

Chapter

7

Phalsa (*Grewia subinaequalis* D.C.)

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Abstract

The Phalsa, scientifically known as *Grewia asiatica*, is an indigenous fruit grown in India. Phalsa is a rich source of vitamins, trace minerals, and is simple to digest. Phalsa is a bushy plant that can thrive in unfavourable climatic and soil conditions. Even 45°C and below-freezing temperatures can be tolerated by this plant for a short period of time. Phalsa remained unexplored with regards to its immense nutritional benefits. The phalsa seed, fruit, and pulp contain numerous functional bioactive compounds that can be used to treat various diseases, and have been found to be highly effective in improving respiratory and cardiac functioning. Its cultivation has been limited to subsistence cultivation and it is sold in the form of raw fruit mostly. There are many challenges as regards to its perishable nature of the berry fruit, and the optimization of the crop yield. Therefore, this chapter highlights its economic and nutritional potential for the food and beverage industry as an effective source of bioactive functional food/beverage ingredients. Based on available information, the uses of different parts of phalsa for medicinal, traditional, and nutritional purposes are described. Besides this, available species and varieties along with package of practices to increase its yield are discussed. The further potential areas of research and developments have been identified for the subsequent authentication.

Keywords: Underutilized, Indigenous, Bioactive, Phalsa, Package of practices

I. Introduction

Phalsa, an underutilised fruit of Indian origin, belongs to the Tiliaceae family. It is also known as Indian Sherbet Berry and has several other names which varied with languages and region. The different names are Phalsa (Gujrati), Dhamin, Parusha and Shukri (Hindi, Marathi, Urdu), Shunkri (Bengali), Phulsa, buttiyudippe and tadasala (Kannada), Phutiki (Telugu), Unnu, palisa, tadachi (Tamil), Shukri (Gujarati), Chadicha (Malayalam), Dhaman (Punjabi), Manbijal (Assamese), Mirgichara and pharasakoli (Oriya), phalsi (Maharashtra), and falsa (Pakistan). Phalsa is a drought-tolerant crop and can thrive in unfavourable climatic and soil conditions. The plants can tolerate high temperature (46 °C) and also freezing temperature. The fruit has high nutraceutical content along with medicinal and traditional uses.

II. Origin and Distribution

Phalsa is India's oldest native fruits. Initially, it was discovered in Varanasi, India, and was later taken by Buddhist experts to Pakistan and other Asian countries. India and South East Asia are home to the phalsa. The genus *Grewia* named after Nehemiah Grew (1641–1712), one of the pioneers in plant physiology. It can flourish at altitudes of up to 3,000 feet. It has been in use ever since the Vedic era. In India, it majorly found in Rajasthan, Haryana, Punjab, Madhya Pradesh, and Uttar Pradesh and lesser scale in Andhra Pradesh Bihar, Gujarat, Karnataka, Maharashtra, West Bengal and the drier regions of South India. In World its presence has been observed in different countries like Bangladesh, Cambodia, Laos, Nepal, Philippines, Pakistan, Sri Lanka, Thailand & Vietnam. In 1914, the phalsa fruit was introduced to the Philippines and in the early 20th Century, the phalsa fruit was introduced to Indonesia.

III. Importance and Uses

Table 7.1: Importance and uses of different plant parts of Phalsa

Sl. No.	Plant parts	Uses	
1	Fruit	Bioactive compounds	<i>A</i> -tocopherol, β -tocopherol, γ -tocopherol, cyanidin-3-glucoside, catechin, delphinidin-3-glucoside, quercetin, quercetin glycosides, quercetin-3-O- β -D-glucoside, naringenin, naringenin glycosides, naringenin-7-O- β -D-glucoside and pelargonidin-3-5-diglucoside
		Nutritional use	Carbohydrate (21.1%), Protein (1.57%), Fat (0.1-0.9%), Fibre (1.2-5.55%), Moisture (80.8%), Calcium (129mg), Phosphorus (39mg), Potassium (375mg), Iron (3.1mg), Vitamin A (0.42-16.11mg), Vitamin B1 (0.02 mg), Vitamin B2 (0.26mg), Vitamin B3 (0.3-0.8mg), and Vitamin C (2.2-4.38 mg).
		Medicinal use	According to Ayurveda, the unripe fruit treat the Vata, Pitta, and Kapha, whereas ripe fruit has diverse uses such as aphrodisiac, burning sensation, cooling effect, diabetes, cures thirst, diarrhea, fevers, remove and cure inflammations and helps to remove the dead foetus, ulcerative colitis, significant menstrual stream difficulties, wounds, and contains antioxidant, anticancer, antiperglycemic and radio protective properties in the fruit.

