

Current Trends in the Emerging Fields of Botanical Research

(Edited Volume 1)



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Title of the Book: Current Trends in the Emerging Fields of Botanical Research

First Volume – August 2023

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ISBN: 978-93-5747-657-7

MRP Rs. 350/-

Publisher, Printed at & Distribution by:

Selfypage Developers Pvt Ltd.,
Pushpagiri Complex,
Beside SBI Housing Board,
K.M. Road Chikkamagaluru, Karnataka.
Tel.: +91-8861518868
E-mail: publish@iiponline.org

IMPRINT: I I P Iterative International Publishers

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Chapter

8

Lasoda (*Cordia myxa* L.)

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Abstract

Lasoda is an underutilized, multipurpose, climate-smart, and deciduous tree of medium size. It has worldwide distribution. Besides high nutraceutical potential it has medicinal potential (anti-diabetic, anti-inflammatory, antiparasitic, antimicrobial, insecticidal, cardiovascular, respiratory, and gastrointestinal) for the treatment of a variety of diseases. This chapter deals with detailed information on various aspects such as botanical description, origin & distribution, uses & importance, species & varieties, nutritional potential, medicinal aspects, production technology, genetic resources, crop improvement methods, and future thrust of Lasoda.

Keywords: Crop improvement, disease, lasoda, medicinal, nutraceutical, pest, underutilized, pollinators

I. Introduction

Indian Cherry, also known as Lasoda, Lehsua, or Gonda (*Cordia myxa* L., also known as *C. oblique* Willd), is a member of the Boraginaceae family and can be found growing everywhere in India except for high hills. It is a medium-sized, drought-tolerant deciduous fruit tree that may grow up to 1500 m in height and is widely distributed in arid and semi-arid parts of North India.

It is appropriate for planting in backyards, roadsides, wastelands, non-cultivable areas, and also in bunds of the farm (Singh *et al.*, 2019; Hanelt & IPK 2001; Samadia 2005) beside these it can also be grown in a different crop-based agroforestry system, home gardens, sole orchard and also a shelter belts. Owing to its deep tap root systems, sunken and covered stomata, and leaf shedding (during summer), waxy and leathery leaves (Chandra & Pareek, 1992) make it an ideal crop plant for wasteland, arid and semi-arid regions. It is known by several names which vary according to the languages of the region (Table 8.1)

In the world, it is found in Australia, Bangladesh, Egypt, India, Pakistan, Nepal, Myanmar, Taiwan, Thailand, Malaysia, China, Polynesia, and Sri Lanka. In India, it is mainly found in different states like Andhra Pradesh, Gujarat, Himachal Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu, and Uttar Pradesh. Being a multipurpose tree, its all plant parts are being used for various purposes such as food, medicine, and others. The lasoda has several medicinal properties such as analgesic, anti-inflammatory, antidote, astringent, anthelmintic, antiulcer, anticatarrhal, aperient, diuretic, demulcent, emollient, expectorant, and laxative. Despite the crop having several medicinal and other uses, the full potential of the crop has not been utilized. Therefore, seeing the present climate change scenario, it can be a wonder crop for the future in arid and semi-arid regions.

Table 8.1: List of names of lasoda in different languages.

Language	Common name	Language	Common name
Arabic	Dabk, Dilk	Assam	Dilk
Bengali	Bohari, buhul, boho-dari, bahubara, Bahnaree, Bahuvar	Gujarati	Vadagunda
English	Anonang, Bird lime tree, Sebesten Plum, Glue berry, Pink Pearl tree, Fragrant manjack, Indian Cherry, Snotty gobbles	Java	Kendal
Hindi	Bhairala, Bhokar, Dela, Gondi, Gundi, Lessora, Rasalla Guslasah, Lasora, Lasura,	Lepcha	Ninut
Kannada	Chikkachalli, Doduchallu	Malayalam	Naruviri, Naruviri
Marathi	Bhonkar, Bhokar	Nepali	kalo bohor, bohor
Malay	Petekat, Sekendai	Philippines	Anonang
Myanmar	Thanet	Sinhalese	Lolu, Lotu
Persian	Sugpistan, Sebestan, Sapistan	Sino-Tibetan	Lao
Punjabi	Lasuda	Tehran	Sepistan
Sanskrit	Bahuvaraka, Bhuselu, Bhukampadaruka, Bhukarbudara, Laghupichhila, Bhutadruma, Kshudrashleshmataka, Laghushelu, Laghushita, Madhubhutadruma, Sukshmaphala, Laghushleshmataka,	Telugu	Nakkera

Tamil	Naruvili, Selu, Sirunaruvili, Vallagu, Vidi, Viri, Virisu, Viriyan, Vidi Maram	Tulu	Challangayi
Thai	Mandong, manma, phakmong	Unani	Sapistan

