai, Kovaikkay, Naripputu, Rattakkovai, Tirattikkovai, Vattakkovai, Velikkovai, Vimpa, Vimpakam, Vimpi, Vimpikai, Kovai
**Telegu:** Kakidonda, Donda Kaya
**Urdu:** Kanduri, kundur
**Punjabi:** kanduri

## BOTANICAL DESCRIPTION

*C. grandis* grows well in warm, humid, tropical regions. In Fiji it occurs in cane fields, degraded land and road sides. In Hawaii it is found at elevations of 0–245 m, whereas in China it can grow at elevations of up to 1100 m (Muniappan *et al.*, 2009; PIER, 2013). According to BCC (2021) Ivy gourd prefers the dry rainforests of the monsoon zone, the tropical and sub-tropical rainforests of the humid coastal zones, and riparian vegetation in these and other locations. This very aggressive smothering vine is regarded as being native to some parts of the Northern Territory. However, it is invasive in other parts of the world and it thought to pose a threat to the environment in many parts of Australia beyond its native range (i.e. in the monsoon zone of northern Australia and the tropical and sub-tropical humid zones of coastal Queensland and northern New South Wales). Ivy gourd could infest the dry rainforests of the monsoon zone, the tropical and sub-tropical rainforests of the humid coastal zones, and riparian vegetation in these and other locations. This species is already a significant environmental weed in Hawaii, where it smothers remnant native vegetation. It climbs and envelops shrubs and trees, forming a dense canopy that impedes light penetration and prevents the growth and regeneration of native plants. Ivy gourd is a perennial climber or creeper (Sambandan *et al.*, 2015; Holstein, 2015). The stems grow up to 5 m, glabrous, when older often white pustulate. Petioles 0.5–5.5 cm, glabrous, rarely some trichomes on adaxial side (Holstein, 2015). With five lobes, leaves are palmate when the shape varies from the heart to pentagon form with size of the leaves around 5-10 centimeters of width and length. At upper surface, the leaf has no hair while the lower is hairy (Chamroeun Keo, 2021). Leaves 3–11 × 3–13 cm, cordate to 3-lobate or 5-edged to 5-lobate, sometimes lobulate. Lobes triangulate, ovoid, oblong, to obovoid. Leaf margin dentate, teeth usu- ally with yellowish-reddish to brownish gland becoming black when dried. Margin rarely with short (< 1 mm), whitish trichomes. Apex obtuse to acute with final tooth. Upper leaf surface glabrous, more or less dense hyaline to white

pustulate. Lower leaf surface glabrous, with glands that are usually framed with lighter color between major nerves, nerves sometimes with white pustules. Probracts < 1.5 mm or missing (Holstein, 2015) (Fig. 1).

**Fig. 1. Ivy gord leaves**

Tendrils simple, up to 7 cm long, elastic with coil like springy character that can wrap around the host to the entire length. Tendril is simple, rarely bifid (Sambandan *et al*., 2015; Holstein, 2015). Flowers are normally star-shaped, large and white and around 4 centimeters in diameter (Chamroeun Keo, 2021). Male flowers 1(–3) solitary, rarely in short racemes. Peduncle 0.3–1.5 cm, glabrous, pedicels of flowers in racemes up to 3.2 cm, glabrous, pedicels of solitary flowers up to 4.5 cm, glabrous. Bracts inconspicuous (< 1 mm), often absent. Perianth tube glabrous. Calyx lobes 1.2–3.5 mm long, lineal, spreading to reflexed, often with reddish to brownish gland on lower side at the acute tip. Corolla 1.7–4 cm long, yellowish buff (mostly African collections) to snow-white (esp. outside Africa). Corolla lobes 0.7–1.7 cm. Filament column and anther head pale greenish, pollen sacs yellow (Holstein, 2015). Female flowers 1(–2) solitary. Pedicel up to 1 cm, glabrous. Hypanthium glabrous, calyx and corolla like in males.

Ovary glabrous. Style columnar, yellowish-green. Stigmas 2-lobed, greenish. Fruit globose to ellipsoid, cultivated also shortly cylindrical, 3–45 × 15 cm, glabrous, unripe greenish with few pale spots and/or lines, becoming scarlet red when ripe. Seeds 5–7 × 2.5–3.5 × 1.2 mm (L/W/H), asymmetrically obovate, face flat. There is no definite test to identify male and female plants at the young age on morphological traits except when it flowers (Holstein, 2015) (Fig. 2). Ivy gourd fruit may be truly smooth, ovoid to ellipsoid in such shape and so small they may be realized as berry. Its dimensions may be 60 mm long by 15-35 mm diameter. As for skin, it may be smooth along with variations of green and white. It may be green with longitudinal stripes as young and next it turns to bright red and ripe. Inside, the clear white flesh of fruit seems like the appearance with taste of cucumber, displaying various seeds. The flesh may be just as crispy and tasty in texture consuming s lightly bitter aftertaste (Fig. 3). It contains many pale flattened seeds 7 mm long (Chamroeun Keo. 2021). The fruit is red (when ripe), ovoid to elliptical, 25–60 mm long, 15–35 mm in diameter, hairless on stalks 10–40 mm long. Seeds are tan-coloured and 6–7 mm long (BCC, 2021). The roots are long and tuberous (Fig. 4). The roots and stems are succulent and help the ivy gourd plant store water through dry seasons (TNAU, 2021). *C. grandis* can be dispersed from seeds as well as from broken pieces of roots and stems. Seeds can be dispersed by birds and feral pigs. Seeds do not exhibit dormancy and usually germinate within 2–4 weeks at 20 °C (BCC, 2021).

## GENETIC DIVERSITY

Variability exists in Ivy gourd for fruit shape, size, color and striping (Fig. 5). Morphological variation was analyzed in wild accessions and cultivars of the vegetatively propagated dioecious *Coccinia grandis*.

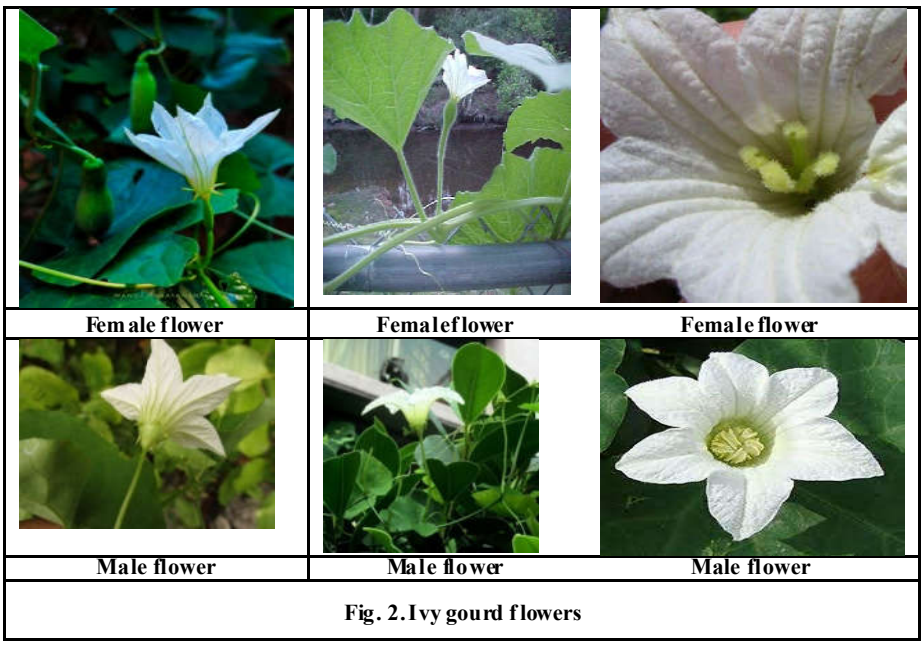
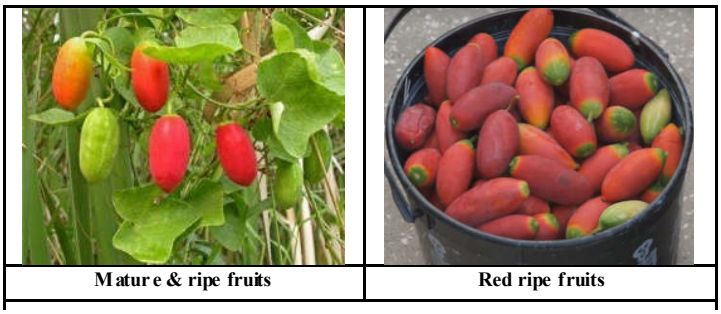



