ARID FRUITS OF TROPICAL INDIA- SCENARIO

Abstarct

Arid climate is mainly characterized by dry climate and low water availability. Arid fruits have undergone various adaptations to have better establishment to this harsh climatic conditions.

The fruits crops grown in this region have special adaptations like deep root zone, low transpiration mechanism, fruit growth coinciding with moisture availability etc. Arid fruit crops have high nutritious value and are being grown in Rajasthan, Gujarat and Punjab etc. in various proportions. Field gene banks are mainly used to store the germplasm of particular crop and are furtherly used to develop resistance against several pest and diseases and improves the outcome produce. These resources must be preserved for upcoming generations to develop any variety and also to maintain ecological balance. In this chapter, information on area and production of fruits in arid zone of India, adaptations of arid fruits, available germplasm and scope of cultivation of potential arid fruits is presented.

Keywords: Arid Fruits, Arid Zone, Adaptation, Germplasm, Rainfall, Temperature, Drought, Salinity.

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I. INTRODUCTION

Arid climate / Dry climate is a climate in which water is always a limiting factor for plant growth and production. It is a climate in which moisture deficiency restricts, but not necessarily inhibits plant growth.

Dry regions have peculiar eco-climatological features. According to the prevailing rainfall pattern, a scanty rainfall zone is an area with 0-250 mm rainfall per annum. In arid climate rainfall is very low and is continued up to 4½ months and remaining are dry months. Erratic rains often in a few big storms of short durations which results in great sum off loss like soil erosion, instead of charging the soil profile. Soils in arid areas are coarse and structure less low soil depth, hard layer/pan and with very low water holding capacity. Sick saline and or alkaline soil is another feature.

Arid zone is also characterized by high temperature with desiccating strong hot winds cause potential evapo-transpiration. In India, The arid zone covers 12% of the country's geographical area. A total of 32 million ha spread over parts of Rajasthan (61%), Gujarat (20%), Andhra Pradesh and Karnataka (10%), and Punjab and Haryana (9%). Arid can exist in tropics, subtropics temperate zones as well.

Scope of Arid Fruit Industry: The scope shall be determined by Nutritional significance and commercial importance. Arid fruits which are nutritionally rich compared to major crops. Arid fruit crops can offer better yield and return per unit area. Adverse climates and problematic soils can be efficiently used to by cultivating adoptable fruits to bring more area under fruit crops, to bridge this gap of demand and supply of production through increasing orchard efficiency and to scale up economic status of country.

II. PRESENT STATUS OF ARID FRUIT CULTURE IN INDIA

Although India is primarily an agriculture dependent country in a large part, agriculture is still a gamble with rainfall. Out of the total geographical area of 329 mha, 143mha is under cultivation. The irrigated area of 13.3 mha in 1901, increased to 65 mha by 1950-51 and expected to reach 110mha by 2025 AD. Hence about half of the net cultivated area will continue to be rain dependent for quite some time in future also. Dry land meets about 50% of the annual production. About 70% of the farmers are having small holdings and most of them possess only drylands. Hence due emphasis is given for dryland research in India.

The arid regions in India occupy nearly 12 per cent of the country’s land surface comprising about 31.7 mha (3,17,000km^2) in the states of Rajasthan, Gujarat, Andhra Pradesh, Punjab, Haryana, Karnataka and Maharashtra. It is amply clear that major arid zone lies in north west region of the country. Economy of their region is mainly based on animal husbandry not sufficient to provide required stability and therefore major part of population leads a nomadic life. The crop productivity is erratic and beset with uncertainty and high-risk factors.

Under rainfed conditions very little fruits are grown inspite of tremendous potential for tree crops like Ber (Ziziphus mauritiana), Lasoda (Cordia myxa), Aonla (Emblica

officinalis), Karonda (Carissa carandas), etc. The existing area under fruit crops in arid zone of the country is provided in the following table.

