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Popular Article

Cultivation of underutilized fruit crops in semi-arid regions

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Abstract

The Indian semi-arid regions are characterized by extreme temperature, erratic rainfall, poor soil and water quality, which ultimately limit the productivity of fruit crops. There is a plenty of scope for quantum jump in fruit production in semi-arid areas. The regions have strength to produce high quality bael, lasoda, khirni, karonda, jamun, chironji, tamarind, wood apple, custard apple, fig, phalsa, mulberry, tamarind, mahua and palmyra palm. These fruits are source of income and nutrional security to inhabitants in arid and semi- arid regions. The nutritional values of most of the underutilized fruits are numerous and they are widely used in formulations of various ayurvedic medicines. Cultivation and consumption of these crops may be helpful in overcoming the nutritional deficiencies predominant in rural/tribal areas. For better success and survival of semi-arid fruits, in-situ budding and grafting has been found better with vigorous growth of grafted plants under arid and semi-arid conditions. However, construction of earthen and concrete check dam according to catchment area, development of micro catchment module, full moon and half-moon terracing and also with the help of horti-silvi-pastoralsystem, water loss could be minimized under dryland conditions. Under semi-arid conditions, application of organic mulch in tree basin is beneficial for successful cultivation of minor fruit crops. Keeping in view the agroclimatic conditions of semi-arid region, it is need of hour to create awareness among farmers regarding the various technologies like high-yielding varieties, water harvesting practices, IPM, IDM, bio-pesticides, biofertilizers, preparation of value-added products and their marketing can enhance the farm income under prevailing conditions of semi-arid region.

Key words: Semi-arid region, Underutilized fruit crops, Bio-pesticides, Horti-Silvi-Pastoral system

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Introduction

Extreme temperatures, erratic rainfall, poor soil conditions, and low water quality define the semi-arid regions of India, which eventually reduce the yield of fruit crops. However, by utilizing solar and wind energy, human labour, and the development of infrastructural facilities, e conditions can be resourcefully used to enhance the productivity through advanced fruit technological interventions, resulting in more income and significantly favoring the doubling of farmers' income. In semi-arid regions, there is enormous potential for a quantum leap in fruit yield. According to Saroj *et al*. (2018) and Singh and Singh (2012), the areas are capable of producing ed fruits like bael, lasoda, khirni, karonda, jamun, chironji, tamarind, wood apple, custard apple, fig, phalsa, mulberry, manila tamarind, mahua, and palmyra palm. Residents in arid and semi-arid regions rely on these fruits as a source of income and nutritional security. The existing low productivity could be enhanced by following improved new sustainable technologies and inputs with or without irrigation. The amelioration of the extreme conditions is also considered vital for life support to the inhabitants. The recent recognition of these environmentally vulnerable regions' potential for producing high-quality produce has not only created new opportunities for ensuring a sustainable way of life and nutritional security, but it has also brought additional areas into fruit production. Because of the development of new varieties and innovations in agro-processes and processing techniques for the production of value-added goods, the area expansion and yield potential of semi-arid fruit crops have improved significantly.

Demographic status of hot semi-arid fruits

In India nearly 37% of total geographical area, or 131 million ha, is made up of semi- arid regions, which are distributed throughout the states of Maharashtra (19%), Karnataka (15%), Andhra Pradesh (15%), Rajasthan (13%) and Gujarat (9.5%) as well as Tamil Nadu (10%), Uttar Pradesh (7%) and Madhya Pradesh (6%). Moisture stress, poor soil and water quality, and other characteristics define semi-arid regions. The semiarid zones' mean annual rainfall is between 290 and 750 mm, which is around 2-3 times lesser than the region's potential evapotranspiration. The reproductive phase of fruit crops should be synchronized with the period of maximum moisture availability, and they must be resistant to abiotic challenges.

Medicinal importance

It is recommended to include most of the underutilized fruits in daily diet since they have a

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variety of nutritional benefits. Due to their abundance in minerals, vitamins, and phytochemicals, they are frequently employed in ayurvedic medicine compositions. Aside from its significance for nutrition, health benefits, and economic worth, the variety of these fruits also has cultural and social value, supporting ecological stability. These crops may be grown and eaten, which may aid in addressing the widespread nutritional deficits in rural and tribal communities. In addition to socio-economic and ecological advantage, such fruits have numerous medicinal properties as its different plant parts have pharmacological activities. Therefore, these fruits are rich in minerals, vitamins and Phyto-chemicals which need to be harvested for commercialization and utilization of wasteland simultaneously. Biological activities of semi-arid fruits are presented in Table 1.