**Fig. 2. Ivy gourd flowers**



Variations of 43 morphological characters, 19 qualitative and 23 quantitative traits, were analyzed among 40 female accessions, including 25 cultivars and 15 wild accessions. Multivariate statistical analyses were used to group accessions according to their morphological similarity. Principal component (PC) analysis revealed that the first three PCs accounted for 50% of the total variance, and differences among the accessions were evidenced principally in relation to fruit characteristics such as fruit weight, fruit length and the number of seeds in each fruit. Analysis of variance carried out in the entire germplasm revealed significant differences within the germplasm, whereas ANOVA carried out between the wild accessions and the cultivars proved the null hypothesis that there are no significant differences between the two groups, and differences were observed only in fruit characters that are targets of human selection. Principal component analysis, UPGMA cluster analysis and discriminant factor analysis revealed strong overlaps between the two groups indicating the ongoing process of evolution and selection in the species (Shaina, and Suhara, 2012). An experiment was conducted to study the genetic variability in ivy gourd [Coccinia grandis (L.) Voigt.] genotypes collected from different parts of Assam and other North Eastern states (Arunachal Pradesh, Tripura and Nagaland) during the summer seasons of 2013 and 2014. Genetic variability in terms of PCV and GCV were high for yield per plant (27.56 and 23.87%, respectively). High heritability in broad sense combined with high genetic advance was recorded for number of fruits per plant (94.39 and 38.57%) followed by fruit weight (93.36 and 32.61%), which were indicative of preponderance of additive and additive × additive type of gene interaction. The desirable additive genes for these traits could be accumulated and fixed in the population through phenotypic selection, thereby genetically improving the ivy gourd genotypes (Saikia *et al.*, 2017).

An experiment was carried out on study of genetic variability in 30 genotypes of ivy gourd at Horticulture Department of Rajasthan College of Agriculture, MPUAT, Udaipur during July to September 2017. Twelve Growth and quality characters were studied. The analysis of variance indicated that the mean sum of square due to genotypes were highly significant for all the characters suggesting the presence of good deal of variability in material studied. High magnitude of genotypic as well as phenotypic coefficient of variations were recorded for traits *viz*., petiole length (27.63% and 29.93%), inter nodal length (22.73% and 23.40%), leaf width (22.63% and 23.35%) and leaf width (22.52% and 23.56%) and highest heritability recorded for inter nodal length (94.30%) followed by leaf length (93.92%), leaf width (91.37%), ascorbic acid (89.48 %), petiole length (85.17%), fruit weight (82.10%), fruit length (79.98%) and chlorophyll content in leaves (78.23%).The highest genetic gain was recorded for petiole length (52.52%) followed by viz., inter nodal length (45.47%), leaf length (45.17%), leaf width (44.34%), fruit weight (34.21%), fruit length (28.24%) fruit diameter (23.31%) and genetic advance were also higher for some characters.

Availability of high GCV and PCV indicates that there is an ample scope of selection in the present gene pool for yield and its components. Crop improvement depends on the magnitude of genetic variability and the extent to which the desirable characters are heritable. High heritability is not enough to make efficient selection in segregating generation unless the information is accompanied with substantial amount of genetic advance. Heritability and genetic advance, when calculated together, would prove more useful in predicting the resultant effect of selection on phenotypic expression, without genetic advance the estimation of heritability will not be of practical value and emphasized the concurrent use of genetic advance along with heritability. Therefore, priority should be given to those traits which showed higher estimates of genetic advance as percent mean while deciding selection strategies and selection based on these characters may be useful in realizing better gain by selection (Jitendra *et al*., 2020). In order to determine the magnitude of variability, 18 genotypes of ivy gourd were evaluated at CHES, Bhubaneswar. Through analysis of variance, a high significant difference was found for almost all thirteen characters indicating a greater opportunity of exploit variability. Genotypic and phenotypic variances were highest for no. of fruit yield /plant and stem girth followed by leaf area and days of flowering. Phenotypic co- efficient of variation (PCV) and Genotypic co-efficient of variation (GCV) were maximum in case of no. of primary branches/plant and minimum for length of inte-rnode, respectively. Heritability was found very high for all characters except length of inter-node and fruit girth. The maximum genetic advance (% of mean) was observed in case of no. of fruit/ plants followed by leaf area and days of flowering. Genotypic coefficient of variation, heritability and predicted genetic gain were high for the characters no. of primary branches/plant, vine length and no. of fruit/ plants suggesting that additive gene action is responsible for expression of these characters (Bharti and Madan, 2020).

**Chromosomes and Sex Determination:** *Coccinia* is one of the few examples in the plant kingdom, in which at least one species has heteromorphic sex chromosomes (Ming *et al*., 2011). *Coccinia grandis* contains 22 autosomes plus 2 gonosomes. Female individuals have homomorphic XX, whereas male individuals have heteromorphic XY chromosomes (). Although Kumar and Deodikar (1940) report males to have two large "X" and females a large X and a smaller Y chromosome, later studies (Chakravorty, 1948; Kumar and Vishveshwaraiah, 1952) reveal that males are heteromorphic and the Y is 25 (Bhaduri and Bose ,1947). Majority of the angiosperm species are co-sexual. Only ~ 6% of angiosperm species are dioecious having separate male and female individuals (Ming *et al*, 2011). *Coccinia grandis* is one such dioecious species having heteromorphic sex chromosomes (Male: 22A+XY and Female: 22A+XX) (Fig. 6).

Sousa *et al*. (2013) document autosome/Y divergence in the tropical Cucurbitaceae *Coccinia grandis*, which is ca. 3 myr old. Karyotyping and C-value measurements show that the *C. grandis* Y chromosome has twice the size of any of the other chromosomes, with a male/female C-value difference of 0.094 pg or 10% of the total genome. FISH staining revealed 5S and 45S rDNA sites on autosomes but not on the Y chromosome, making it unlikely that rDNA contributed to the elongation of the Y chromosome; recent end-to-end fusion also seems unlikely given the lack of interstitial telomeric signals. GISH with different concentrations of female blocking DNA detected a possible pseudo-autosomal region on the Y chromosome, and C-banding suggests that the entire Y chromosome in *C. grandis* is heterochromatic. During meiosis, there is an end-to-end connection between the X and the Y chromosome, but the X does not otherwise differ from the remaining chromosomes.