		Traditional use	Used in preparation of juice, candies and soft beverages
2.	Bark	Medicinal use	It is used to for treatment of biliousness, Vata and Kapha. Beside these it treats urinary problems, burning sensation of reproductive system. The infusion of the bark is used as a demulcent, febrifuge, and treatment for diarrhea
		Traditional use	The mucilaginous extract of bark is used for clearing the sugarcane juice. The bark is used as substituted for soap, and bark fiber is used to manufacture twines.
3.	Root	Medicinal use	The root is used as an astringent and stomachic. It cures gleet, gonorrhoea, osteoporosis, stiffness, strep throat, tissue and wound healing, and cures other problems with the blood, heart, and lungs.
		Agroforestry use	The root system helps in preventing soil erosion from wind & water.
4.	Leaves	Bioactive compounds	Kaempferol, quercetin, Delphinidin-3-O- glucoside, Peonidin 3-O- glucoside, Peonidin-3-O (6"-acetyl glucoside), Cyanidin-3-O (6"-acetyl glucoside), Pelarigonidin-3-O-malonyl glucoside, Pelarigonidin-3- O-(6" acetyl glucoside)
		Medicinal use	The phalsa leaves have various medicinal uses such as anti-microbial, antiplatelet, antibacterial, anticancer and antiemetic activities. It is also helpful in curing the nose and eye diseases, piles, rheumatism, relieving joint pain, splenic enlargement are also used to treat skin outbreaks
		Traditional use	The young leaves are used for animal fodder. Due to excellent adsorbent capacity, it is also used as bio-sorbents to remove lead from contaminated water.
5.	Stem/ Wood	Traditional use	The tree's wood/stem is being used for building shafts, shingles, and bows
		Bioactive compounds	Betulin, β -sitosterol, β -amyrin, erythrodiol, friedelin, lupeol, lupenone and taraxerol
		Medicinal use	It has analgesic and anti-inflammatory properties.
6.	Seed	Nutritional use	Ash (5.08%), Carbohydrate (39.74%), Fibre (26.16%), Lipid (fat) (11.19%), Protein -17.41%
		Medicinal use	Act as an antifertility agent and shows anti-implantation and abortifacient activities
7.	Flower	Bioactive compounds	Quercetin and quercetin glycosides, quercetin-3-O- β -D-glucoside, naringenin-7-O- β -D-glucoside, β -sitosterol, grewinol, 3, 21,24-trimethyl-5,7dihydroxyhentriacontanoicacid δ -lactone, 2-

			hydroxy-3-methyl, 3,4-altrosan, 4H-pyran-4-one, hexadecanoic acid, tetradecanoic acid, and lupenone
8.	Whole plant	Agroforestry use	• Can be used as a hedge • Due to its sturdy growth habit, it have promise as a dune fixing plant in desert reclamation projects. • Suitable for intercropping with other plants as this plant may not affect other crop growth adversely. • The litter of the phalsa leaves increase or improves the physical and chemical characteristics of the soil

Source: Agarwal & Mishra (1979); Khurdiya & Anand (1981); Srivastava (1953); Ali *et al.*, (1982); Laxmi & Chauhan (1976); Joshi *et al.*, (1980); Tripathi, *et al.*, (1973); Lakshmi *et al.*, (1976), Haq *et al.*, (2013).

Taxonomic Classification

Kingdom- Plantae

Phylum - Magnoliophyta

Class - Rosopsida

Order - Malvales

Family - Tiliaceae

Genus - *Grewia*

Species – *G. subinaequalis* DC.

IV. Botanical Description

Grewia subinaequalis DC, formerly known as *Grewia asiatica* L, is the botanical name for phalsa.

The description of important plant parts is described as below:

Plant: The phalsa plant is a medium-sized, drooping shrub that can reach heights of up to 4 meters if unpruned. The stem is greyish in hue and has rough bark. It has numerous long, slender branches that are hanging. The young branches are covered in dense hair.

Leaves: The leaves are simple, alternating, widely cordate to ovate in form, and have a pointy tip. The leaves are 1-2 cm in petiole length, 20 cm long, and 15 cm wide. The receptacle has a hairy upper half and measures 3 to 4 mm.

Flowers: The flowers have tiny, vivid orange-yellow flowers with a diameter of 1 to 2 cm. There are five glabrous, rectangular sepals that are 1 to 5 cm long. The petals are also five, but they range in length from 5 to 7 cm, and they are orange to yellow in colour.

Fruits: Fruits range from 1.0 to 2.0 cm in diameter, 1.0 to 1.5 cm in length, and weigh 1.0 to 2.0g on average. 45 to 55 days after blossoming, fruits are ready. Not all of the fruits in a cluster ripen at once. The fruits change colour as they ripen, going from pale green to cherry red or purplish red, and then to dark purple. The fruit becomes soft and sensitive and develops a very thin, pale blush when it is fully ripe. Near the skin, the flesh's bright greenish-white colour changes to a purplish-red. The fruits have a mild, pleasant flavour and a sweet acidic taste. The fruit typically contains one hemispherical, 5–7 mm-sized seed.