Source: <https://www.easyayurveda.com/2016/12/21/lasoda-cordia-dichotoma-shleshmataka/>, <https://www.bimbima.com/herbs/lasora-cordia-dichotoma-medicinal-used-and-health-benefits/11/>

II. Taxonomic Classification

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order: Boraginales

Family: Boraginaceae

Genus: *Cordia*

Species: *Cordia myxa*

III. Botanical Description

Tree: It is a deciduous perennial shrub or small tree that can grow up to 12 m tall. It has a bole that might be straight or twisted with a grey, broken bark. The crown is dense, and the limbs are crooked. Branchlets have hair when they are young; as the age proceeds, they lose their hair and become glabrous.

Leaves: The leaf of lasoda is simple, petiolate, and alternate (0.5–5 cm), with 3–15 cm in length and 3–20 cm in width.

Flower: The inflorescence is a loose panicle, 3–8 cm long, with many flowers. Flowers are unisexual, white to creamy in hue, and with somewhat variable shapes (campanulate or tubular campanulate for calyx), the flowers are also unisexual. Clusters of drupes make up the fruits. They have a globular-ovoid shape, measure 2–4 cm in diameter, and are either yellow, apricot, or (when fully developed) blackish. They have a tasty, mucilaginous pulp that is almost transparent. The pit (pyrene) is described as broadly ellipsoid to globose, 12 mm long, strongly wrinkled, and containing 1–2 seeds (Meghwal *et al.*, 2014 and Oudhia, 2007).

Fruits: Lasoda fruit is of drupe type and starts appearing from July to August. Fruit colour ranges from light to dark, even pink, it usually becomes darker on

ripening. The pulp is fairly translucent because it contains viscid glue similar to mucilage.

IV. Origin, Distribution and Diversity

Lasoda is native to India and its natural habitat has an origin along the Himalayan range up to 1,500 meters, whereas its distribution and diversity can be found in different parts of the world i.e. Australia, Bangladesh, Egypt, India, Pakistan, Nepal, Myanmar, Taiwan, Thailand, Malaysia, China, Polynesia, and to Sri Lanka. In India, it is mainly found in different states like Andhra Pradesh, Gujarat, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Madhya Pradesh, Punjab, Rajasthan, Odisha, Tamil Nadu, and Uttar Pradesh (Table 8.2)

Table 8.2: Distributions of Lasoda tree in different parts of India.

Sl. No.	States	Districts/ cities
1.	Andhra Pradesh	Anantapur, Chittoor, Kurnool, Kadapa, East Godavari, Srikakulam, Vishakapatnam
2.	Gujarat	Kachchh, Porbandar
3.	Himachal Pradesh	Kangra, Bilaspur, Hamirpur, Mandi, Solan (Dharampur), Una, Sirmaur, Shimla (Rampur and Jeori)
4.	Haryana	Rewari (Bawal), Mahendergarh, and Bhiwani
5.	Karnataka	Raichur, Bellary, Gulbarga, Koppal, Bijapur, Kolar
6.	Kerala	Kannur, Kottayam, Kasaragod, Malappuram, Thrissur, Kozhikode, Idukki, Kollam, Alappuzha, Wayanad, Palakkad,
7.	Maharashtra	Akola, Nanded
8.	Madhya Pradesh	Dhuliya, Jabalpur
9.	Odisha	Mayurbhanj, Puri, Sambalpur, Gajapati
10.	Rajasthan	Ajmer, Alwar, Bikaner, Behror-kotputali, Bhilwara, Pali, Jodhpur, Barmer, Jalore, Jaipur, and Nagaur
11.	Tamil Nadu	Coimbatore, Salem, Dharmapuri, Tiruvannamalai
12.	Uttar Pradesh	Jhansi, Lalitpur

V. Uses and Importance

Lasoda being a multipurpose and climate-resilient crop has diverse uses and importance for not only human beings but also for nature. Its fruits can be consumed in several ways such as raw, dried, or pickled. The fruit contains several essential antioxidants, proteins, nutrients, vitamins, minerals, fibers, and another bioactive compound which is having high medicinal value. The different uses of its plant parts are described in Table 8.3.

Table 8.3: Uses of different plant parts of Lasoda tree.