These findings and a review of plants with heteromorphic sex chromosomes reveal no relationship between species age and degree of sex chromosome dimorphism. Its relatively small genome size (0.943 pg/2C in males), large Y chromosome, and phylogenetic proximity to the fully sequenced *Cucumis sativus* make *C. grandis* a promising model to study sex chromosome evolution. Gautam and Banerjee (2013) have obtained the plant material from Agartala, Tripura and maintained throughout the year in the garden of National Chemical Laboratory (NCL), Pune. Flowers and leaves were collected from soil grown male, female and hermaphrodite *Cocainia grandis* plants and were stored at -80 □C for molecular analysis. *Coccinia grandis* (Ivy gourd), is a dioecious member of Cucurbitaceae family, bears male and female flowers on separate individuals. The male plants carry 22A + XY and female plants carry 22A + XX chromosomes. But rare hermaphrodites with chromosome constitution as 22A + XX, bearing perfect flowers are also observed in wild. They have attempted to characterize the morphological differences between male, female and hermaphrodite flowers at different stages of floral development. They have observed that the sex expression of *C. grandis* is not stable. Spraying of silver nitrate ($AgNO_3$) on female plant at an early stage of flower development produces bisexual flowers instead of female flowers. Conclusions from the study are as follows:

- From the morphological characterization of flowers, we could conclude that there is no phenotypic differences in whorl 1 (sepals) and whorl 2 (petals) of all three sexual forms.

**Fig.4. Tuberous root**

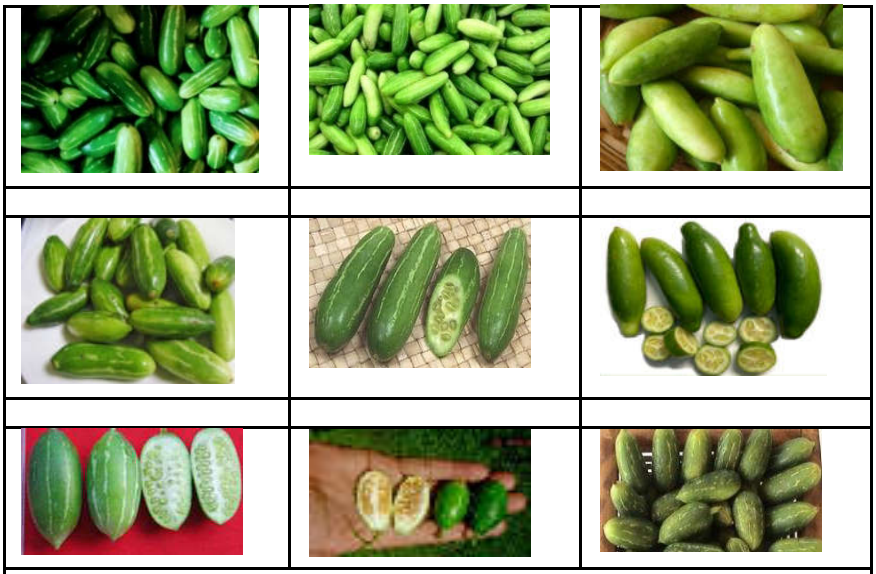


**Fig.5: Variability for fruit shape, color and size in Ivy gourd**

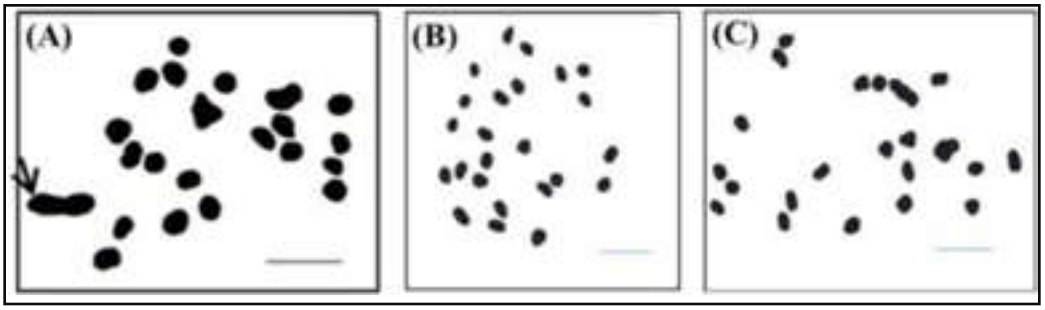



**Fig. 6. Metaphase plates of *C. grandis* showing chromosomes 2n = 24; (A) Male plant (Arrow indicates Y chromosome), (B) Female plant, and C) Gynomonoecious plant.**

However, morphological differences were found in whorl 3 (stamens) and whorl 4 (carpels) in male, female and natural hermaphrodite flowers (Fig. 7).

- Their observations suggest that female flowers develop by arresting stamen growth in initial hermaphroditic floral primordia. At stage 4 of flower development, it is seen that there is arrest of stamens in female flower. There is no abortion of the stamens at later stages of development and reason for retention of these stamens is also not known. The male flower is unisexual right from stage 1 with no development of female reproductive organs. One of the possible mechanisms of development of male unisexual initial hermaphroditic floral primordia. The other possible mechanism could be the initial floral primordia itself is unisexual with no development of opposite sex organs from the inception of flower formation (Fig. 8 & 9).
- Leaf epidermal morphology analysis showed that the number of stomata are more in natural hermaphrodite than male and female plants. The increase in the number of stomata could be an adaptation for natural hermaphrodite plants.
- Phylogenetic analysis establishes that natural hermaphrodite belongs to the same clade as *C. grandis*, indicating that natural hermaphrodite is one of the sexual forms of *C.*

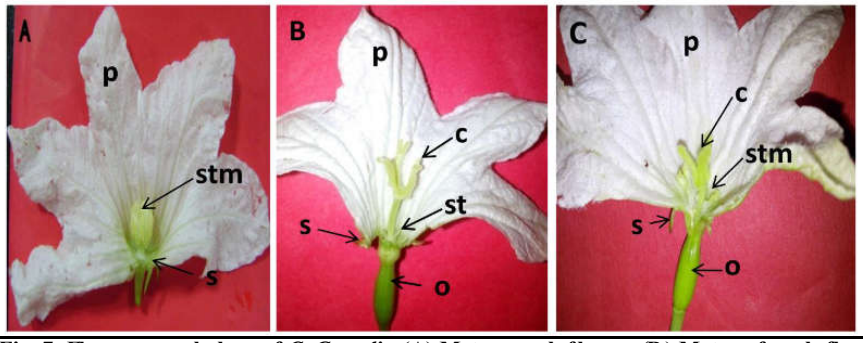



**Fig. 7: Flower morphology of *C. Grandis*. (A) Mature male flower, (B) Mature female flower, (C) Mature natural hermaphrodite flower. s- sepals, p- petals, stm-stamens, st- rudimentary stamens, c- carpels, o- ovary**