Species and Varieties

The *Grewia* genus has about 140 species, 40 of which are indigenous to India. However, *Grewia subinaequalis* is important for commercial purpose. Beside this other important species are *Grewia tilifolia*, *Grewia belosa*, *Grewia glabra*, *Grewia micrococas*, and *Grewia optiva*. Within the tiliaceae family, only the genus *Grewia* yields fruit that can be consumed. The description of important species is as follows:

Table 7.2: List of important *Grewia* spp. and their description:

Items	Descriptions
<i>Grewia tenax</i> (Frosk.)	
Common name	Gangerun, Gangan (India) Guddaim" (Sudan, Africa), Phalsa Cherry, White Cross berry, and Raisin Bush.
Distribution	World: Algeria, Afghanistan, Botswana, Chad, Djibouti, Ethiopia, Iran, India, Kenya, Mali, Mauritius, Morocco, Namibia, Niger, Nigeria, Pakistan, South Africa, Saudi Arabia, Sudan, Senegal, Somalia, Sri Lanka, Tanzania, Uganda, Zimbabwe India: Andhra Pradesh, Gujarat, Karnataka Maharashtra, Rajasthan, Tamil Nadu
Botanical Description	Multi-stemmed, sub- erect shrub that can reach a height of 3 m. White blooms that occasionally have cream or golden tints and measure 5.0 to 35 mm in length appear to have a

	jointed pedicel. Petals are white and elongated to slightly lanceolate, measuring 5–12 mm long. Sepals are 8–16 mm long and have a greenish exterior. According to Gebauer <i>et al.</i> , (2007) fruit is often a drupe that is 1–4 lobed, 8–12 mm wide, and 6–8 mm long with lobes that are 5–6 mm wide and have an orange, yellow, or reddish colour. Most flowering and fruiting take place between August and November. The flower is hermaphrodite, and honey bees in particular are used for pollination.
Uses	Medicinal Uses Leaves: Leaves and twigs are used to cure infections, tonsillitis, trachoma, fracture, stone problems, urticaria, dysentery, fever, hepatitis, and animal delivery, Root: Root is used to cure fracture and stone problems, urticaria, dysentery, jaundice, asthma, and pulmonary infections Bark: Bark glue used as plaster and entire plant extract ointment can be used locally for hard tissue restoration Fruit: Fruit is used in porridge, special diets (for pregnant women and children due to high iron content increase the haemoglobin count), edoema and bone break Traditional uses The branches can be used to make charcoal and are used as firewood. The bark, which is utilised in the making of ropes and for binding in the construction of houses, produces fibre that is ligno-cellulosic and has a good tensile strength. Weapons like clubs, bows, and bolts are made from timber.
Important traits	It is a highly drought-resistant plant.
<i>Grewia flavescens</i>	
Common Names	Donkey-berry, Sandpaper raisin (English), Chathurakall (Shenkadasi Malayalam), Khatkhathi (Marathi) and Semparandai (Tamil)
Distribution	It grows widely in temperate areas with moderate summer rainfall at medium to low altitudes. World: South Africa, Yemen, Saudi Arabia, and India India: Andhra Pradesh, Telangana, Karnataka, Kerala, Odisha, Tamil Nadu
Botanical Description	It is a hardy and a multi-stemmed shrub or small tree that can reach a height of 5 metres. Dark grey-brown is the colour of its bark. The main stem has a deep groove and four angles. Branchlets have coarse hairs when they are young, which later smooth out. The single, shallowly 2-lobed, or

	occasionally 4-lobed fruits are glossy with coarse white hairs and have lobes that are each 8–14 mm in diameter. The flowering season lasts from December through March.
Uses	The Wood is used to make knobkerries, sticks, and bows. The young branches are used for making baskets
Important traits	It is frost and drought resistant plant.
<i>Grewia villosa</i>	
Common name:	Mallow raisin, Mallow-leaved crossberry (English), Battigargale (Kannada), Kharmati (Marathi) and Thottukalla (Malayalam)
Distribution	World: Africa, Arabia, Botswana, Egypt, India, Kenya, Mauritania, Somalia, Namibia India: Andhra Pradesh, Kerala, Maharashtra, Tamil Nadu
Description	It is a deciduous shrub that grows to a height of about 3 m. It has highly unique leaves and young sections that are covered in whitish silky hairs. Nearly spherical leaves up to 12 cm across, opposite, on stalks up to 4 cm; paler and more hairy underneath, with five noticeable veins. Yellow-red-brown flowers are in tiny clusters. While fruit is ready in South Africa in the months of April and May, flowering takes place in India from June to September. Fruit that is 1 cm across, reddish-brown, velvety and hairy when ripe, and contains 1-2 seeds per nut. The wild tree are locally used as food and medicine. The plant can withstand exceptionally hot weather and an average annual rainfall of 200 to 800 millimetres.
Uses	Medicinal uses: The tree's varied parts are used to treat conditions like syphilis, spleen problems, eye pain, stomach pain and wounds in Kenya. Other uses: The leaves are used as a source of fodder since they are particularly appealing to livestock. The bark's extract is used as glue for tobacco leaves. The wood of species is used for making the walking sticks, bows, arrows, and spear shafts are all made from its wood
<i>Grewia tiliifolia</i>	
Common name	Daminiya (Sinhala) and (chadachchi) in Tamil
Distribution	World: Africa, India, Sri Lanka, Myanmar, China, Pakistan, Thailand, Cambodia, Vietnam. India: Andhra Pradesh, Punjab, Madhya Pradesh, Odisha, Karnataka, Tamil Nadu
Botanical	It is a medium-sized to giant tree that can grow up to 30 feet