Table 1: Area and Production of Fruits in Arid Zone States of India

STATE	AREA (ha)	PRODUCTION (T)
Andhra Pradesh	20,772	-----
Gujarat	1,600	21,400
Karnataka	10,852	-----
Punjab	11,534	72,581
Rajasthan	2,451	57,056
Haryana	6,255	29,350
TOTAL	53,464	-----

III. IMPORTANT ARID FRUIT SPECIES OF OUR COUNTRY

1. BER – Ziziphus mauritiana
2. POMEGRANATE – Punica granatum
3. AONLA – Emblica officinalis
4. CUSTARD APPLE – Annona squamosa
5. Sour sop– Annona Muricata
6. GUAVA – Psidium guajava
7. JAMUN – Syzygium cumini
8. FIG – Ficus carica
9. PHALSA – Grewia subinaequalis
10. DATE PALM – Phoenix dactylifera
11. KARONDA – Carissa carandus
12. WOOD APPLE – Feronia limonia
13. BEAL – Aegle marmelos
14. TAMARIND – Tamarindus indica
15. WEST INDIAN CHERRY -Malpighia glabra
16. MULBERRY – Morus spp.
17. KHER – Capparis aphylla
18. PILU – Salvadora oleoides
19. LOSODA – Cordia myxa
20. ROSE APPLE – Syzygium jambos
21. CARAMBOLA – Averrhoa carambola
22. LAKOOCH – Artocarpus lakucha

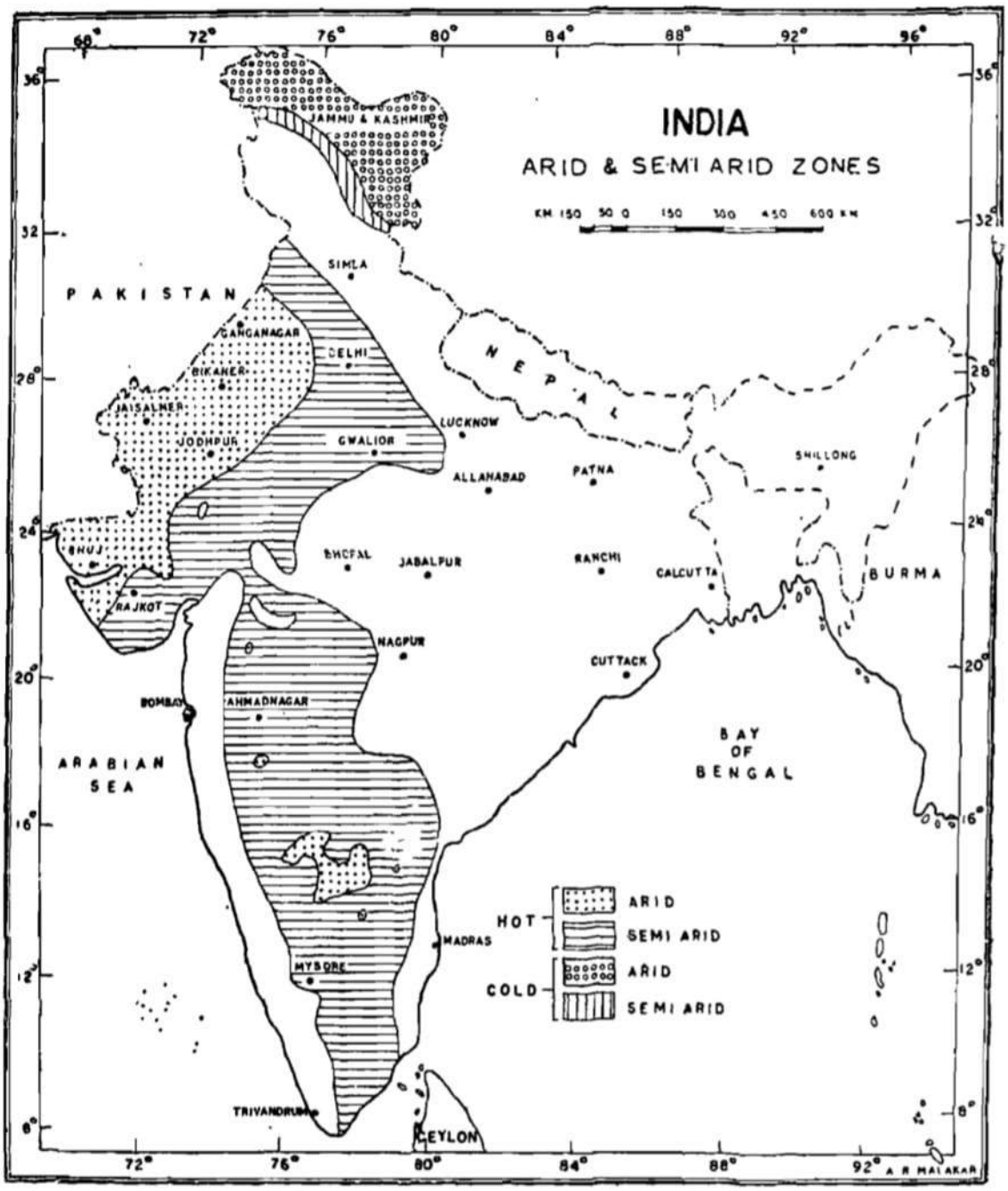
Ber known as Indian jujube is commercially grown in Haryana, Punjab, Uttar Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Bihar, Maharashtra, Andhra Pradesh and