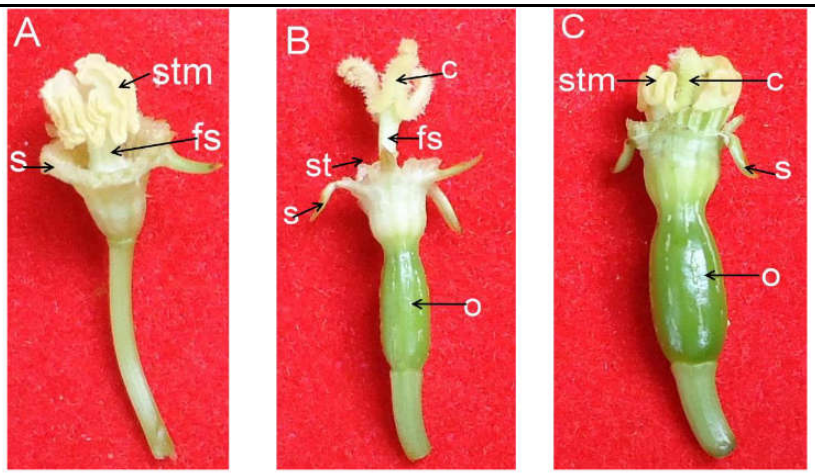



**Fig. 8. Lateral view of *C. Grandis* flowers with petals removed. (A) Mature male flower, (B) Mature female flower, (C) Mature hermaphrodite flower. stm-stamens, st- rudimentary Stamens, fs-floral stalk, c- carpels, o- ovary, s- sepals**

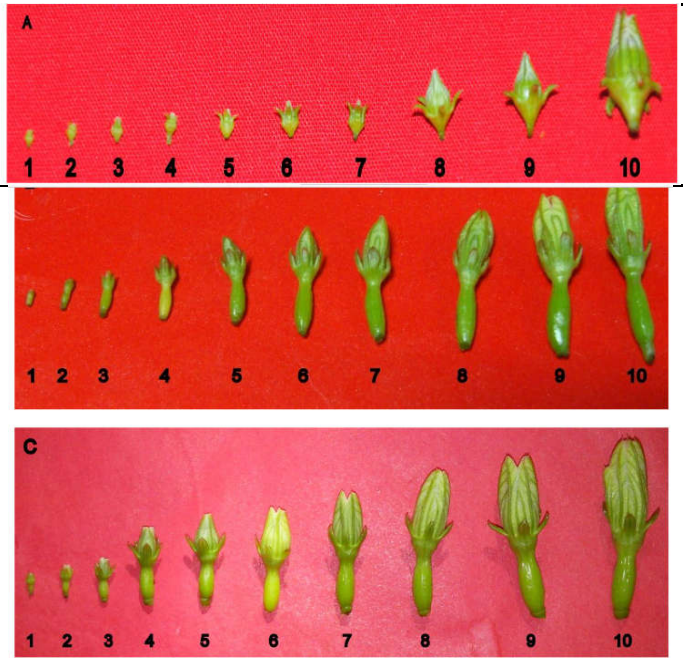



**Fig. 9. Different stages of floral development in *C. grandis*. Male, (B) female and (C) natural hermaphrodite flower buds are arranged from stage 1 to 10**

- They have developed a genetic markers which could be useful to identify sex at the vegetative stage of the plant through RAPD approach. Our results indicate that sex-related genomic differentiation exists among male, female and natural hermaphrodite.
- Y chromosome is seen to be morphologically distinct among the other male metaphasic chromosomes. But it is difficult to distinguish female from natural hermaphrodite on the basis of cytology because both consists of the same chromosome constitution (22A + XX)(Fig. 10).
- They have also observed that the sex expression in *C. grandis* can be altered by the application of silver nitrate ($AgNO_3$). Application of $AgNO_3$on female plants leads to the formation of hermaphrodite flowers instead of female flowers (Fig. 11).
- Sex modification in female flowers depends on the dosages as well as the frequency with which silvernitrate solution is applied.
- By morphological characterization of male, female, natural hermaphrodite and $AgNO_3$ treated flowers, we observed that unlike natural hermaphrodite, the flowers developed from plants treated with 5% $AgNO_3$, lacks carpel development in whorl 4. Instead, there is development of three convoluted stamens similar to male flowers. Higher dosage of $AgNO_3$ found to be lethal for the plants.
  - Comparative analysis of proteome profiles of male, female and $AgNO_3$ flower buds by two-dimensional gel electrophoresis suggests that there is differential expression of proteins in these three sexual states. Further investigations in this respect could unravel the effect of $AgNO_3$ on flower development in *C. Grandis*.

Sousa *et al*. (2016) compared the sequence composition of male and female *C. grandis* plants and determined the chromosomal distribution of repetitive and organellar DNA with probes developed from 21 types of repetitive DNA including 16 mobile elements. The size of the Y is largely due to an accumulation of certain repeats, such as members of the Ty1/copia and Ty3/gypsy super-families, an unclassified element, and a satellite, but also plastome- and chondriome-derived sequences.

An abundant tandem repeat with a unit size of 144 bp stains the centromeres of the X chromosome and the autosomes, but is absent from the Y centromere. Immunostaining with pericentromere-specific markers for anti-histone H3Ser10ph and H2AThr120ph revealed a Y-specific extension of these histone marks. That the Y-centromere has a make-up different from all remaining centromeres raises questions about its spindle attachment and suggests that centromeric or pericentromeric chromatin might be involved in the suppression of recombination. Devani *et al*, (2017) stated that *Coccinia grandis* (ivy gourd), is a dioecious member of Cucurbitaceae having heteromorphic sex chromosomes. Chromosome constitution of male and female plants of *C. grandis* is 22A + XY and 22A + XX respectively. Earlier we showed that a unique gynomonoecious form of *C. grandis* (22A + XX) also exists in nature bearing morphologically hermaphrodite flowers (GyM-H). Additionally, application of silver nitrate ($AgNO_3$) on female plants induces stamen development leading to the formation of morphologically hermaphrodite flowers (Ag-H) despite the absence of Y-chromosome. They found out that many genes involved in stamen initiation, tapetal development, and pollen maturation were down regulated in female buds compared to male buds. Interestingly, ethylene response-related genes were upregulated in female buds compared to male buds indicating a probable role of ethylene in stamen suppression similar to monoecious cucurbits such as melon and cucumber. They speculate that the Y-chromosome might express genes that inhibit ethylene signaling or suppress the carpel development, the site of ethylene production leading to the formation of stamens in male flowers. This was supported by the observation that $AgNO_3$ treatment suppressed ethylene responses and induced stamen development in female flowers of *C. grandis*. The ivy gourd is a diploid with 2n=24. Extensive studies on karyotype and chromosome biology have revealed a pair of heteromorphic chromosomes in the male plant.

There is a large chromosome in the male plant and two x chromosomes in the female plant. The male plant has 22 autosomes with a pair of XY chromosomes and the female plant with 22 autosomes and a pair of chromosomes (TNAU, 2021). Aside from research on the sex chromosomes, a few studies on the genome of *C. grandis* have been undertaken. Guha *et al*. (2004) report the 4C nuclear DNA content of female *C. grandis* as 8.37 ± 0.14 pg, whereas that of male *C. grandis* is 10.17 ± 0.24 pg. This means that the difference between X and Y chromosome adds about 20% to the complete DNA content.