Description	in bole length and 7 feet or more in girth. The leaves are stipulate, oblong with an oblique base, acuminate, and crenate-dentate; the flowers are small and carried on stout axillary peduncles; the drupe is globose and the size of a pea, 2-4 lobed, black, and edible. The bark is grey or dark brown. The yellow blossom closely resembles the genuine Phalsa flower. Tiliifolia is a botanical name that means "leaves resembling Tilia."
Uses	Medicinal uses: It is used to treat pita and kapha, hyperdipsia, rhinopathy, pharyngopathy, cough, skin conditions, itching, wounds, ulcers, hematemesis, general weakness, and cancer. To prevent hair loss, <i>Grewia tiliifolia</i> 's crushed bark is used as a hair wash. Other uses: Cordage is made using a fibre extracted from the inner bark. The wood is strong and fine-grained and utilised for all applications requiring elasticity, strength, and toughness, including shafts, shoulder poles, masts, golf clubs, tool handles, and oars.
<i>Grewia optiva</i>	
Common names:	Beul, Dhaman, Bhimal, biul, beul, bhiunal, dhaman, bihul, (Hindi); ghotli, shyalphusro (Nepali), dhanvanah, todana (Sanskrit)
Distribution	World: Afghanistan, Bhutan, India, Nepal and Pakistan India: Haryana, Himachal Pradesh, Jammu and Kashmir, Madhya Pradesh, Punjab, Uttar Pradesh, Uttarakhand, West Bengal
Botanical Description	A small to medium-sized deciduous tree, typically grows to a height of 9 to 12 metres. It has a crown with a spreading shape, and its transparent bole measures around 1 metres in diameter. This tree has strong, rough-looking branches with a smooth pale silvery brown appearance. The leaves have an opposing phyllotaxy, an ovate acuminate shape, measure 5-13 cm x 36 cm, have serrated margins, are pubescent on the abaxial side, and have a rounded base. Stipules are present and are 0.5 cm in length and are caducous in nature. Flowers range from one to eight, with single peduncles that are axillary and range in length from 0.8 to 1.8 cm. Fruit is referred to botanically as a drupe or stone fruit and has one to four lobes with a diameter of 0.8 cm. When unripe, fruits are an olive green colour, becoming to black as they grow.
Uses	Medicinal uses: Utilized as a kind of traditional medicine to cure a variety of illnesses, including eczema, rheumatism, typhoid, bowel and bladder problems, cough, dysentery,

	diarrhoea, small pox, and malaria. The produced made from them also have antibacterial and antimalarial properties Other Uses: Its bark is used as shampoo and soap. The leaves are excellent for mulching. Due to very deep tap root system, it is typically grown to prevent soil erosion. Beside this it is considered a good forage crop.
<i>Grewia monticola</i>	
Common names	Asegaai wood, Silver raisin, Donkey berry (English)
Distribution	World: Tanzania, Uganda, Zambia, and Botswana, Africa, Namibia, Tanzania, Malawi, Mozambique, Zimbabwe
Botanical Description	It is a tiny tree or shrub that can grow to a height of 10 metres. The stem is uneven. It has rough, gray-brown bark. The immature branchlets are rough, thickly hairy, and range in colour from white to pale brown. They eventually turn grey or brown. The leaves are pointed at the apex, alternating, simple, and elliptic-oblong to ovate in shape. They are 3-veined from the asymmetrically lobed or rounded base, leathery, slightly rough due to stray star-shaped hairs, or smooth, green to grey-green, and slightly wrinkled, below velvety grey or white, with stray russet hairs on veins, and irregularly and coarsely serrated margins. The leaf stalk, or petiole, is around 5 mm long and hairy. Between October and March, the flowers bloom. They are tiny, bright yellow, borne in axillary clusters at the tips of branches, frequently in abundance, with sepals up to 10 mm long and shorter petals. The fruits are fleshy drupes that are up to 8 mm in diameter, spherical, and meaty. When ripe, they become yellowish-orange and crimson.
Uses	This <i>Grewia</i> 's crimson wood is used to make assegai shafts, walking sticks, and ornaments.
Important traits:	It is a robust, frost-resistant shrub or small tree that can grow in sand or clay soils and doesn't need a lot of water.

Varieties: Till now only one variety "**Thar Pragati**" has been developed by ICAR-CIAH Bikaner, Rajasthan. The description of the variety is as follows:

It is dwarf, early precocious bearer (bearing in 3rd year), drought tolerant and suitable for high density planting. Plant height reaches up to 2.20 m and has spreading growth habit with thick stem, dense foliage and drooping branches. Fruit ripens in 60 days from fruit set. It is dual purposed (table and for processing) variety in which fruit ripens in 60 days after fruit set. It yields 3-4 kg fruit per plant with average fruit weight of 2.1 g and 1.9g pulp weight. The

pulp percent is around 90.4%, fruit is round in shape with deep purple color. Fruit contains good amount of TSS (20.12 °Brix), Vitamin C (19.12 mg/100g) acidity (3.12 %), total sugar (12.42 %), and reducing sugar (8.10%).