Sl. No.	Plant Parts	Category	Uses
1	Leaves	Nutritional Value	Crude protein: 12%-15%, crude fibers: 16%-27%, nitrogen free extract :42%-53%, ether extract: 2%-3%, total ash: 13%- 17%, total calcium: 2%-4%, phosphorus: 0.3%
		Medicinal uses	Useful as an application to wounds, ulcers, and in headache, decoction of leaves is used in cough, liver damage and cold.
		Traditional uses	The leaves are good sources of fodder.
2	Seed	Chemical compounds	Arachidic acid, amyriins, behenic acid, betulin, oleic acid, linoleic acid, palmitic acid, hentricontanol, hentricontane, hesperitin-7-rhamnoside, lupeol-3-rhamnoside, octacosanol, sitosterol, stearic acid, sitostero-13-glucoside, taxifolin-3,5-dirhamnoside
		Nutritional Value	Moisture: 32 g/100 g, fatty oils: 46%, Proteins: 31%
		Medicinal uses	Anti- Inflammatory
		Traditional uses	Highly effective in treating itching, scabies, and ringworm.
3	Fruits	Nutritional Value	Protein: 1.8-35g, fat: 1.0-37g, carbohydrate: 12.2-57.08g, oxalic acid: 25 mg, potassium: 1.66g, pectin: 4.5%, fibre: 0.3 g, calcium: 40-55 mg, phosphorus:60-275 mg, iron: 0.5-0.6 mg, zinc: 0.02-2.0 mg, copper: 0.16-1.0 mg, manganese: 0.2-2.0 mg, chromium:

			0.02-0.2 mg, crude protein: 8.32g, lipid: 2.2g, crude fibre: 25.7g, ascorbic acid: 40 mg, moisture: 82.5 %, ash: 2.13 %, TSS: 10.2 %
		Medicinal uses	Used in traditional medicine for cicatrizant, astringent, anti-inflammatory, anthelmintic, anti-diabetic antimalarial, anti-ulcer, cholera, diuretic, dropsy, dysentery, dyspepsia, demulcent, febrifuge, appetite suppressant, cough suppressant, expectorant, headaches urinary infections, lung diseases, leprosy, chest and urinary infections and reducing the negative effects of inflamed plasma, liver, and colon.
		Traditional uses	Immature berries are used as a vegetable and to make pickles after removing the stone and sticky white pulp. The sticky pulp is used to make glue. The immature fruits laden shoots are used as vegetable fodder.
4	Bark	Medicinal Uses	It is used to treat dyspepsia and fevers, bark powder extremely used in the treatment of skin disease and broken bones, bark juice used in treatment of colic. Bark paste is used for treatment on spider bites and eruptive boils.
		Chemical /bioactive	The bark contains, tannin, Cathartin, Gallic acid, and β -sitosterol. D-glucose, D-xylose, L-rhamnose, D-glucuronic acid, D-arbinose, lactose, and L-fructose among sugars, and glycine, leucine, glutamic acid, cystine, alanine, threonine, aspartic acid, and proline are also present in plant.
		Traditional Uses	Generally used for making ornamental furniture, house posts, beams, plank scantlings, planks, dugout canoes, boats, tea boxes, cart shafts, axles, yokes, well-curbs, agricultural implements, combs, gun stocks, naves, spokes, etc. It is also used for making quality toys, bowls, and wooden utensils.

Sources: Tripathi, (2020); Jamkhande *et al.*, (2013); Al-snafi (2016); Meghwal *et al.*, (2015); Bhatnagar *et al.*, (2016)

VI. Species and Variety

Species

There is over 250 species in the genus *Cordia*, most of which are found in the World. The other *Cordia* species are *Cordia gharaf* (also known as *Cordia rothii*), *Cordia macleodi*, and *Cordia sebestin* L. There are two types of gonda: those with small fruit and those with enormous fruit. The size of the fruits and leaves is where these two plants most significantly diverge. The average weight of large fruited varieties is 8.25 g, whereas little fruited varieties weigh just 3g. Some *Cordia* species include *C. francisci*, *C. martinicensis*, *C. myxa*, *C. serratifolia*, and *C. ulmifolia*, among others. Some species are following:

Table 8.4: List of different *Cordia* species, botanical description and their uses

Sl. No.	Species Name	Botanical Description	Uses
1	<i>Cordia boissieri</i>	It grows to a height of 5-7 m and has a symmetrical, spherical crown that is 3-5 m in circumference. The ovate leaves are 5 to 9 cm wide and 9 to 18 cm long. Despite being evergreen, it will lose leaves if there is frost damage. The tree produces 3-5 cm long white funnel-shaped flowers all year long. The drupes are yellow-green or olive-like in colour and range in length from 1.2 to 2.4 cm. Fresh fruit is delectable but has a little amount of poison that makes both humans and other animals queasy.	• Fruits are used to make jams and jellies • Rheumatism and lung disease are also treated with the leaves. • The wood is employed in construction and as fuel.
2	<i>Cordia curassavica</i> (Black sage)	It is a multi-branched shrub with a strong sage scent that can grow to a height of 3 m. Its leaves range in shape from rectangular to ovate and are 40-100 mm long and 15-60 mm wide. The tiny white flowers, which are gathered at the ends of the stems, have corollas that are 4-6 mm long and formed like funnels. The 4-5 mm long seed is inside each of the small, luscious crimson fruits.	• It is used to treat gastrointestinal, pulmonary, and dermatological conditions.