**BREEDING**

This is a highly cross pollinating and asexually propagated crop. There is no significant plant breeding work carried out in this crop. Almost all the present day cultivars of ivy gourd have been developed by farmers as clonal selections, mainly from seedling progenies spontaneous mutations. However, studies have been made on pollen morphology and physiology in Ivy gourd. High-yielding clones have been developed by KAU Mannuthy, IIHR Bengalouru, UAS Dharwad, and IGKV Raipur (IIHR. 2022; Singh and Singh, 2014; Agri.Farming, 2019). Allahabad Agricultural Institute-Deemed University, Allahabad, U P, has also identified 6 high yielding genotypes, namely AAIIG 1, AAIIG 2, AAIIG 3, AAIIG 4, AAIIG 5 and AAIIG 6 (Hitesh Nag *et al*. 2012). The fruits of the different varieties vary in shape, size and stripe pattern. There are also few types in which plants with male flowers are absent and the fruits produced on the female plants are parthenocarpic. Some types having bitter fruit, not suitable for human consumption, are also found occasionally (TNAU, 2021). There are two major types of Ivy gourd viz., non-striped and striped Ivy gourd (Fig. 12) (Agri.Farming, 2019).

**The following varieties have been developed by a few Research Institutions:**

***Sulabha:*** This is an improved variety of ivy gourd with long fruits released by Kerala Agriculture University, Vellanikkara, Mannuthy. Fruits are 9.5 cm long and weigh about 18 g each at maturity. The fruit shape is cylindrical and fruit colour is pale green with continuous striations. This variety comes to flowering in 37 days after planting, and the first harvest can be taken in 45–50 days. It produces female flowers in the axils of leaves. The fruits are set parthenocarpically. It yields on an average 6 tonnes/ha/year (Agri.Farming, 2019).

***Arka Neelachal Sabuja:*** This high yielding variety of ivy gourd has been released by CHES, Bhuvaneshwar of Indian Institute of Horticultural Research (IHR), Bengaluru. The plants are very vigorous (>10 m long) and produce high biomass. Fruits are dark green in appearance with fractured stripe and conical in shape. It gives 70-80 harvest per season (10-11 months) and yield upto 20-25 t/ha (IIHR. 2022).

***Arka Neelachal Kunkhi:*** This high yielding variety of ivy gourd has been released by CHES, Bhuvaneshwar of IIHR, Bengaluru. A dual-purpose (salad as well as cooked) early variety with high yield (20-25 t/ha). Fruits are extra-long (8-9 cm), weighing around 15-20g, uniform, cylindrical with attractive stripes. It produces around 800 fruits in a season with yield potential of 15-20 t/ha (IIHR. 2022).

***DRC-1:*** This is a high yielding genotype identified by University of Agricultural Sciences (UAS), Dharwad. It gives a yield of 842 q/ha (29 kg/plant/year). It is perennial vine type cultivar. It spreads up to 2-3 meters on pendal system. Leaves are big narrowly serrated, with big fruits with white stripes on fruits. Fruits are ready for harvest after 50-60 days after planting and is susceptible to powdery mildew. Fruits are oval to cylindrical in shape. Average fruit length 5.7 cm, fruit diameter 2.06 cm, average fruit weight 20.13 gm and TSS was 3.8 (Dharmatti *et al*., 2008).

***Indira Kundru-5:*** This is a high yielding genotype released by Indira Gandhi Krishi Vishwa Vidyalaya (IGKVV), Raipur. It is cultivated commercially in Chhattisgarh (Agri.Farming, 2019).

***Indira Kundru-35:*** This is a high yielding genotype released by IGKVV, Raipur. It is cultivated commercially in Chhattisgarh (Agri.Farming, 2019).

***Kashi Bharpoor:*** It is a semi-perennial creeper and mostly termed as poor man's vegetable. It is a hardy crop and has a very high fruit-bearing capacity. At Indian Institute of Vegetable Research, Varanasi a promising genotype of ivy gourd (VRSIG-9) was identified for its release and commercial cultivation. Its fruits are oval-shaped, light green with white spots. It is propagated by rooted stem cuttings. It starts bearing fruits 45-50 days after planting. It is grown in Uttar Pradesh, Madhya Pradesh, Bihar, Chattishgargh, Jarkhand and Odisha (Singh and Singh, 2014) (Fig. 13).

sweet fruits. It is suitable for culinary purpose and salad. It is a clonal selection from Annaikatti type (Pugalendhi *et al*., 2012).

Allahabad Agricultural Institute-Deemed University, Allahabad, U P, has also identified 6 high yielding genotypes, namely AAIIG 1, AAIIG 2, AAIIG 3, AAIIG 4, AAIIG 5 and AAIIG 6 (Hitesh Nag *et al*. 2012).

## CULINARY USES

A variety of recipes from all over the world list rashmato, the fuit, as the main ingredient.

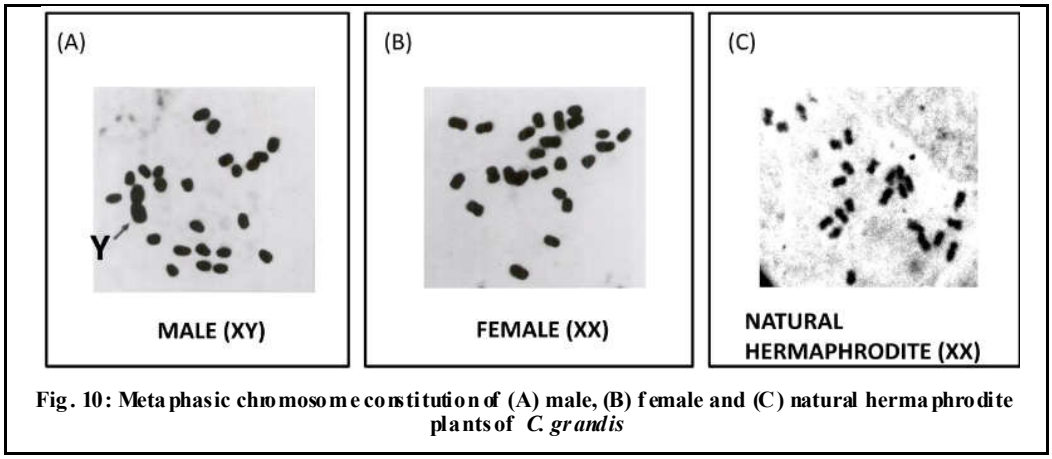



**Fig. 10: Metaphasic chromosome constitution of (A) male, (B) female and (C) natural hermaphrodite plants of *C. grandis***