V. Production Technology

Soil and Climate

The phalsa plant grows fruitfully and flourishes in a wide range of soil types, including fine sand, clay, and even limestone. The optimum pH of the soil should be between 6.1 to 6.5. Phalsa is typically planted on marginal land near urban markets to facilitate speedy fruit commercialization. However, a better fruits yield and higher quality can be produced when grown in well-drained loamy soil.

Phalsa is a subtropical fruit crop which can grow in diverse range of climates except temperate conditions. In areas with distinct summer and winter seasons, the plant thrives and as the temperature decreases in winter season, the plants shed their leaves and enter into the dormant stage whereas in warmer climates, there is no dormancy, and the plant does not lose its leaves. It can thrive in a wide range of temperatures (3°C to 45°C). The plants can tolerate frost up to some extent however; they are unable to tolerate freezing temperatures for long duration.

Planting, Spacing and Planting System

Phalsa can be planted at the spacing of 2.5 to 4 m apart during rainy season for better results (July-August). However, planting can be done in February - April if irrigation facility is available. Before planting, pit should be dug out and optimum dose of FYM and fertilizers need to be given at the time of planting. Being short statured crop phalsa is mainly grown as intercrop in orchards, rarely farmers go for sole plantation of Phalsa. Phalsa is normally grown as filler crop, paired row planting system, and on bunds of the field.

Manure and Fertilizers

Phalsa responds well to nitrogen and high phosphorus levels increase the fruit's sugar content whereas high potassium levels suppress sugar and promote acidity. Nijjar (1969) asserted that 1 Kg of nitrogen/plant is sufficient to produce an acceptable crop. According to Chundawat & Gupta (1974), for high yield 15 kg of FYM and 125 g of nitrogen /bush after sprouting should be applied whereas Pundir & Pathak (1981) reported that NPK dose of 100 Kg, 40 Kg, and 25 Kg /hectare should be applied for better growth and yield. In

In addition to main nutrients, phalsa plants also need regular supply of micronutrients. Iron deficiency is particularly sensitive to the plant. According to Singh & Singh (2003), 100g of N/ plant produced a better yield than other treatments. Zinc sulphate (0.5%) and ferrous sulphate (0.4%) have beneficial effects (Wali *et al.*, 2005).

Irrigation

Phalsa being a drought-resistant crop doesn't require frequent irrigation. For getting high yield and quality fruit irrigation should be given at time to time from fruit set to fruit development every 15-20 days or depending on soil moisture and climatic conditions.

Pruning

Pruning is an essential and important process in for cultivation of phalsa crop for getting good quality and higher yield. If plants remained unpruned, height of the plant will be more with low quality and lesser yield. The pruning must be done annually to remove the previous year growth and to promote new growth because the phalsa bear fruit mainly on current season growth. In comparison to other pruning intensities, Ghaffoor *et al.*, (2001) found that 100 cm pruning resulted in the greatest number of clusters/plant and the highest yield/plant (18.41 kg). While in Pakistan, pruning on December 22nd produced the more fruit clusters/plant with highest yield of 18.17 kg /plant. In Rajasthan, Singh *et al.*, (2004) found that pruning a shoot by 50 cm increased yield compared to other treatments. According to the conditions in Kanpur, Singh & Singh (2003) found that pruning at 75 cm above ground produced the highest yield. The findings of the various trials show that winter pruning at a height of 75 to 100 cm boosts fruit yield and quality. Regular pruning keeps the fruiting zone within reach, minimizes tree size, and improves fruit quality and quantity while also making harvesting easier.

Propagation

Phalsa is mainly propagated through seed however it can be propagated through cutting (soft wood cutting, semi-hard wood and hardwood cutting), grafting, and layering (Ground and air layering), although the most common is still seed propagation. For seed propagation, normally 1000-2000 g (1-2 kg) seed are needed for planting in one hectare. Seed remains viable for 3-4 months at normal room temperature and up to 6 months in refrigeration. Fresh seed starts germinating after 15-20 days and translating in field should be done after 6-8 months depending on the growth.

The phalsa plant can be easily propagated using hardwood cuttings. Wood type and planting date plays a crucial role in rooting of phalsa cuttings (Singh *et al.*, 1961). Auxin treatment (IAA, IBA, NAA) can aid in the germination of hardwood cuttings of the phalsa that are difficult to root. Jauhari (1960) had reported that a treatment of 100 ppm IBA for 24 hours resulted in 60% success in cutting. Singh (1961) reported a 68% success rate in hard wood at 100 ppm IBA. Higher roots have been observed in hardwood and soft wood cutting with extended dips (24 hours), low levels of IBA, and NAA. Additionally, rooting was seen to be induced when IBA, NAA, or their mixes were administered fast (5 minutes to 2 hours). Baghel *et al.*, (2004) found 10 to 20% rotting in rooting soil, including biofertilizer, in semi-hard woodcutting. Phalsa can also be propagated through layering in which treatment with auxin (IAA, IBA, NAA, 2,4-D) improves roots in both the ground and air layering. IBA and NAA together at a higher dose resulted in more success than IBA and control. Phalsa can be propagated through grafting also by defoliating the scion 1-2 weeks before grafting has been observed to increase graft success.