Tamil Nadu. Presently 52,000 ha area with 0.5 Mt production is under arid areas of India. In dry areas, under rainfed conditions, 50-80 kg. fruits/tree can be obtained. As fruit perish soon, to increasing availability fruits can be stored at 3^0 C and 85-90% relative humidity for 30-40 days. Pomegranate cultivation is increasing very fast in dry parts of the country as there is vast scope for export of this crop from semi-arid and arid regions of the country. It is being grown in 2,61,000ha with 2.31 Mt production.

Fig is grown at around 3,000 ha area in Maharashtra, Karnataka. Custard apple growing states are Andhra Pradesh, Maharashtra, Karnataka, Rajasthan and Tamil Nadu and in foot hills of Aravalli, custard apple is highly perishable need to be exploited by value addition.

Aonla is a medicinal fruit plant and cultivated in over **50**,000 ha area with production of 112 Mt. Aonla is mostly cultivated in the states of Uttar Pradesh, Maharashtra, Gujarat, Rajasthan, Andhra Pradesh, Karnataka, Tamil Nadu, Himachal Pradesh.
Date palm is being grown in Haryana Gujarath Rajasthan partly in Tamilnadu and kerala. Highly suitable for extreme dry areas comprising Jaisalmer, Barmer and western parts of Bikaner and jodhpur districts which are the potential regions of its cultivation. Present production of fresh fruit is about 171522 MT.

The available, statistics reveals that inspite of tremendous potentialities, area under fruit crops is dismally low resulting in inadequate supply of their commodity leading to malnutrition. It has been probably due to ignorance as fruit traditional culture has been associated with fertile garden lands with assured water source and therefore, scientists and farmers, have paid less attention on this dry zone cultivation. There is a great scope to increase fruit production in these arid areas subsequently economic conditions of the people, their nutrition, health standards and to provide stability in life. (Renu Bansal, 2016)[2]



	Indian arid zone	per cent	Indian semi-arid zone	per cent	India
Area (000 Sq kms)	388	12.13	969	30.28	3200
Population (millions 1971)	20	3.65	170	31.07	547
Livestock population (millions 1966)	23	6.68	122	35.46	344

Figure 1: Fourteen years of arid zone research

IV. PLANT GENETIC RESOURCES

Field repository at CIAH, Bikaner (Table 1 and 2). conserving valuable genetic source of major arid horticultural crops. 318 Ber genotypes are being maintained. Gola, Seb, Umran, Kaithli and Banarasi Kadaka are performing well under arid conditions.