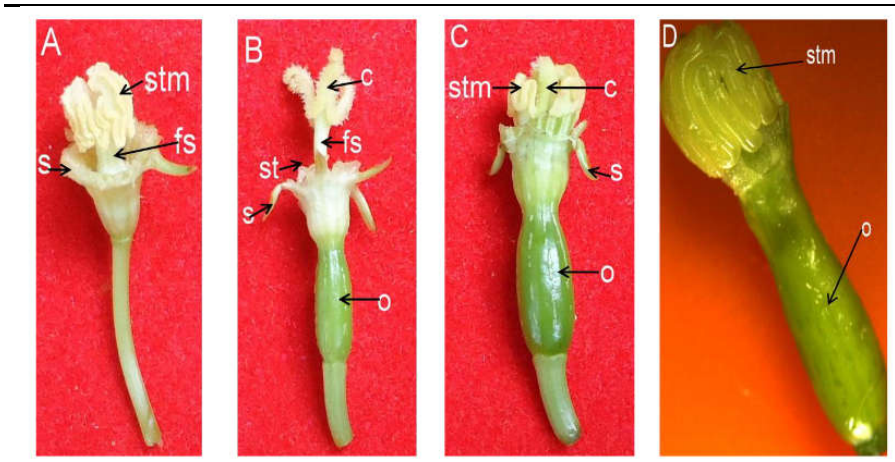



**Fig. 11: Morphological differences in male, female, natural hermaphrodite and $AgNO_3$ treated C.grandis flower buds (A) Mature male flower, (B) Mature female flower, (C) Mature natural hermaphrodite flower and (D) $AgNO_3$ treated Mature flower. s-sepals; p- petals; stm - stamens; st-rudimentary stamens; fs - floral stalk; c - carpels and o - ovaryd**

| Fig. 12: Nonstriped fruits | Striped fruits |
|---|---|

Thai cuisine, it is one of the ingredients of the kaeng khae curry. Cultivation of Rashmati in home gardens has been encouraged in Thailand due to it being a good source of several micronutrients, including vitamins A and C (TERI, 2021). In India, it is eaten as a curry, by deep-frying it along with spices, stuffing it with masala and sauteing it, or boiling it first in a pressure cooker and then frying it. It is also used in *sambar,* a vegetable and lentil-based soup. Ivy gourd is rich in beta- carotene (Namita, 2015).

**Edible uses of Ivygourd are asfollows (Namita, 2015):**

- Leaves and fruits of the plant are consumed as veggies. There are numerous of edible purposes of this plant.
- In Thailand, it really is consumed in boiled as well as fried form.
- Curries and soups are prepared utilizing the green ivy gourds. It is extremely well-known in India and Africa.
- Ripe gourds may also be consumed without cooking in several cultures.
- Its leaves are frequently utilized in preparing a type of herbal tea right after drying it.
- The unripe fruits can be created into pickles.
- Indian cuisine is rich also it utilizes Ivy Gourds in many dishes where it is stuffed with spices just before deep frying them.
- Indonesian cooking includes cooking these types of fruits in coconut milk.

The fruit of Ivy gourd has been used in many cuisines, however it is the leaf that did not get the attention it deserved. Leaves are used for preparing a green curry, that is tasty, highly nutritious and coincidentally helps diabetics too. Whilst very tender fruits can be eaten raw, the green fruit is usually cooked and made into a vegetable (Das, 2020) (Fig. 14). Long lean stem tops and young leaves have been cooked and consumed as potherb and added to soups. Green fruits have been used either as salads or cooked and mixed to curries. (Chamroeun Keo. 2021). The immature fruits are cooked and used in *sambar* or fried. The tender shoots are also eaten (TNAU, 2021).

**Ivygourd is consumed in various ways as given below (HBT, 2021)**

- **Soup:** Young Fruits, terminal leafy shoots and leaves are consumed fried, blanched, fried or even boiled with Soups, noodles and rice.
- **Koloban:** Leaves and terminal shoots are used in Koloban for rice table as well as in Sayur and Sambelan in Indonesia.
- **Stir-fries:** Young leafy terminal tips are blanched for dipping in chilli paste or used in stir-fries.
- **Ivy gourd and minced pork soup:** It can be mixed with soup dishes like ivy gourd and minced pork soup, porcine blood curd soup, or mixed vegetable soup and noodles.
- **Porridge:** For young children, young leaves are boiled and mashed and is included in Porridge.
- **Curries:** Young Fruits are fermented and used in Soups and curries with rice and fries in Thailand.
- **Pickled:** Young green fruit are pickled and also can be consumed by dipping in chili paste.
- **Comfited:** Ripe fuit can be consumed raw or comfited.
- **Curry:** It can be consumed as a curry, by deep-frying it; stuffing it with masala and sautéing it.
- **Sambaar:** It may also be used in sambaar, a vegetable- and lentil based soup.
- **Stew:** Red fuit are eaten raw, or they are peeled and cut into pieces and prepared as a stew with onions and tomatoes and other vegetables in East Africa.
- **Soups and curries:** In Ethiopia and India Immature green fruits are prepared in soups and curries.
- **Vegetable:** Leaves are also eaten as a vegetable by Mursi tribe in Ethiopia.
- The seeds are chewed in Kenya and Ethiopia.

**NUTRITIONAL VAILUE**

Apart from their delightful taste Ivy gourd is a good source of nutrients, vitamins and mineral. Consuming 100 gram of ivy gourd supplies, 1.4mg of Iron, 0/08mg of Vitamin B2 (Riboflavin), 0.07 mg of Vitamin B1 (Thiamine), 1.6g of Total dietary fiber and 40 mg of Calcium (TERI, 2021). 100 gm of Ivy gourd fruit has Ascorbic acid 1.4 mg; Ca 40 mg; Carbohydrate 3.1 g; Energy 75 kJ (18kcal); Fat 0.1 g; Fe 1.4 mg; Fiber 1.6 g; Niacin 0.7 mg; P 30 mg; Protein 1.2 g; Riboflavin 0.08 mg; Thiamin 0.07 mg; Water 93.5 g (Namita, 2015; Indiamart, 2021; HBT, 2021; Chamroeun Keo, 2021).

**MEDICINAL USES**

**Namita (2015) reported the following medicinal uses:**

- The leaves are very effective for treating diabetes as well as keeping the sugars under control.
- It is a superb treatment for a multitude of skin ailment just like leprosy, psoriasis as well as scabies.
- They happen to be utilized for dealing with tongue sores, diarrhea and jaundice. Flowers are generally beneficial in healing jaundice.
- Roots of the plant have already been utilized in Chinese medicine since they have numerous therapeutic qualities.
- A tonic made from the leaves is really a noted Thai medicine for the treatment of patients.
- Their essence have been combined in a variety of therapeutic preparations that are offered as capsules as well as tinctures.
- Some other conditions just like respiratory mucosae as well as bronchial inflammations may also be cured along with it.
- Leaves, fuits as well as stems possess the capacity to support hypertension.

**According to Agri.Farming (2019) some of the health benefits of Ivygourd asfollows:**

- Ivy gourd contains laxative properties.
- Ivy gourd may normalize blood sugar levels.
- Ivy gourd is also used in ayurvedic practices in India.
- Ivy gourd is a good source of vitamin C.
- Ivy gourd possesses detoxification and anti-bacterial properties.
- Ivy gourd possesses curative properties for asthma, jaundice, bronchits, and skin problems like leprosy, scabies, and psoriasis.
- Ivy gourd juice may be helpful in keeping healthy skin.

Das (2020 reported that Ivy goud is anti-diabetic, antimicrobial, helps heal wounds, relieves pain (analgesic), decreases fever (antipyretic), protects liver (hepatoprotective), antidyslipidemic, healing cataracts, anticancer, and also highly nutritious. An excellent remedy for those suffering from high sugar: Take 2-3 tablespoons (30-45ml) of freshly expressed juice of tender *Coccinia grandis* leaves three times daily for 21 days. The leaves are also used for dressing up wounds. A paste of these leaves can be used along with the leaves of basil and *Vinca rosea*. Juice expressed from the stem is used to treat cataracts. According to TNAU (2021) leaves, stems and roots have medicinal uses in ayurvedic and native systems for treatment of skin diseases, bronchitis and diabetes and also for lowering blood sugar levels. Indiamart (2021) reported that Ivy gourd helps to lower blood sugar level, prevents obesity, eliminates long-lasting fatigue, protects the nervous system and provides more energy and a healthy metabolism. Fiber keeps the digestive tract healthy. It also prevents kidney stones.