Plant Growth Regulators

Plant growth regulators sprays have been effective in phalsa by increasing fruit set, yield, and uniform ripening. According to Chundawat and Singh (1980), GA treatments considerably boosted vegetative growth while 2,4-Dichlorophenoxyacetic acid(2,4-D), PCPA (para-chlorophenoxyacetic acid), and OCLPA @80 ppm significantly inhibited it. The exception to this was when GA was combined with 2,4-D and PCPA. Treatments that delayed vegetative growth also had significant effects on crop production and epinastic effects on leaves. Overall, the proportion of fruit set and the number of flowers per branch dropped with each treatment. However, the effect on fruit drop was most pronounced at these doses, with GA 60 ppm recording the largest reduction, followed by 2,4,5-T (5 ppm), GA (60 ppm), and urea (1%). GA treatments could be used to achieve early maturity. The maximum fruit was produced by GA (60 ppm) + 2,4,5-T (5 ppm) treatment. The spray of NAA 150 ppm significantly increased the number of flowers/shoot (151.21), the number of fruits /shoot (60.74), the weight of 100 fruits (49.80 g), juice percentage (57.78%), and maximum fruit yield (1.71 kg/plant and 5800 kg/ha), followed by NAA 200 ppm. The fruit quality improved noticeably as a result of the treatment with Ethrel @1000 ppm followed by Ethrel @750 ppm in terms of TSS (25.23%), reducing sugar (2.01%), and total sugar (5.74%). Application of SADH (Succinic acid 2, 2-dimethylhydrazide) @1000 ppm of was proven to increase production and fruit quality. Chundawat & Gupta (1974) found that SADH (1000 ppm) also reduced plant height. According to Singh & Singh (1981), spraying plants with 60 ppm GA₃, 5 ppm 2,4,5-T, or 2.5 ppm 2,4-D or 60 ppm GA₃ enhanced fruit size and improved fruit quality. According to study

the use of plant growth regulators resulted in increases the size of the fruits. The application of 2,4-D @ 2.5 ppm treatments, during blossoming and eight days later, increased the yield by 74%. When the crop was treated with 60 ppm GA and 5 ppm 2,4,5-T, the yield was seen to rise by 64%.

Flowering and Fruit Development

Generally flower bearing in phalsa initiate after 15-18 months after planting and 3 years for commercial production. The flowering begins in February or March and lasts for approximately a month. Phalsa flowers need cross-pollination to generate better fruit even though they are hermaphrodites. According to Gill *et al.*, (2001), self-pollination (23.00%) had a substantially lower percentage of fruit set than open pollination (61.60%), despite being hermaphrodites; phalsa flowers need cross-pollination to produce better fruit. According to Gill *et al.*, (2001), self-pollination (23.00%) had a much lower rate of fruit set than open pollination (61.60%).

Pollination and Pollinators

Phalsa is a cross-pollinated fruit crop, and pollination is carried out by insects like honey bees, wasps, and fly etc. During its blooming time, attracting a greater number of pollinators among them few are are leaf cutter bees (*Megachile lanata*, *Coelioxys apicata*, *Megachile* sp.) Yellow banded wasp (*Vespa orientalis*), common paper wasp (*Polistes olivaceus*) italian bee (*Apis mellifera*), giant bee (*Apis dorsata*), Indian bee (*Apis cerana indica*), little bee (*Apis florea*), stingless bee (*Tetragonula iridipennis*), sweat bees or halictid bees (*Halictus* spp.), carpenter bees (*Xylocopa fenestrata*, *Xylocopa pubescence*), flesh fly (*Sarcophaga* spp., *Chrysomya* spp.), hover fly (*Eristalinus tabanoides*), pioneer white (*Anaphaeis saurota*), and African monarch (*Danaus chrysippus*, *Amata passelis*). The phalsa flower blooms in the last week of February, and the fruits begin to ripen on the second week of April and continue until the middle of June. The main insect pollinators for phalsa include *Apis florea*, *A. Mellifera*, *A. Dorsata*, *Megachile bicolor*, and *Chalicodoma cephalotes*.

Harvesting and Yield

Phalsa fruits reach maturity 40 to 55 days after blooming. Fruit turns from green to scarlet red in April or May. Ripe fruits of a dark purple hue are selected for the local market, while mature fruits of a crimson red hue are selected for export. Harvesting is done manually due to the small size of the fruits and the fact that not all fruits mature at the same time. Harvesting lasts for approximately a month and is done regularly on alternate days due to the fruits'

continuous and gradual ripening on clusters. Each plant normally yields 5 to 10 Kg of fruit annually.

Storage and Value Addition

The fruits are perishable in nature and remain fresh for 2-4 days at room temperature. Therefore, it must be sold as early as possible. In comparison to refrigeration and ambient temperature, Ray & Bala (2016) found that deep-freeze (10 days) was extremely effective in extending the shelf-life and maintaining the quality of phalsa cultivars. Several processed products such as RTS, nectar, chutney (Meethi), fruit juice powder and squash are being made from phalsa.