Ber variety Tikadi found frost tolerant and best suited for coldest winters of arids. Among 154 genotypes of Pomegranate germplasm maintained Ganesh, Jalore Seedless, Mridula, Phule Arakta, Bhagawa and G-137, are the better suitable to arid areas for high yield and quality.

It is found that Aonla variety NA-7 (Neelam) is the prolific bearer followed by Chakaiya and NA-6 (Amrit).

Out of 17 Bael genotypes, NB-9 and NB-5 perform well under irrigated hot arid conditions (Anon., 2011). NDUAT, Faizabad recommend new Bael genotypes NB-16 and NB-17 for cultivation. Scientists of CHES, Godhra, developed three bael varieties for semi-arid conditions, viz. Goma Yashi, Thar Divya and Thar Neelkanth. All of them are better than earlier developed varieties of bael in terms of tree vigour, yield and quality (Singh et al., 2013)[3]

V. BIODIVERSITY OF HORTICULTURE IN ARID ZONES

Arid region occupies about 12.02% of the geographical area of India. 31.7 million ha area is with prevailing hot arid regions which is spread areas in Rajasthan, Gujarat, Haryana, Punjab, Andhra Pradesh.

'Thar Desert' of India possess highest flora and fauna among the desert ecosystems of the world. mainly occupied by dry grassland, trees, thorny bushes, and arid fruits and vegetables of economic importance.

Native fruit species of this region are Khejri, ker, kumat, karonda, kachri, pilu, lasora, bitter apple, cactus pear, phog, kheep, etc. which are unexploited and underutilized . Conservation, Research and sustainable utilization of theses species at commercial level promots of nutritional security. There is a scope for introducing species and varieties for crop diversification in Arid regions (Saroj *et. Al.*, 2020)[4].

VI. UNDERUTILIZED ARID FLORA

In the hot arid region of India, a large number of naturally grown plant biodiversity can be seen across the roadsides and on the sand dunes of barren lands (Table 3). These flora are totally grown under rainfed conditions and show typical characteristic of adaptation under harsh situation of an arid ecosystem. Other than cultivated fruit crops in arid regions, these flora have economic importance for livelihood of this region and play a greater role to maintain agro-ecological balance of an arid ecosystem. Besides horticultural importance, these naturally occurring plant biodiversity of arid region could be the potential source of biotic and abiotic stress tolerant genes. Thus, the conservation of such unexploited arid flora is also to be taken as a priority area for future prospective.(Saroj *et.al*., 2020)[4].

Table 2: Unexploited and Economically Important Plant Biodiversity of the Arid Region

S.NO	Common Name	Botanical Name	Uses
1.	Ker	Capparis decidua	Pickle and vegetable
2.	Kher	Acacia senegal	Ingredient of panchkuta
3.	Pilu	Salvadora oleoides	Tooth-paste making, Fuel
4.	Phog	Calligonum polygonoides	Culinary utilization
5.	Khiip	Leptadenia pyrotechnica	Vegetable and shelter
6.	Bitter Apple	Citrullus colocynthis	Medicinal values

VII. CRITERIA OF SELECTION OF FRUIT SPECIES

The selection of fruits species/verities is very important for arid areas as most of fruit trees are perennial, raised plantations remains productive for 20-60 years. Critical stages of crop cycle of selected fruit species should coincide with the period of maximum water availability. Species should exhibit low evapo-transpiration losses. Flowering and fruiting should be finished before the onset of peak summer. Slection of bahars is important for fruits like guava, pomegranate, acid lime which flowers and fruits three timesin a yearin distinct bahars. Mrig bahar (flowering in rainy season)is preferred as water availability is limiting factor in aridareas. The crop selected should have following characteristic:

1. Hardy, drought tolerance
2. Deep root system to draw water from deeper layers of soil profile.
3. Natural defoliation mechanism in summer to minimize transpiration.
4. High water use efficiency.
5. Xerophytic character like sunken and covered stomata, wax coatings, hairiness, as in fig, phalsa, Ber etc.
6. Tolerance to salinity, alkalinity,calcarious soils which e.g., Aonla, Bael, karonda. datepalm
7. Short duration varieties fruiting period in shortest possible time selected.
8. Varieties of higher yields with quality. (Narayan *et.al*., 2016)[1]