**According to TERI (2021) following are the medicinal uses of Ivy goud:** The leaves are highly effective in treating diabetes and keeping the sugars in check. It is an excellent cure for an array of skin infections like leprosy, psoriasis and scabies. They have also been used for treating tongue sores, diarrhea and jaundice. Flowers are mainly useful in healing jaundice. Roots of this plant have been used in Chinese medicine as they have a number of medicinal properties.

Fig. 13: Kashi Bharpoor

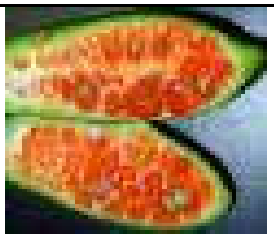
Fig. 14: Ivy gourd greens/tendershoots

Fig. 15: Ivy gourd plants on pandal/bower

Fig. 16: Pruning of Ivy gourd plant

Immature fruits with tender seeds

Slightly mature fruits with tender seeds



Ripe fruit with mature seeds

Fig. 17: Immature fruits and Ripe fruits

A tonic made out of the leaves is a noted Thai medicine for treating patients. Their essence has been blended into a number of medicinal formulations that are available as tablets and tinctures. Some other ailments like respiratory mucosae and bronchial inflammations can also be healed by it. Leaves, fruits and stems have the power to stabilize high blood pressure. According to IIHR (2022) Ivy gourd showed many health benefits where it has an excellent property which normalizes the blood sugar levels; hence it is used for diabetes patients. It is rich in vitamin C, contains laxative properties, its juice helps to maintain the skin in a healthy condition. It has many properties that act the best medicine asthma, jaundice, bronchitis, leprosy, psoriasis, rabies, etc. It is rich in potassium. It reduces fat by increasing metabolism.

**TRADITIONAL USES**

Ivy gourd is used in traditional Indian medicine in India for various diseases, and seems to have a general antibacterial effect (Holstein, 2015). The following traditional uses of Ivy gourd are also reported (HBT, 2021; Chamroeun Keo. 2021):

- From ancient times ivy gourd is used as anti-inflammatory, anticonvulsant, wound healing, bronchial inflammation, antiulcer, coughs, purgative, respiratory mucosae, antiemetic, astringent poultice and treatment of diabetes mellitus, gout and skin diseases, asthma and antipyretic.
- To reduce high blood pressure and to treat abscesses, fruits, stems and leaves are used.

Leaves when mixed with gingelly oil (sesame oil) is used to treat ring worm, psoriasis and itch, when mixed with ghee to cure sore, skin diseases, cutaneous eruptions of small pox.

- Leaves are used for treating bronchitis, burns, skin eruptions, syphilis and gonorrhea, jaundice and rheumatism.
- Juice of the leaves, stem and roots serve as a cure for intermittent glycosuria, diabetes, sore-tongues, intermittent glycosuria, enlarged glands earaches, and skin diseases like pityriasis and also treats urinary tract infection, other related troubles.
- Dried root bark has cathartic properties.
- To alleviate pain in joints, skin lesions, apthous ulcers and diabetes, root tubers are used.
- Green fruit are chewed to cure sores on tongue and the dried fruit are used to remove eczema.
- Coccinia powder is used for treating liver weakness, vomiting and worm infestation, gastro – intestinal disturbances, purifies blood, dysentery, curbs infection in the body, effective against long-lasting cough and cold and provides good results for bronchitis and asthma.
- Stem infusion is given for vertigo, the roots used for high fever, the leaves for skin complaints in Moluccas.
- Roots are used to treat intestinal ailments in Niger.
- Fresh or dried roots are crushed, boiled and used for stabbing pain and kidney infections in Ethiopia.
- Fresh cotton wad dab in a boiled preparation of crushed, fresh or dried leaves is used to treat snake poison in the eyes in Somalia.

## PRODUCTION TECHNOLOGY

**Production States:** In India, Ivy gourd is widely grown in southern, eastern and western regions, mainly in states like Karnataka, Tamil Nadu, Kerala, Maharashtra, Andhra Pradesh, Gujarat, Telangana, Orissa, and West Bengal (Agri Farming, 2019).

**Climate Required:** This vegetable crop thrives best in humid and warm climatic conditions. The ideal temperature range of 20°C to 32°C is best for its growth, quality and good yield. This vegetable can be cultivated throughout the year. However, peak seasons of fruiting are the rainy season and summer (IIHR. 2022; Mini. 2022). It grows in full as well as partial sunlight (TERI, 2021). The ivy gourd grows best in warm and humid climate. The optimum temperature requirement is 20 - 30 degree celsius. In southern region, it continues to produce fruits almost throughout the year but the peak seasons of fruiting are summer and rainy seasons. In the northern plains the plants remain dormant during winter and produce fruits only once in a year (TNAU, 2021).

**Soil Requirement:** Well-drained rich sandy loam soils are best for its cultivation.
Heavy clay soils, acidic and alkaline soils should be avoided. The soil pH of 6.0-6.5 results in the best yield and quality of the vegetable (IIHR. 2022). Soil rich in humus is best for growing Ivy Gourd but it may also grow in other types of soil. It is better grown in well drained soils (TERI, 2021). The most suitable soil for growing ivy gourd is well drained sandy loam. Heavy clay is to be avoided. The best soil pH is 6.5. The crop does not grow well in acidic and alkaline soils (TNAU, 2021).

**Land Preparation:** Plough the land/soil until fine tilth is achieved and to kill any weeds. Apply any well-rotted manure along with micronutrients (IIHR, 2022; Mini, 2022).

**Planting Material:** It is propagated through vegetative means by stem cuttings. 12–15 cm long stem cuttings of pencil thickness with 5–6 leaves are taken. The male and female flowers are borne on separate plants (dioecious). Both male and female plants, therefore should be planted to ensure proper fruit set. Cuttings are taken mostly from female plants. For proper fruit setting, there should be one male plant per 10–12 female plants. Usually cuttings from mature vines are taken in October, when fruiting is almost over, to ensure the sex and variety to be planted. The stem cuttings are made about 60–90 cm long from one year old fruiting vines of both male and female plants. In order to ensure maximum fruit set, 10–12% male plants is considered adequate. As it is a dioecious crop, for good fruit set normally 10% male plants should be accommodated (Prem Nath and Swamy, 2016).