Insect- Pest & Diseases

Phalsa is affected by many diseases and insect-pests. The important diseases and insect -pests with important system and control measures are described below:

Diseases

Table 7.3: List of different disease and their control measures

Sl. No.	Causal organism	Symptoms	Control measures
1.	Leaf spot disease (<i>Cercospora grewiae</i>)	• This disease is prominent in the wet season. • Tiny brown lesions form on both surfaces of the damaged leaves.	• Dithane Z-78 @ 0.3% or Blitox @ 0.2% can be used as control measure
2.	Rust (<i>Dasturella grewiae</i>)	• Light brown spots form on the underside of leaves. • In severe conditions defoliation of plant leaves takes place	• Apply alternate sprays of DM-45 @ 0.3% and Sulfex @ 0.2% at intervals of 15 days.
3.	Powdery Mildew (<i>Oidium Sp.</i>)	• Appearance of the powdery growth on the leaves.	• Avoid overhead watering to prevent this disease. • Removed and disposed off affected parts to prevent the disease from spreading to healthy plants

4.	Phyllosticta leaf spot (<i>Phyllosticta grewiae</i>)	• Long, narrow, purple or black dots appear along the leaf veins further these spots combine and cover whole area of the leaf. • The leaf could eventually decay and fall.	• Remove and discard the infected plant's diseased leaves.
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Sources: www.farmer.gov.in; www.agritech.tnau.ac.in; www.agrihunt.com; www.eagri.org; www.aos.org; www.extento.hawaii.edu; www.ipm.ucanr.edu; www.ipm.ucanr.edu; www.agrifarming.in

Insect Pest

Table 7.4: List of different major and minor insect-pest and their control measures:

Sl. No	Causal organism	Symptoms	Control measures
Major Pests			
1.	Phalsa bug (<i>Gargara mixta</i>)	• The bugs exude honeydew secretions that attract ants and that lead appearance of fungus disease (black sooty mould) in plants.	• Controlled by dusting with 5% BHC
2.	Mango Mealy bug (<i>Drosicha mangiferae</i>)	• Mealy bugs are found in dense clusters under the leaf surface, like a thick mat with waxy secretions. • They secrete honeydew which attracts ants and promotes the growth of black sooty mould, which hinders the ability of plants to produce food • Adults and nymphs sucking plant sap weaken the plant, which also causes the leaves to wilt and turn yellow • Defoliation and even death of the plant can result from severe infestation	• During the months of June and July, remove grasses and weeds like <i>Clerodendrum inflortunatum</i> by ploughing • Spray diazinon at 0.04%, dimethoate (30EC), monocrotophos (36SL 2.5–3.3L), methyl-demeton (25 EC), or malathion (50 EC) as control measure.

		• The wilting and eventual drying of infested tissue is brought on by the excessive and ongoing draining of plant sap • It significantly affects the fruit set of crop	
3.	Bark eating caterpillar (<i>Indarbela</i> sp.)	• In severe cases, the damaged areas die off as the caterpillar bores holes in the major branches and trunk.	• By mud-plugging hole • Pouring kerosene oil or petrol into the holes
4.	Hairy caterpillar (<i>Euproctis fraterna</i>)	• Defoliation is brought on by caterpillars feeding on the leaves. • The damaged leaves resemble a sieve	• Spray 5% neem seed kernel extract (NSKE), or 5 ml neem oil per litre of water to kill larvae in their early stages • Use 2ml/lit of either chlorpyrifos 20 EC or quinalphos 25 EC
5.	Citrus psylla (<i>Diaphorina citri</i>)	• New shoots and young leaves are both attacked by psylla. • Vegetative and floral parts become distorted and growth is also inhibited	• Collect and dispose off the affected plant parts • Spray malathion 0.05% or carbaryl 0.1% or any other systemic pesticides
6.	Chafer beetle (<i>Holotrichia consanguinea</i> Blanc) & Brown beetle (<i>Anomala</i> sp)	• The freshly developing insects severely harm both mature leaves and new sprouts when the monsoon season begins. • Additionally, it has been discovered that grubs harm the roots. • Due to the significant defoliation, the crop canopy is smaller and the fruit yield is decreased.	• Heptachlor and phorate, both applied in granular form at 3 kg/ha results in the best control. • Fipronil 4G @ 25 kg/ha, imidacloprid 17.8 SL @ 0.25 ml/lit, and thio-methoxam 50 WG @ 0.2/lit can be used to minimise the incidence of white grubs by 95%–100%