Table 1. Biological activities of underutilized semi-arid fruits

Crop	Biological activities
Bael	Anticancer, sedative, hypnotic, analgesic, anticonvulsive, hypothermic, antimalarial, antipyretic, antidiuretic, antitumor, cardioactive, antihyperglycemic, antidislipidemic, antiinflammatory, antiulcer, antiseptic, antiallergic, antidirrhoea, astringent, antibacterial, antihelminthic, antispasmodic, artiemicide, cytotoxic anti-diabetic, antidiabetic
Jamun	Antidiabetic, antihyperglycemic, antifungal, anti-inflammatory, antimicrobial, antibacterial, gastroprotective, antifertility, anorexigenic, antidiarrheal, ulcerogenic and anti-HIV.
Mulberry	Antidiabetes, hypertension, anaemia, and arthritis antioxidant, antimicrobial, and neuro-protective and anti-inflammatory.
Karonda	Astringent, appetizer, antipyretic, antidiabetic scabies, intestinal worms, diarrhoea antipyretic, appetizer, antiscorbutic, antihelminthic
Fig	Metabolic, cardiovascular, respiratory, antispasmodic, anti- inflammatory, antidirrhoea, respiratory haemorrhage, diuretic, diabetics, anthelmintic tuberculosis and anticancer.
Phalsa	Astringent, stomachic, demulcent, rheumatism, antiinflammation, administered in respiratory, cardiac and blood disorders, antimicrobial, anti-platelet, antiemetic, anti-cancer properties anticancer, antioxidant, radioprotective and antihyperglycemic properties
Wood apple	Antimutagenic, hypoglycemic and hyperlipidemic vomiting and hiccups, dysentery, indigestion and induce bowel boils, diuretic activity, anti-bacterial and antifungal.

Plant genetic resources

Conservation of genetic resources of underutilized fruits is important, because these species

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are at the verge of extinction and many are threatened and endangered. The diversity of some of the underutilized fruits is well studied while for other underutilized fruits relatively little has been done yet. Gaps in collection are found between the species and regions. According to IPGRI conservation (both in-situ and ex-situ) of genetic diversity of underutilized fruits are very poor. This fact indicates that furthermore that the vast bulk of genetic resources of underutilized fruits are in the hands of users and local communities.

In this context, intensive crop specific surveys in target variability pockets and explorations were undertaken in arid and semi-arid regions of diversity rich areas of state, viz. Gujarat, Madhya Pradesh, Uttar Pradesh, Chhattisgarh, Haryana, Punjab, etc. and a large number of germplasms of semi-arid fruits were collected over the years for systematic evaluation, characterization and conservation of indigenous germplasm at CHES, Godhra. In past few years, the genetic resource conservation of semi-arid horticultural crops is being maintained in field repository at CIAH, Bikaner, and its regional center CHES Godhra and CAZRI Jodhpur. The genetic resource conservation of major semi-arid fruit crops is also maintained in field repository of SAUs and other ICAR Institutes (Meghwal *et. al*., 2022).

Varietal wealth of underutilized fruits

The environmental conditions of hot semi-arid regions are very harsh hence; selection of plant species and their varieties for such region for growth and production is important. The crop must have one or other characters like deep root system, summer dormancy, high 'bound water' in tissues, reduced leaf area, sunken stomata, thick cuticle, wax coating of pubescence, presence of latex, and ability to adopt shallow, rocky, gravelly and undulated wasteland. Keeping these facts in view, the importance of underutilized fruits in changing climatic scenario, research work on collection, characterization, evaluation and conservation of underutilized fruits have been initiated at CIAH, Bikaner, and its regional center CHES, Godhra, and high-yielding quality varieties were developed. Varietal wealth developed is given in Table2.