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3	<i>Cordia dichotoma</i>	It is an evergreen tree of small to medium size with a short bole and spreading crown. The stem's bark is greyish brown in colour and either smooth or longitudinally furrowed. Flowers are white, bisexual, short-stalked and blooms only at night. The fruit is globose-shaped and lustrous, starting out yellow or pinkish-yellow before becoming black and developing viscid pulp.	• The immature fruits are used as vegetable fodder and pickle purpose. • The leaves make excellent fodder as well. The leaves are used as a food source for the larvae of the butterfly • The seed kernel has therapeutic qualities.
4	<i>Cordia lutea</i> (Yellow cordia)	It can grow into a small tree or shrub that is 8 metres (26 feet) tall. Branches are hairy when young. The undivided leaves have extremely finely toothed margins and are oblong to spherical in shape, measuring 4–10 cm (1.6–3.9 in) and are positioned alternately. The leaf's upper side is rough-textured but hairless, while the lower side bears hairs. It is easily recognized because of its massive golden blossoms.	• The flower, also known as "overo" in traditional Peruvian medicine. It is frequently used to treat liver conditions and, in northern Peru, prostate inflammation.
5	<i>Cordia platythyrsa</i> (West African cordia)	The tree grows to a height of more than 30 m and a diameter of 1 m. The wood has a spectrum of hues, from a mellow yellow to almost white. It has a low density (0.5 g/cm^3), spongy, fibrous structure, and a Monnin hardness of 1.3.	• Wood is very soft with a spongy, fibrous texture. • It is largely used in the production of furniture, interior joinery, household items, canoes, and musical instruments.
6	<i>Cordia sebestena</i>	On maturity, it can grow to a maximum height of 8 to 9 m, with a spread that is nearly equivalent. The crown resembles a circle or a vase in shape. If only one trunk is allowed to form, it can expand to a diameter of 30 cm. The dense, evergreen foliage has alternate, 18 cm long, dark green, leathery, ovate leaves with wavy margins. These leaves are covered in microscopic hairs that give them a rough, "sandpapery" appearance. It has drought resistance.	• It is a popular ornamental plant in tropical gardens due to its attractive flowers. • It can serve as a useful coastal subject and also planted in parking lots and road medians.

7	<i>Cordia sinensis</i>	It ranges in size from a small shrub to a 12-meter-tall multi-stemmed tree. The cream to brown stem bark has different tones. The colour of flowers is either cream or white. Conical in shape, the fruit is orange or crimson and has one to four large seeds hidden beneath a viscid, mushy pulp.	• The fruits and gum of this species are edible and used in many different types of food. • The wood is used to make furniture, tools, and firewood. • Leaves can be used as fodder • The fruit is used to make juice or beer with tamarind. • Its fruit are vital source of nutrition for birds and monkeys.
8	<i>Cordia subcordata</i>	It can grow to a height of 7–15 m. It has ovate leaves that are 5–13 cm wide and 8–20 cm long. The tubular flowers of <i>C. subcordata</i> have a diameter of 2.5–4 cm and are produced in cymes or panicles. The flower has orange petals and pale green sepals. Although flowers bloom throughout the year, the majority are produced in the spring. Flowers are round, 2–3 cm long. There are four or fewer 10–13 mm long seeds/fruit.	• The edible seeds can consume during times of hunger. • The tree's wood is termite-resistant and utilized to build umeke (bowls), utensils, and umeke lau (huge calabashes). • Leis were made from the flowers, and the leaves were used to make a dye for kapa cloth and aho (fishing lines). • Bark is used to extract the fibre used to produce baskets and garlands.
9	<i>Cordia sulcata</i>	It can develop into either a small tree or a large shrub and can reach up to a 20 m height. This plant has simple, alternate leaves with rough, hairy surfaces and dark green surfaces. Branching, determinate, tall clusters of fragrant, cream-colored flowers are produced by the plant. The white, 1-cm-wide ripe fruits have a waxy texture and gooey content inside.	• Wood is soft and light weight; it is used to make barrels, boxes, poles, charcoal, and fuel. • The mucilage from the tree's fruit is used as glue and to keep dreadlocks in place. • Plant parts were

			utilized for folk medicine (bronchitis & diuretic).
10	<i>Cordia trichotoma</i>	The tree's trunk has a diameter of 70–90 cm and is typically 20–30 m tall. They produce white blooms with five petals that are oblong in form. They feature simple, broad leaves and drupes for fruit.	• It is largely used and sold for fine furniture all over the world due to its excellent wood quality and trunk form. • Its trees are mostly found in Brazil's Amazonas jungle.