7.	Phalsa caterpillar (<i>Giauras ceptica</i>) & Leaf eating caterpillar	• Caterpillars consume leaves, and if the infestation is severe, the entire tree may become defoliated.	• Spraying Carbaryl and Endrin (0.1%) is recommended.
Minor Pests			
1.	Oriental fruit fly (<i>Bactrocera dorsalis</i>) & <i>Bactrocera</i> <i>nata</i> (Peach fruit fly)	• The fruits are internally fed upon by maggots, followed by fruit drop of diseased fruits. • The fruit damage can vary from 40-65%.	• Use insecticide sprays containing proteinaceous liquid attractants to control adult oriental fruit fly populations adjacent to crops. • Kill the adults with traps
2.	Citrus leaf miner (<i>Phyllocnistis citrella</i>)	• Caterpillar scraped the epidermis of young leaves and tender shoots. • Leaves turn silvery and wither away.	• Using pheromone-baited traps, leaf miners can be controlled • Many parasites and predators, such as small non-stinging wasp species like <i>Cirrospilus</i> and <i>Pnigalio</i> kill citrus leafminers • The use azadirachtin or spinosad in insecticides results in some effectiveness against larvae and safety for natural enemies
3.	Cowpea Aphid (<i>Aphis craccivora</i>)	• After pruning, aphids start to appear on the sprouts, the nymphs eat the leaf sap and reduce plant vitality • In severe conditions plant growth is stunted or even fatal.	• Spray Methyl demeton 25 EC 500 ml/ha or Dimethoate 30 EC 500 ml/ha. • Spray of azadirachtin (Neemix), neem oil (Trilogy), and pyrethrin (pyganic)

		• Aphid secretes a lot of honeydew which attracts the growth of sooty mould and which reduce photosynthesis.	can be used as control measure.
4.	Pink mealy bug (<i>Maconellicoccus hirsutus</i>)	• It appear on the fruits, flowers, and leaves, sucking the sap. • In extreme cases, it completely reduce a plant's vigour. • It feeds by injecting the plant with its poisonous saliva, which results in growth deformity characterised by curled and wrinkled leaves.	• Apply neonicotinoids (dinotefuran, imidacloprid, and thiamethoxam) or foliar applications of organophosphates (acephate and chlorpyrifos), pyrethroids (bifenthrin), neonicotinoids (acetamiprid) can be used as control measures
5.	Carpenter ant (<i>Camponotus compressus</i>) & Fire ant (<i>Solenopsis geminata</i>)	• Ants cause damages to phalsa fruits • The damaged fruits remain with cracks and gives bad look to the mature fruits. • The activity of ants species is more during fruit maturity stage	• May be chemically controlled by using baits laced with the active component hydramethylnon. • Neem extract (azadirachtin) is potential control measure for fire ant

Source: Butani (1978); www.farmer.gov.in, www.agritech.tnau.ac.in, (2014); Sharma, *et.al*, (1970), www.agrihunt.com, www.eagri.org, www.agritech.tnau.ac.in, Narasimha *et. al.*, (2011); www.aos.org, www.extento.hawaii.edu, www.ipm.ucanr.edu, www.ipm.ucanr.edu

Crop Improvement

Cytogenetic & Inheritance Pattern

The diploid chromosome no of phalsa is $2n = 2x=32$. Due to self-pollination and the availability of only tall and dwarf kinds, there isn't much variation reported in Phalsa. It is necessary to identify the phalsa germplasm for the crucial qualities of bold fruits, small seeds, synchronized fruit maturity, and prolonged fruit shelf life.

Breeding Objectives for Crop Improvement

Very limited research has been done for crop improvement of phalsa fruit. Therefore, much has been done to develop better varieties with desirable traits. Therefore, some of the breeding objective on which research work has to be done in future are as follows

- Develop high yielding variety with a good combination of acid and sugar
- Develop cultivars with uniform ripening and good keeping quality
- Develop cultivars resistant to biotic and abiotic stresses
- Develop cultivars with synchronous ripening

Breeding Methods

Crop improvement is an important and essential for increasing and sustaining crop yields. Various methods are adopted for crop improvement, but in phalsa only selection methods was attempted and much has to be done through other breeding methods like mutation and hybridization which is still lacking in case of phalsa fruit. The selection approach of breeding in phalsa fruit is described as below.

Selection

One of the earliest techniques for crop improvement is selection. However, the development of phalsa has not received much attention. In Phalsa, there isn't a much cultivar available except one i.e. "Thar Pragati" which is released by ICAR-CIAH Bikaner, Rajasthan but there are local preferences for various growing environments. Different phalsa germplasm have been given names like "Local" and "Sharbati" by some growers. At Haryana Agriculture University, Hissar, two unique types—Tall and Dwarf—were identified. These two varieties differ from one another in terms of leaf size, fruit size, and fruit weight, as well as plant height, fruit yield, and other physical characteristics. These two varieties did not differ noticeably in terms of fruit weight, edible portion, seed weight, or juice output. The taller kind contained more reducing sugars than the shorter type.

Future Thrust

Phalsa being an underutilized and climate smart crop has great scope in future for due to its high nutraceutical value. Therefore, following points must be addressed in the future

- Phalsa fruit has a limited shelf life and is only thought to be appropriate for local marketing. Therefore, choosing phalsa genotypes for bold fruit with improved shelf life may be emphasized.
- Thrust may also be given to synchronized flowering plant varieties to cut down on labour costs associated with fruit harvesting.
- Its genetic base is rather small, but it can be broadened through mutagenesis, interspecific hybridization, and the selection of bud mutants or soma clonal variants.
- Due to their low glycemic index and anticancer properties, phalsa fruits have a significant therapeutic value, hence cultivars with superior medicinal properties should be favored.

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