VIII. ARID FRUIT CROPS

Large number of fruit crops are being cultivated in arid regions. In past few decades, considerable area has come up under fruits like Aonla, Ber, pomegranate, Annona, fig and phalsa in different parts of the country. Ber has spread from northern states to the western and southern India from a mere 12,000 ha in 1978 to nearly 86,000 ha in 2015- 2016 with a production of about 0.90 million tons. Similarly, the area under pomegranate has also leaped to over 2.16 lakh ha. Likewise, Aonla, presently cultivated on 80,000 ha with the production of 2, 80, 000 tons. This has become possible as a result of the research and developmental efforts of the different organizations of NARS. (Saroj et.al., 2020)[4]

Under-utilized horticultural crops like., Bael, Jamun, Karonda, Mulberry, Phalsa, Lasoda, Chironji, Pilu, Mahua, Wood apple, Manila Tamarind, Ker, Khirni, Cactus pear etc. are not exploited well. Such fruit trees are not only hardy but have high nutritional and nutraceutical values which need proper attention. A list of arid fruits with other details are given in Table 3

Table 3: List of Major Arid Fruits in India

Common Name	Botanical Name	Family	Chromosome No.	Origin
Bael fruit	Aegle marmelos	Rutaceae	36	N. India
Cactus pear	Opuntia ficus-India	Cactaceae	22-88	Mexico
Ker	Capparis decidua	Capparidaceae	14, 16	India
Chironji	Buchanania lanzan	Anacardiaceae	-	Peninsular
Lasoda	Cordia myxa	Boraginaceae	-	India
Custard Apple	Annona squamosa	Annonaceae	14,16	T. Africa
Date Palm	Phoenix dactylifera	Palmeae	36	Gulf, Iraq
Fig	Ficus carica	Moraceae	26	S.E. Asia
Aonla	Emblica officinalis	Euphorbiaceae	18,28	India
Ber	Ziziphus mauritiana	Rhamnaceae	24	India
Jamun	Syzygium cumini	Myrtaceae	40	India
Karonda	Carissa carandas	Apocynaceae	12	India
Khejri	Prosopis cineraria	Leguminosae	-	Thar Desert
Mulberry	Morus alba	Moraceae	308	N. China
Phala	Grewia subinaequalis	Tiliacaea	36	India
Anar	Punica granatum	Punicacaea	18	India
Tamarind	Tamarindus indica	Caesalpiniaceae	24	T. Africa
Wood Apple	Feronia limonia	Rutaceae	18	India

(Saroj et.al., 2020)[4]

IX. GERMPLASM UTILIZATION FOR MITIGATING CLIMATIC CHANGE

In spite of harsh climate, the arid regions have rich genetic resources of diverse fruit and vegetable crops. The ICAR- CIAH Bikaner-Rajasthan is maintaining and conserving germplasms of various arid fruit and vegetables in National Field Repository of the institute (Table 5). The institute has DUS center for Date palm, Ber, Aonla, Bael, Jamun, Muskmelon and Watermelon. research out come released several disease resistant high yielding/ abiotic stress tolerant cultivars/hybrids. ICAR-CIAH, Bikaner is working released several improved varieties suitable for arid environment (Saroj, 2017) [Table 5]. Such genotypes can be utilized in crop improvement programme as well

Table 4: Germplasm of Fruit Crops Conserved at ICAR-CIAH, Bikaner Field Gene Bank

Common Name	Botanical Name	Germplasm
Ber	Ziziphus spp.	340
Wood apple	Feronia limonia	10
Pomegranate	Punica granatum	150
Mahua	Madhuca latifolia	50
Cactus pear	Opuntia ficus-indica	80
Chironji	Buchanania lanzan	30
Lasoda	Cordia myxa	66
Khirni	Manilkara hexandra	30
Date palm	Phoenix dactylifera	55
Custard apple	Annona squamosa	9
Aonla	Emblica officinalis	50
Sapota	Achras zapota	7
Ker	Capparis decidua	32
Jamun	Syzygium cumini	50
Bael	Aegle marmelos	21
Tamarind	Tamarindus indica	25
Karonda	Carissa carandas	8
Fig	Ficus carica	3