Source: <https://en.wikipedia.org/wiki/Cordia>

Varieties

Maru Samridhi: Released by ICAR-Central Arid Zone Research Institute, Jodhpur Rajasthan. The average fruit yield potential is around 85 kg /plant with an average plant height of around 4-5 meters, and canopy diameter is around 7 meters. It is a regular fruit bearer and high-yielding variety which starts bearing fruit in the third year after planting. Flowering takes place in February - March, and fruits ripening take place in April - May. The edible portion is 84.6%, the average fruit weight of 10.5 g, crude protein is around 11.06%, crude fiber is around 13.4%, and with 15.3% dry matter.

Thar Bold (CIAH/LS-3): It is an early and prolific bearing variety released through selection by ICAR-CIAH Bikaner. The average yield potential is around of 1.5–2.0 q tender fruits/tree. Fruits are bold and born in clusters. Its fruit are suitable for pickles, vegetables, and also for dehydration purposes. Fruits can also be used for processing as well as for consumption.

Karan Lasoda: Released by SKNU (Sri Karan Narendra Agriculture University) Jobner Rajasthan. The plant is vigorous and perennial type and reached commercial bearing after 4-5 years. The leaves are larger in size (length of 17.20 cm) and green to dark green.

VII. Production Technology

Soil and Climate

It can be grown in almost every type of soil, from clay to sandy, but loamy medium soils with lots of organic matter are preferred. The best soil is well-drained, deep, and productive, with high water-holding capacity. The pH

of a soil should be between 5.5 and 6.4 for growth and development. It has a high salt tolerance.

Lasoda can thrive in both subtropical and tropical conditions up to an altitude of 1500 m. It thrives in semi-arid and desert regions and needs little upkeep. It goes dormant during the colder months. The plant needs warm temperatures, enough sunshine, and quiet winds in order to produce fruit. It can survive temperatures ranging from 22 to 50°C and precipitation of 760 to 2250 mm per year. Once established, it can withstand drought very well.

Propagation

Lasoda can be propagated through both sexual (through seed) and asexual propagation (Patch budding & 'T' budding). Since *lasoda* is a cross-pollinated crop, therefore propagation through seed is not recommended because it leads to variability in the plant vigour, bearing potential, fruit productivity, and other quality parameters of the fruits. Among the vegetative propagation techniques, "T" budding has been proven quite effective; during August, more than 90% success was attained. Bud wood from actively growing shoots was discovered to be the most conducive for propagation by budding. It is advised that 60–75-day old seedling rootstocks can be utilized as a rootstock for budding. Over *Cordia dichotoma*, *Cordia gharaf* has shown to be the superior rootstock.

Planting System and Spacing

Lasoda can be planted in a square system or rectangular system at spacing of 5-7 m (Meghwal & Roy, 2011). Pit is prepared during summer with 1 x 1 x 1 m sized pits filled with the mixture of soil, 15-20 kg FYM and 50 g Methyl Parathion 5 % dust.

Manure and Fertilizer

At the time of the pit filling, approximately 20 kg of FYM is combined with the soil. In 2nd Year addition of 10 kg of FYM /plant is made in July and August (Meghwal & Roy, 2011). Around 40 kg FYM or 30 kg of compost/plant /year should be used starting at age 5 year (Meghwal & Singh, 2019). Before fruiting, the FYM/compost should be applied twice in similar amounts, once in July and once in February.

Irrigation

During establishment, lasora plants need constant irrigation during the first three years. If the soil is under moisture stress after planting, the initial irrigation is normally provided just after planting. In the first week of February, the first irrigation should be started. After that, irrigation should be applied regularly at intervals of 7–10 days (approximately 400 L/plant/irrigation based on open pan evaporation), up until the last week of April, depending on the weather (Singh *et al.*, 2020). By the end of April, the fruit harvest is complete, and irrigation is then discontinued to conserve water. It's crucial to have enough drainage to avoid water stagnation.

Weeding

Hand weeding and root trimming must be done frequently during the early stages of plant development. A few shallow hoeings are typically sufficient to encourage improved plant growth. Fluchloralin at 2 kg/ha and bromacil at 1.5–2.0 kg/ha should be used before planting to suppress weeds and boost production. Depending on how active the weed is, three to four weedings at 40, 80, 110, and 150 days after planting are acceptable.