Table 2. Different promising varieties of hot semi-arid fruits

Crop	Varieties	References
Bael	Goma Yashi, Thar Divya, Thar Neelkanth, NB-7, NB-9, NB-5, CISHB-1, CISHB-2, Pant Aparna, Pant Shivani, Pant Sujata, and Pant Urvashi	Pandey *et al.*, 2014

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Jamun	Goma Priyank, Thar Kranti, Konkan Bahadoli, Jamwant, Paras, Rajamun, Rajendra Jamun-1,	Singh and Singh 2012
Custard apple	Washington PI 98797, Washington PI 107005, British Guinea, Barbados seedling, Island Gem, Bullocks Heart, Pink Mammoth, Balanagar, Mammoth, Red Sitaphal, Yellow Sitaphal, Phule Janki and Sindhan	Hiwale 2015, Vikas 2018
Mulberry	Thar Lohit, Thar Harit, Victoria-1, China White, Saharanpur, Local-1, Saharanpur Local-2, S-13, S-34, S-146, S-7999, S-1635, Chak Majra	Saroj *et al*., 2018 and Singh *et al.*, 2019
Karonda	Pant Manohar, Pant Sudarshan, Pant Suverna, Konkan Bold, Thar Kamal	Saroj *et al*., 2018,
Wood apple	Thar Gaurav	Yadav *et al*., 2018
Phalsa	Thar Pragati	Saroj *et al.*, 2018
Lasoda	Thar Gold, Paras Gonda, Puskar Local, Maru Samridhi	Saroj *et al.*, 2018
Mahua	Thar Madhu, NM-2, NM- 4, NM-7, NM- 9	Saroj *et al.*, 2018
Fig	Poona Fig, Dianna, Dinkar, Conadria, Excel, Chalisgaon	Hiwale 2015, Singh *et al*.,2019

Propagation

The need for their genuine planting material is rising daily due to the significance of these fruits. Techniques for vegetative propagation have been standardized for commercial multiplication in order to meet the demand for planting material. In plants grown from seeds, the variation has been found. So, vegetative techniques of propagation are utilized for the majority of plant species, excluding a few plant species. Many semi-arid fruits can be propagated using vegetative means, such as stem cutting, layering, stooling, and grafting. Patel *et al*. (2016) reported that seed priming treatment improves the germination and vigour of seedling in custard apple. Under dryland condition, in-situ establishment of jamun orchard has been found successful with better survival. In order to optimize the production of semi-arid fruit crops, propagation techniques of jamun, lasoda, khirni, wood apple, manila tamarind, custard apple, mahua, bael, chironji, etc. have been standardized for large scale multiplication of plants presented in Table 3 (Ghosh, S.N. and Bera, B., 2015). For better

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success and survival of semi-arid fruits, in-situ budding and grafting has been found better with vigorous growth of grafted plants under arid and semi-arid conditions. No work on the standardization of rootstocks has been done on such crops till now, which needs attention to assess vegetative compatibility and vigour, fruiting, fruit quality and usefulness to wastelands. Generally, seeds of local seedling plants are used as rootstocks for multiplication.

Agro-techniques followed in growing of underutilized fruit crops

Intercropping during the initial years of an orchard of bael, chironji, wood apple, and jamun under arid and semi-arid conditions had no negative effects on plant growth up to seven years. Intercropping in an orchard with 10m x 10m spacing, however, can be done for up to 10 years.

Table 3. Commercial methods of propagation of semi-arid underutilized fruit crops

Fruit crops	**Time period**	**Commercial propagation method**
Tamarind	July-August	Soft wood grafting and patch budding
Custard apple	April- May	Soft wood grafting
Bael	May-June	Soft wood grafting and patch budding
Jamun	April -May	Soft wood grafting, patch budding
Wood apple	April- June	Soft wood grafting and patch budding
Karonda	June -July	Seeds and cutting
Phalsa	December-January	Seed and hard wood cutting
Mulberry	February-March	Cuttings
Fig	July- February	Cutting, patch budding

The revenue was enhanced two to three times by intercropping guar, cucurbits, okra, and leguminous vegetables. Guar cultivation in orchards has the added benefit of producing 800 kg more seeds than cowpea. Due to the higher organic carbon content in these areas, cover crops including

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lobia, moth bean were shown to improve the light soils' ability to retain water. Intercropping reduces the chance of crop failure during drought years and increases production per unit area in a commercially feasible way. (Singh *et al.*, 2019).