Table 5: Varieties of Arid Horticultural Crops Adopted for Mitigating Ill Impact of Climate Change

Crop	Variety	Characteristics
Aonla	Goma Aishwarya	Early and drought tolerant
Bael	Goma Yashi	semi dwarf tree and suitable for dryland
Ber	Thar Sevika Thar Bhubhraj	Performing well under arid climate
	Thar Malti	Diseases and pest resistance
Jamun	Thar Kranti	Diseases and pest resistance
Pomegranate	Goma Khatta	Drought tolerant
Karonda	Thar Kamal	Moderately drought tolerant
Mulberry	Thar Lohit	Frost (-2 ºC) and high temperature (49 ºC)

X. ADOPTABILITY TO WEATHER ABERRATIONS OF ARID FRUITS

Weather aberrations from the normal climatic pattern, sometimes have adverse influence on various crops in the arid region. For example, in general, frost occurrence is a common phenomenon in arid regions during December– January, but sometimes it was happened in first fortnight of February. Similarly, severe hailstorm of marble size was occurred in Bikaner district of Rajasthan in the month of March, 2016, which badly affected cultivated crops especially, date palm, rapeseed and mustard. In 2019, prolonged winter and rains in the month of February-March significantly affected few crops like date palm and lasoda (Cordiamyxa) and thereby delayed flowering.

Likewise, in phalsa also, under arid region, flowering mainly commences from the second fortnight of February and completes up to 20th March, and fruit harvesting/picking starts from third week of April and completed up to first week of May. This year due to prolonged winter, flowering commenced in the month of April, 2019, therefore fruit ripening started from the second week of May ultimately fruit picking/harvesting delayed by about 20-25 days.

Such weather aberrations not only affect horticultural crops in arid region but also effect field crops, pulses, oilseed crops, etc. (Saroj et.al., 2020)[4].

XI. CLIMATIC ADAPTATIONS OF VARIOUS ARID CROPS

1. Ber: Most popular fruit tree for arid and hot regions.

- Deep and extensive roots penetrates through hard pan to draw moisture from deeper layers.
- Ber tree can tolerate temperature as high as 49- 50°C though, fruit set is adversely affected if the temperature shoots above 35°C during flowering/fruit setting period. (Meghwal *et.al*.,2007)[5]
- Drops leaves in summer.
- Ability to withstand drought.
- High salt tolerance
- 6.Ber grows on wide variety of soils from gravelly, shallow soils to deep aridisols to some extent in entisol.
- slightly alkaline soils are good for growth and production of ber. (Meghwal *et.al*.,2007)[5]

2. Custard Apple

- Grows very well undulated stony lands even on shallow soils leaving it to the nature
- Flowering coincides with maximum moisture availability period
- Sheds off leaves during water stress
- Plants can florish under dry conditions and can withstand drought spells
- In arid conditions with assured water off season fruits can be obtained.

3. Bael

- Grows in subtropical conditions with hot dry summers and mild winter.
- Bael can tolerate the extremes temperatures and minimum soil moisture regime.
- Young plants need to be protected from the temperature below 4℃ and desiccating hot winds. (Singh.*et.al*., 2018)[6]
- Can be grown in marginal lands
- Adoptable to stony land. pH 5-10, tolerates alkaline and
- It can thrive well in swampy, alkaline and stony soils having pH range from 5.0-10.0, where many other fruit trees fail to establish.