VIII. Canopy Management

Canopy management in the Lasoda is crucial to improving fruit quality and productivity and must be done timely when needed. In canopy management following operations are being done

1. **Training & Pruning:** The lasoda plants need to be kept low to the ground. The shoots that are growing straight up are kept, and the remainder is trimmed. Three to four evenly spaced upright developing limbs are permitted to emerge as the primary scaffold throughout time. The criss-cross, dry, disease and insect pest affected branches can be trimmed time to time which will help in better light penetration into the canopy, reduction in pest and disease and also better-quality fruit with high yield. If training and pruning are being done timely, then different operation such intercropping, weeding, spray of plant growth regulator and harvesting will become easy.
2. **Leaf defoliation:** In canopy management of Lasoda, leaf defoliation is necessary to get consistently uniform and early yield. Roy & Meghwal (2012) recommended defoliation from late December to early January. By withholding irrigation (November–December), the leaves of Lasoda plants turn yellow and fall naturally. Leaf defoliation in lasoda can be done either manually or through the chemical spray. During the 1st week of January,

foliar application of ethrel @ 1000 ppm encourages simple leaf fall. This defoliation can lead to early and uniform fruiting which in turn fetches high market prices of the produce due to avoidance of the adverse effect of high temperature in late season (Roy & Meghwal, 2012).

IX. Flowering and Pollination

In Lasoda generally, flowering starts 3-5 years after planting in the middle of February-April and fruiting in March-May (Vashishtha *et al.*, 1985). Eight morphological steps are taken by the flower bud once it initiates, and it takes 13 days from bud initiation to anthesis, which takes place between 7.15 and 7.45 pm. The fruit set is generally about 25% (Vashishtha *et al.*, 1985). The plant is cross-pollinated, while a little amount of self-pollination cannot be ruled out. The white, fragrant blossom of Lasoda is very alluring and attracts a variety of insect pollinators. The principal pollinators include several insects, such as bees and wasps. Besides this number of pollinators of different orders such as hymenoptera (*Apis florea*, *Apis dorsata*, *Apis cerana*, *Apis mellifera*, *Megachile* sp. and *Polistes* sp.), coleoptera (*Coccinella septempunctata* and *Chilomenes sexmaculata*), diptera (*Eristalinus obliquus*, *Eristalis* sp., *Bactrocera nigrofemoralis* and *Chrysomya rufifacies*) and lepidoptera (*Mythimna separata*, *Plusia* sp. and *Thysanoplusia orichalcea*) also visit the Lasoda flowers.

Fruit Set, Harvesting and Yield

The fruits are ready for harvest after about 30-40 days of fruit set and fruit ripening takes place after 50-60 days of fruit set. Harvesting is generally done staggered and depends mainly on the purposes for which fruit is to be used. Generally, for pickles and culinary purposes, the fruit is harvested when they are still green in color and mature. Fruits should be harvested in clusters with stalks. Fruit begins to ripen in the first week of May. Fruits become quite sweet when they ripen and turn yellowish. The yield of Lasoda plant depends on several factors i.e. soil, climate, age of the tree, variety, and management practice. Yield varies from 5 kg/plant (young plant) to 100 Kg/plant whereas on average 8-year-old plants yield 30-40 kg of fruit /tree. In dry locations of Jaisalmer, Chandra Pareek (1992) recorded a 32.4 kg yield tree from *Cordia myxa* at an 8-year-old plant age. It produces 100-150 kg of fruits/tree under typical rainfall conditions, depending on the genotype's genetic potential and the local climate at the time of blooming and fruit set. Healthy fruits of Lasoda are packed in bamboo baskets or gunny bags.

Insect and Pest

Insect and pests cause severe damage to agricultural products intended for human foods and animal feeds. In addition these biotic agents cause direct as well as indirect damage to the plant systems, leaves, fruits, and seeds. Apart from the climatic limitations, they are also one of the limiting factors for crop production in arid and semi-arid ecosystem. In lasoda the major pest are lac insects, weevils, tinged bug, & lasoda mirid bug whereas among the minor pests aphid, jassid and gall midge are observed in the lasoda crop. The description and control major of insect pest of Lasoda are mention in Table 8.5.