Under dryland conditions, various fruit crop models can be adopted to minimize the risk and enhance the productivity. Bael, aonla and jamun based cropping model are found to be beneficial in term of enhanced yield and income. Bael + aonla + karonda + drumstick, bael+ chironji+ fig+ custard apple, bael+khirni+phalsa +wood apple cropping models are useful to enhance the productivity of dryland tracts of the country (Singh *et al.*, 2019). Layout and plantation of these crops should be done at closer spacing with proper management of canopy so that productivity and income can be doubled and farmer can generate income throughout the year for better livelihood.

The consistent use of organic mulches has been proven to be beneficial in enhancing the soil's physical and chemical characteristics, microbial flora, earthworm population, soil aeration, and moisture-holding capacity, which in turn led to improved plant development and production. Under semi-arid conditions, application of organic mulch (paddy straw, grasses, maize straw etc.) in tree basin is beneficial for successful cultivation of fruit crops like bael, jamun, custard apple, wood apple, mahua and chironji. It reduces the loss of moisture from the soil, enhances the rate of rainwater absorption in the soil, and controls the growth of weed. Organic mulches not only improve the soil properties and its moisture holding capacity, also reduce soil temperature (2-8°C) during summer, and increase the yield up to 20-25 per cent under dryland conditions of semi-arid ecosystem (Singh *et al*., 2019).

The productivity of many arid and semi-arid drought hardy species of fruit crops like bael, aonla, acid lime, mahua in India is very low (4-5 t/ha) compared with other major fruit crops grown in India. Many reasons may be attributed to the low productivity and to solve this problem, there is a need to develop high-yielding varieties/hybrids that are resistant to biotic and abiotic stresses having dwarf stature and responds to the pruning. By adopting the scientific practices of canopy architecture management and high-density planting, yield can be doubled in lesser time and from lesser area.

Bael, Jamun, Chironji, and Mahua have all been reported to benefit from high-density planting at a spacing of 5m x 5m, which has been proven to increase production and decrease harvesting difficulties. (Singh *et al*., 2019). However, crops like phalsa, and karonda can be

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accommodated at lesser spacing with help of proper training and pruning. By adopting double hedgerow system of planting, the productivity and income per unit area can be enhanced to 2-2.5 times over conventional square system of planting under the rainfed condition. Bael, jamun, chironji and khirni are recommended for planting at 5m × 5m distance under semi- arid conditions to double the productivity (Singh *et al*., 2019). Proper canopy architecture of jamun and bael has been standardized (Singh *et al*., 2011 and Singh *et al*., 2019).

In India's semi-arid areas, the soils are deficient in nutrients, organic carbon, and water-holding ability. Due to the existence of a calcium carbonate layer at a lower depth, the soil depths in these areas are lower, making fertilizer management challenging. To effectively grow crops on such soils, improved fertilizer management is necessary. Fertilizers with ammonium-N or urea should be absorbed into the soil or transferred into the root zone by irrigation or rainfall to prevent ammonia volatilization. Band placement of P minimizes soil contact thus reducing or delaying the formation of insoluble Ca and Mg phosphates. Crops planted on calcareous soils may require above normal levels of K and Mg fertilizer for satisfactory nutrition. Using tolerant rootstocks and varieties reduces the severity of nutrient related disorders. Deficiency of micronutrients can be corrected through foliar application of chelates. Adequate K supply and organic matter application in the form of cakes, FYM and organic wastes can improve the availability of microelements. Enriching soil with organic matter is found beneficial for sustainable production of fruits in fragile agro-climatic conditions.

Most of the minor horticultural crops of semi-arid regions of India are often available only in the local markets and are practically unknown in other parts of the world. Today, consumers are becoming increasingly conscious of the health and nutritional benefits of their food basket. So, these fruits need to be popularized in national and international markets. Practically to larger extent, it can be achieved through developing suitable processing and marketing strategies for minor horticultural fruit crops. In this regard attempts have been made as karonda, bael and aonla based organic products are becoming more popular in the domestic markets. Growing of crops through organics not only hikes the price of produce but also improve soil health.