**Propagation and Planting:** Normally this crop is propagated vegetatively through stem cuttings (in some areas by seeds, but it takes more than a year to establish a plant if they are propagated through seeds). The stem cuttings should be semi-hardwood and about 20 cm long with thickness about 2cm. The stem cuttings should have at least 4 to 6 leaves. 2 or 3 cuttings should be planted about 6 cm deep with basin diameter of 60 cm. The distance between the basins should be about 2 meters (TNAU, 2021; IIHR. 2022; Mini. 2022). Stem cuttings can also be planted in polybags and planted in the field when the shoots have come. The planting is done in June-July or February-March. The plant population in a field should have female and male plants in a ratio of 10: 1. The plants are perennial, replanting is advocated after every 4-5 years. The vines are trailed on bowers or bamboo pandals of 1.25-1.50 m Height (Fig. 15). The dimensions vary according to the requirement (TNAU, 2021). The planting should be done before the rainy season/monsoon starts (June to July) or in the spring season (Feb to Mar) (Mini. 2022). As it is a dioecious crop, for good fruit set normally 10% male plants should be accommodated. The proportion of male to female plants must be checked at flowering time because it is easy to identify male flower (thin base) and female flower (swollen base). Excess male plants should be thinned out. It is observed that ivy gourd produces fruits by vegetative parthenocarpy in the absence of male plants. It is cross pollinated by insects (Bharathi, 2007). The Planting should be done before rainy season/monsoon starts (June to July) or in the spring season (Feb to Mar). The ratio of female and male plant population in a field should be 10:1. As the ivy gourd plants are perennial, replanting is recommended after every 4 years. The plant vines should be supported by 2-meter bamboo sticks. Sometimes due to inadequate pollination, the healthy flowers might suddenly droop, so maintain the correct proportion of male: female ratio, for better production. This might also be due to environmental factors, lack of soil fertility, and irrigation. Hence maintain the soil fertile rich with manures-fully decomposed manure, etc (IIHR. 2022). Ivy Gourds can also be grown from seeds. Growing them from seeds is a long tedious process because maturation of seeds takes place late. Sow the seeds in March placing 2 - 3 seeds in hill. The seed usually germinates within 2 - 4 weeks at 20°C. Thin to the best seedling in a hill (TERI, 2021).

**Manures and Fertilizers:** About 20-25 tonnes of FYM are applied at the time of basin preparation and planting. The fertilizer requirements are 60-80 kg N, 40-60 kg P and 40 kg K per hectare. Both manures and fertilizers are applied every year before fruiting starts (TNAU, 2021; IIHR. 2022).

**Pruning of Ivy Gourd Vines:** Ivy gourd overgrows and can turn invasive if left unchecked. So, it's important that you prune off the stems that are growing out of limit. Make sure that the pruning shear is sharp and well-oiled. After pruning dispose of the fallen stems, or they might root. Once the plant has stopped producing after the fruiting season, you can prune it off, leaving only 2-3 feet of thick bottom stem left. The fresh growth will start from it again (Balconygarden, 2022). The Ivy gourd plants start fruiting in about 3 months after planting. Once fruiting is completed, the vines of about 8-10 mm thick should be pruned leaving about 70 cm long vines. Plants are pruned twice in a year, in September and April. For each plant, about 5 kg of FMY should be applied after pruning (TNAU, 2021; IIHR. 2022; Mini. 2022). When the vines start to look a bit weak and there is a change in colour of the leaves to yellow, pruning is to be done (Fig. 16). Most important in cultivation of Ivy gourd is the timing of pruning the vines. Repeated prunings are recommended as the newly developing vines produce more flowers and yield more. Pruning the vines must be done every 3- 4 months to maximize yield (Prem Nath and Swamy, 2016).

**Irrigation:** The plants require light irrigation at 10-12 days interval during summer. Watering may not be necessary in rainy season. The soil should have adequate moisture during flowering and water logging is harmful to the plants (TNAU, 2021). During its growing stage, it requires sufficient water for steady growth (TERI, 2021). Irrigate the plants immediately after the plantation is done. During the hot summer season, these plants require light irrigation at a 1-week interval. Irrigation may not be required in the rainy season. Using drip irrigation will be beneficial to maintain adequate moisture during the flowering stage. As these plants are sensitive to water stagnation, make sure the soil to have well drainage to avoid water logging in the field (Mini. 2022; IIHR. 2022). It is recommended to irrigate the crop at the time of plucking the fruit. Mornings and evenings when the sun is not harsh is a good time to irrigate the crop. Irrigating once in two days when soil temperature is high is recommended ((Prem Nath and Swamy, 2016). Drip irrigation can also be practiced wherever it is available.

**Weed Control:** In Ivy gourd farming, weeding and light hoeing should be done during the early phase of plant vine growth. (TNAU, 2021; Mini. 2022; IIHR. 2022)

**Pests and Diseases:** Aphids, Whiteflies, Mites and Thrips are the main pests found in Ivy gourd cultivation. Appropriate chemical control measures should be taken for these pests. In the latest improved variety "Sulabha" no major pests and diseases are known (IIHR. 2022).

**Harvesting:** Hand-harvesting of Ivy gourd normally does not kill the plant, but rather breaks the vine blankets into smaller pieces and the

plant is able to re-establish when it touches the ground. These methods can make the infestation of insect pests worse and further the need for more rigorous control methods (Namita, 2015). Ivy gourd will be ready for harvesting in 3 months period. Hand-picking or sickle is used to harvest the vegetable. Handpicking may damage the vine, so better use a small cutter to harvest the Ivy gourd vegetable (IIHR. 2022). Ivy gourd bears fruits almost throughout the year where mild winter prevails. In regions where severe winter occurs, it bears fruits for 8–9 months. Fruiting starts during March to June. Second flush starts with the rains and fruiting continues till October. The economic life of Ivy gourd is 3–4 years. Fruits of Ivy gourd, like other gourds, are harvested at the immature stage while still tender with immature seeds **(Fig. 17)**. The fruits should be harvested twice a week ((Prem Nath and Swamy, 2016).

**Yield :** The plants start fruiting in 10-12 weeks after planting (TNAU, 2021). The flowering starts after 50-60 days of planting. The average yield is about 10-15 tonnes per hectare (TNAU, 2021). The Ivy gourd/tindora plant start flowering after 3 months of planting. The average yield of 12 to 15 tonnes per hectare can be obtained with good farm management practices. This vegetable has good demand in local markets and this plant gives good yield within a short period of time with minimal investment (IIHR. 2022). The immature fruits after harvesting can be stored at room temperature for about a week (TNAU, 2021).

**Cost of Production and Profit:**

Costs involeved and the profit in 1 acre Ivy gourd/Coccinia farming are given below (IIHR. 2022):
Land preparation costs: Rs. 5000
Costs of seeds or Stem cuttings: Rs. 1500
Fertilizers cost: Rs. 2000
Pesticides cost: Rs. 1000
Labor cost: (Rs. 500-10 no.): Rs. 5000
Miscellaneous cost: Rs. 3000
Marketing costs: Rs. 2000
10% of total costs: Rs. 1925
Total cost of 1 acre *Coccinia* farming: Rs. 19250
Income returns in Coccinia cultivation: Coccinia are sold at he rate of Rs. 10/kg at the nearest vegetable market. Therefore, income for 10 tonnes is 10000kg * Rs. 10=Rs. 1,00,000

**Profit= income – total cost = Rs. 1,00,000 – Rs. 19250 = Rs. 80,750**

Therefore, on an average, a farmer can earn up to Rs. 80,750 from 1 acre Ivy gourd/coccinia farming only if he takes proper care and management. The price may also vary that depends on the coccinia price/kg fluctuations in the market. As, their roots, leaves, and stems are having medicinal values, their income can also be addes advantage to the farmer.

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