Table 8.5: List of different insect pest of lasoda and their control measures

Sl. No.	Insect and Pest	Symptoms	Control Measures
Major Insect/Pest			
1.	Lac insects (<i>Kerria lacca</i>)	- It consumes the sap from particular plants and is sedentary in habit, is more susceptible to attack by a variety of pests and illnesses. <i>K. lacca</i> parasitoids and predators are responsible for around 50% of crop loss.	Spray endosulfan @ 0.05% at 30-35 days into the crop cycle.
2.	Weevils (<i>Barioscapus cordiae</i>)	Adult attack the fruits as well and eat the sepals, green pedicel, and pollen grains found inside the buds.	Spray chlorpyriphos 20 EC at 2.5 ml/litre or quinalphos at 0.05%.
3.	Tinged bug (<i>Dactyla cheriani</i>)	- Nymph and adult damage the leaves - Leaves become yellow and eventually dry.	- Collect and dispose the infected leaves and insect life stages. - Spray NSKE 5% or methyl demeton 25 EC 2ml/lit or dimethoate 30 EC 2ml/lit.
4.	Lasoda mirid bug (<i>Creontiades biseratense</i>)	- It damages different parts of plants such as fruit, flowers, and terminal buds on plants by sucking sap. - Plants can lose their terminal bud if attacked before fruit set, resulting in stunted and branching growth.	Spray insecticides such as dimethoate, and indoxacarb

		On young flowers, feeding damage can result in drying and blasting within 3–4 days.	
Minor Insect/Pest			
1.	Aphids	- Aphids sucks the saps from leaves and stems - Leaf discoloration, curling, yellowing of leaves resulted into restricted growth. - Secretion honeydew leads to development of fungus on plant surfaces by attracting ants.	- Spray insecticidal soaps and oils. - Spray from petroleum or oils obtained from plants like neem or canola.
2.	Jassids	Leaves become yellowish and bronzed followed by curling towards downward, and reddening starts to appear.	- Avoid weeds and wild grasses near the crops. - Mineral oil and neem oil can be used to control the pest.
3.	Gall midge	- Appearance of "onion leaf" or silver stem in the place of the centre leaf. Formation of a tubular gall or hollow cavity at the base of the infected tiller. - A leaf becomes curled, distorted, and wilted leaves followed by defoliation and stunted growth of plants.	- Release <i>Platygaster oryzae</i> parasitized galls at 1/10 sq.m. 10-12 days after transplantation. - Ploughing must be done after the harvesting of the crop. - Application of potash fertiliser is highly recommended. - Install infrared light trap

Source: Ravi *et al.*, (2015), Kumar, K., & Haldhar, S. M. (2019), Vidhya *et al.*, (2017), Meghwal, et al, (2015)

X. Disease

In lasoda crop, fungal (Brown leaf spot, Pink disease) and bacterial (Canker) disease cause significant losses to the fruit yield. Therefore, it becomes essential to adopt timely control measures for better quality fruit production and high yield. The detailed information of different disease of lasoda and their control measure is mentioned in below Table 8.6:

Table 8.6: List of different diseases of lasoda and their control measures

Sl. No.	Disease & Disorders	Symptoms	Control Measure
1	Brown leaf spot (<i>Drechslera australiensis</i>)	• Appearance of tiny, dark-brown or purplish patches on the leaves, which later on becomes larger and their centres turn lighter-brown or ashy. • The entire leaf blade becomes girdled after the spots cluster.	• Application of copper-based fungicide before the start of new leaves flush followed by 1-2 spray during the active growth phase and fruit development.
2	Pink disease (<i>Corticium salmonicolor</i>)	• Formation of swelling or sunken areas on main stem. • Branches/bark may crack or split.	• Timely frequent pruning and burning diseased branches and cultural control can be implemented. • Avoid shade conditions because it leads to formation of high humidity which is favourable for the growth of spores and infections.
3	Die back	• Slowly dying of twigs, branches, shoots, or roots, beginning at the tips. • Slow dieback of a tree's upper branches is known as "staghead," and the dead, leafless limbs have an outward appearance of a stag's head.	• Cut the die back portion, then paste copper oxychloride at a rate of 0.3%, or use of 1% bordeaux spray can be used as control measures.
4	Canker	• Formation of round to uneven shaped sunken, bloated, flattened, cracked, discoloured, or dead regions on stems (canes), twigs, limbs, or trunk are among the symptoms.	• Maintain good sanitation in the field to avoid the spread of canker pathogens. • Pruning the dead and dying branches.

Source: Meghwal, et. al, (2015)

XI. Crop Improvement

Breeding Objectives for Crop Improvement

The selection method is the most commonly used breeding method in lasoda. Therefore, it is essential to adopt other breeding methods (hybridization & mutation) for developing better traits specific cultivars for high yielding and resistance to different stresses. The main objectives of lasoda breeding should focus on the following aspect

1. To develop a regular bearer, cluster bearer, and high-yielding variety
2. To develop climate resilient variety having resistance//tolerance to abiotic stresses
3. To develop a variety having more shelf life
4. To develop variety with increased pulp-to-stone ratio and bigger fruit size.
5. To develop variety having resistance/tolerance to leaf spot, pink disease, canker die back, and gummosis.