Post-harvest management

The crucial procedures for obtaining a higher price on the market are grading and packing. The product is protected from harm and spoilage while maintaining its quality and freshness due to

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the packaging. The most practical and cost-effective packing container for transporting semi-arid horticultural goods is a corrugated fiber board box (CFB) or a wooden box with sufficient cushioning elements. The substance used for padding should be biologically inert. Better than the conventional materials like straw and grasses are molded pulp trays, honeycomb, and cell packs. Because there aren't enough storage facilities in semi- arid dryland areas, a lot of fruits and vegetables are wasted. Proper storage facilities, such as cold storage, CA storage, and ZECC storage significantly minimize post-harvest loss and increase farm profitability (Singh *et al*., 2019, Singh and Singh, 2012). The fruits grown in semi-arid regions have been prepared into various processed products by the people utilizing their acquired traditional knowledge like sun drying, pickling etc. The pre-treatment of many fruits with hormone and harmless chemicals results in better quality end products. Solar drying and electric tray dehydration of fruits and vegetable help to reduce dust load on the product and retain natural colour. Mal nutrition in resource poor areas of semi-arid region is a major problem particularly in women and children. Fruits like tamarind, custard apple, bael, khirni, karonda, phalsa, mulberry, wild noni, wood apple etc. are a rich source of vitamins, minerals and dietary fibers. Compared to other fruits, bael fruits are richer in riboflavin. Minerals and carbohydrates found in fruits like custard and wood apples are essential for maintaining bodily and physiological function. These fruits are highly perishable in nature, the marketing of which is a major problem, e.g., custard apple gets spoiled within 2-3 days of harvesting, if not consumed (Singh *et al*., 2019). Also, with the glut in the market, the prices of these fruits drop down drastically making it uneconomical for the farmers to sustain production; the result is that the farmers uproot the trees owing to low price in the market. To avoid the situation, there is a need to extend shelf-life of these fruits and to develop post-harvest value addition technologies which are simple and adaptable at the farm level. This will not only result in developing small-scale industry but it will also provide employment to the rural masses throughout the year resulting in increased income of both farmers and workers. Efforts made at the CIAH Bikaner and region research Centre CHES, Godhra were successful and many products, viz. dried and dehydrated fruits, RTS, squash, fruit bars, candies, fruit concentrates, powders, wines, and condensed fruit juices through solar drying, were prepared and demonstrated to stakeholders for further commercialization. Large quantities of the tamarind pulp are pressed and preserved, and under dry circumstances, the pulp preserves for about a year. The mature fruit of chironji can be used to make a wide variety of beverages. Different types of sweets are made by using various kinds of

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kernels. Fruit pulp can be used to produce items like squash, RTS, and nectar. Value added products of different hot semi-arid fruits are given in Table 4.

Table 4. Semi-arid fruits and their value-added products

Crop	Value added products
Bael	Preserve, RTS, nectar, ice cream, slab, squash, cider, canned bael slices, pickles and powder
Chironji	Dried kernels, fruit bar
Karonda	Pickle, candy, jelly, jam, preserve, wine, Chutney
Wood apple	Squash, powder, pickle, chutney, jelly, fruit bar
Khirni	Dehydrated fruits, fruit bar, RTS, jam
Jamun	Juice, RTS, squash, syrup, carbonated drink and wine
Phalsa	Juice, squash, syrup
Lasoda	Pickle, culinary
Custard apple	Jam, beverages, ice cream
Tamarind	Tokku (chutney), panipuri masala, juice concentrate, pulp powder, jam, syrup, candy toffee, tamarind kernel powder
Mulberry	Juice, squash and syrup
Mahua	Biscuits, cakes dried powder, seed oil and wine
Fig	Fig paste, concentrate, powder, nuggets, jam

Conclusion

Considering the semi-arid region's agroclimatic conditions, it is imperative to educate farmers about the various technologies that can increase farm income, such as high-yielding varieties, water

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harvesting techniques, the use of organics, IPM, IDM, bio-pesticides, and biofertilizers, as well as the preparation of value-added products and their marketing. Unproductive land can be turned productive by choosing the right crops that can thrive in unusual agroclimatic conditions via careful planning and the holistic integration of the necessary technology. Because the majority of semi-arid fruits cannot be utilized directly for table purpose and thus fetches low prices in the market. Therefore, farmers' economic condition may be successfully enhanced together with greater health and nutritional security through processing, value addition, and their effective marketing. In order to effectively control malnutrition, so-called "hidden hunger," and other nutritional deficiencies among the impoverished rural people and more vulnerable socioeconomic groups, particularly tribes of the country, concentrating emphasis on such fruit crops is an effective strategy to support a diversified and nutritious diet.

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