- It can tolerate salinity up to 9 dsm^{-1}
- It can also be successfully grown in saline, sodic and sandy wastelands provided the soilis treated with gypsum and pyrite before plantation. (Singh *et.al*., 2018)[6]

4. Fig

- Subtropical deciduous fruit undergoes dormancy at low temperatures.
- One of the most drought and salt tolerant shrub
- It tolerates winter temperatures as low as 10℃. (Isa *et.al*., 2020)[7]
- Early fruit maturity if temperature goes up to 38^0C
- Fig is quite frost tolerant
- Tolerates waterlogging to some extent
- Require dry climate for quality fruits.

5. Aonla

- Mature Aonla tree can tolerate freezing as well as high temperature of 46℃, sometimes heavy damage occurs owing to frost in hot arid ecosystem of western of Rajasthan. (Singh *et.al*., 2019)[8]
- Tolerates slight acidic to saline sodic soils with pH up to 9.5
- leaves shedding during waterstress
- Dormancy of fertilized fruitlets (April-June)
- Aonla can be grown in marginal degraded lands.
- It can be grown in acidic to saline /sodic having pH upto 9.5, ESP 35 and ECE
- 6-9ds/m soils. (Singh *et.al*., 2019)[8]
- Excellent quality in sandy loam with a pH of 7-7.5

6. Karonda: Mature aonla tree can tolerate freezing as well as high temperature Mature aonla tree can the plants are susceptible to frost in winter and sometimes heavy damage occurs owing to frost in hot arid ecosystem of western part of Rajasthan

- Hardy shrub with thorny xerophytic nature.
- Wide range of soils including saline and sodic soils

7. Phalsa

- The plant tolerate temperature as high as 44℃.
- In winter it goes dormant and shed its leaves. (Singh *et.al*., 2018)[9]

8. Wood Apple

- Wood apple, a native of India is one of the hardy trees of arid and semi arid regions. It is highly suitable fruit tree for semi-arid and arid ecosystem. (Kiran *et.al*., 2019)[10]
- Adapted to a wide range of soil conditions including degraded soil as it can tolerate salinity to certain extent. It is an ideal tree to be exploited for growing in wastelands.

9. Jamun

- It can be grown in semi-arid sub-tropical regions with an annual rainfall ranging from 350-500mm
- The jamun requires dry weather at the flowering and fruit setting. (Singh *et.al*., 2007)[11]
- Plants survive in alkaline soils up to pH 10.5
- Tolerates sodic and saline soils particularly in ravine lands degraded land.
- Adopted to wide range of ecological conditions.
- Can be grown in marshy soils.
- Requires dry weather during flowering and fruit set.
- Survives under shallow water table conditions
- Jamun plants survive in alkali soils upto pH of 10.5.

10. Wood Apple

- Hardy tree
- Grows luxuriantly on waste lands with degraded soils of semi/arid regions

11. Khejri

- The high temperature 35-46℃ conditions and prolonged period of drought in combination with sandy soil creates an environment where few rainfed crops can survive.
- Generally found to be potential and stable in the arid and semi-arid areas that receive about 150-500mm of rainfall and which is concentrated between months of June-September. (Samadia *et.al*., 2015)[14]

12. Phalsa

- The pH of the soil should be 7.5-8.5 for successful cultivation. (Singh *et.al*., 2018)[9]

13. Cactus Pear

- It can survive and perform well under alkaline, heavy, gravely and rocky soils also have option for acidic soils.
- Many cacti thrived well in harsh, dry, sandy arid and semi-arid environments. (Kumar *et.al*., 2018)[12]
- The ideal conditions for cactus pear cultivation re sunny warm summer and cool dry winters where temperature does not fall below -5℃ during spring and early summer and annual precipitation between 300-600mm. (Kumar *et.al*., 2018)[12]

14. Chironji

- The species can grow almost in any soil that is devoid of any nutritional content, like gravelly red soils, saline and sodic soils.
- It can thrive well even in the fissures of barren rocks. (Malakar *et.al*., 2022)[13]

- The species prefers dry sub-humid climate and can withstand a highest temperature of 45°C to a minimum temperature of 1°C.
- It can be cultivated in low to moderate annual rainfall of 750-1200 mm. (Malakar *et.al*., 2022)[13]

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