XII. Cytogenetics and Inheritance Pattern

The diploid chromosome number of Lasoda is $2n=48$ ($n=24$). Nagar *et al.*, (2013) reported a strong positive correlation between different traits such as leaf, stone, pulp: stone ratio, and fruit. However, the quantity of flowers/cymes was negatively correlated with the above parameters. Samadia (2007) reported that the fruit weight and leaf size of lasoda had large GCV (genotypic coefficients of variation) and PCV (phenotypic coefficients of variation), as well as strong heritability and genetic progress. Additionally, he found a substantial and positive association between fruit weight, diameter, and length and deduced that larger leaves may result in larger fruit and vice versa. Nagraja *et al.*, (2012) in his study found strong heritability and genetic progress for different traits such as fruits per cluster, fruit weight, and TSS. High GCV and PCV were found by Bhatnagar *et al.*, (2015) for the weight of the bunch and the number of fruits/bunches of Lasoda fruit. They discovered significant epistasis for all of these traits, with substantial heritability for fruit weight (89.51%), bunch weight (99.39%), number of fruit branches/bunch (86.74%), number of fruits/bunch (97.07%), total soluble solids content (96.32%), and pulp: stone ratio (98.79%). The predominance of additive gene influence of characters like fruit weight (61.13%), bunch weight (82.63%), number of fruit branches/bunch (70.87%), number of fruits/bunch (98.60%), and pulp: stone ratio (132.42) is indicated by the high genetic advance for these characters, which would favour the improvement of lasoda genotypes through selection. High genetic progress and high heritability for the fruit traits of lasoda indicate that there is plenty of scope for selection.

XIII. Genetic Resources

The research work on lasoda collection and crop improvement has been attempted in India and is being done at different ICAR institutes, agricultural universities, and KVK's. The list of different institutions working in Lasoda crops is mentioned below in Table 8.7.

Table 8.7: List of institute/SAU's working on Lasoda crop

Sl. No.	Institute/SAU's	State
1	Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Bawal	Haryana
2	Sri Karan Narendra Agriculture University, Jobner,	Rajasthan
3	College of Horticulture and Forestry, Jhalrapatan (Agriculture University, Kota)	Rajasthan
4	ICAR-Central Arid Zone Research Institute, Jodhpur, Bikaner	Rajasthan
5	ICAR- ICAR - Central Arid Zone Research Institute, Jodhpur	Rajasthan
6	ICAR- National Bureau of Plant Genetic Resource	New Delhi

XIV. Crop Improvement Methods

Selection

Till now three varieties i.e. Maru Samridhi (ICAR-CAZRI, Jodhpur Rajasthan), Thar Bold (ICAR-CIAH Bikaner), and Karan Lasoda (SKNU Jobner Rajasthan) have been released through selection method of breeding. Selecting desirable, high-yielding genotypes from the seedling population and maintaining those genotypes through clonal multiplication or budding is the greatest way to improve it. In Rajasthan, Haryana, Gujarat, Madhya Pradesh, Himachal Pradesh, and Uttar Pradesh, NBPGR has collected the genetic diversity of lasoda. The gathered germplasm had enormous variations in fruit weight, shape, size, surface feature, pulp content, seed size, weight, and form. In Kotputli, Rajasthan a farmers found a promising new addition that bears large, bold fruits and has a glossy surface. Saini *et al.*, (2002) surveyed Haryana and Rajasthan, India, from May to June 1996 to identify and select prospective lasoda genotypes that are suitable for commercial production. Because of its economic importance and drought tolerance, the study on the survey, collecting, propagation, assessment, and improvement was initiated at the Central Arid Zone Research Institute in Jodhpur during the years 2000–2001. Between 2000

and 2004, 13 germplasm accessions were collected from diverse areas in Rajasthan and Gujarat and subjected to improvement through selection testing. Different accessions differed in terms of fruit size, shape, yield, and pulp-to-stone ratio. Based on fruit yield and other desirable traits, two elite genotypes, CAZRI-G-2021 and CAZRI-G-2025, were discovered (Anon., 2011|12).

XV. Conclusion

Lasoda is an underutilized and climate-smart crop that can play a vital role in the environment and human life due to its multipurpose role (nutritional value, medicinal and traditional uses). Being an underutilized crop, very less work on crop improvement has been done in this crop. Researchable concerns include the availability of trait-specific varieties, commercialization of value-added goods, and economically viable production systems. In India's arid and semi-arid regions, systematic scientific effort on its propagation, crop improvement (Selection, hybridization, & mutation), DUS characterization, standardization of production technology, management of diseases and pests, post-harvest management technologies and value addition may be focused for this crop.

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