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Arid zone is a treasure trove of indigenous and minor vegetables

The hot arid zone of the country is spread over nearly 31.7 million hectare area of which 41.5% is arable and 19% is cultural wasteland. The major part of hot arid region is found in Western Rajasthan (19.62 Mha) and North-western Gujarat (6.2 Mha). This region is endowed with several vegetable crops which are not only rich source of nutrients but also possess several medicinal properties. The promising material has been exploited in the form of improved varieties having tolerance against biotic and abiotic stresses which are making strident in arid region of the country. The neglected crops like spine gourd and *jhaar karela* are gaining popularity due to their anti-diabetic properties which also possess resistance against biotic and abiotic stresses.

THE DESERT has diverse agro-climatic conditions (arid, semi-arid and sub-humid tropics) and the nature has imposed some restrictions which limits the scope for diversification through vegetable crops. However, these conditions favour successful cultivation of several vegetable crops like kachri (*Cucumis callosus*), snapmelon/phoot (*Cucumis melo* var. *momordica*), mateera (*Citrullus lanatus*), long melon/kakri (*Cucumis melo* var. *utilissimus*), round melon/tinda (*Praecitrullus fistulosus*), ridge gourd (*Luffa acutangula*), cluster bean (*Cyamopsis tetragonoloba*), etc. leafy (palak, *Chenopodium*, fenugreek, *Amaranthus*), legumes (Indian bean) also have good potential under limited irrigation water facility by adopting suitable production and protection technologies. The vegetable crops like *arya* (*Cucumis melo* var. *chate*), *mathkachar*, spine gourd (*Momordica dioica*), *jhaar karela* (*Momordica balsamina*), ivy gourd (*Coccinia grandis*), *etc.* are naturally grown in different parts of arid zone particularly on neglected places and possess wide genetic diversity. The arid zone is endowed with wide genetic diversity of several vegetable crops given in Table 1.

Table 1. Vegetable crops having wide genetic diversity in arid zone

Common name	Botanical name	Chromosome no. (2n)
Kachri	*Cucumis callosus*	24
Snapmelon	*Cucumis melo var. momordica*	24
Long melon	*Cucumis melo var. utilissimus*	24
Arya	*Cucumis melo var. chate*	24
Round melon	*Pracitrullus fistulosus*	24
Spine gourd	*Momordica dioica*	28
Jhaar karela	*Momordica balsamina*	22
Mateera	*Citrullus lanatus*	22
Bitter apple	*Citrullus colocynthis*	22
Cluster bean	*Cyamopsis tetragonoloba*	14
Moth bean	*Vigna aconitifolia*	22
Khejri	*Prosopis sineraria*	24

ICAR-Indian Institute of Arid Horticulture, Bikaner, Rajasthan is maintaining large number of germplasm of different arid vegetable crops. The collected germplasm has been evaluated, characterized, purified and utilized in improvement programmes. Several promising varieties suitable to arid ecosystem has been developed by utilizing the available germplasm. The promising improved varieties are mentioned in Table 2.

Kachri *(Cucumis callosus)*

Kachri is a drought hardy and high temperature tolerant crop (up to 46°C), found in the arid zones during rainy season. Unripe fruits are bitter in taste but at ripening they become edible. The mature fruits (Table 3) are usually cooked with various vegetable preparations, *chutney*, pickles and are also used for garnishing the vegetables or as salad. Kachri is one of the components of the delicious vegetable popularly known as *Panchkuta* in the desert districts of north-western India. Kachri can be cultivated successfully both during rainy and spring-summer season. It requires warm and dry weather with plenty of sunshine for growth and production. The optimum temperature for seed germination is 20-22°C whereas, 32-38°C is optimum for vegetative growth and fruit setting. Its growth is severely retarded below 12°C and plants are killed instantly by frost or at temperature below 4°C during severe winter.

Table 2. Improved varieties of different cucurbits developed by the institute

Crop	Varieties
Kachri	AHK-119, AHK-200
Snapmelon	AHS-10, AHS-82
Mateera	AHW-19, AHW-65, Thar Manak
Long melon	Thar Sheetal
Ridge gourd	Thar Karni
Sponge gourd	Thar Tapish
Ivy gourd	Thar Sundari
Khejri	Thar Shobha
Brinjal	Thar Rachit
Cluster bean	Thar Bhadavi
Palak	Thar Hariparna
Indian bean	Thar Kartiki, Thar Maghi

Table 3. Nutritive value of kachri (per 100 g of fresh edible fruit)

Moisture	88.2%	Fibre	1.21%	Copper	0.0046 mg
Carbohydrate	7.45%	Calcium	0.09 mg	Zinc	0.052 mg
Protein	0.28%	Phosphorus	0.0029 mg	Manganese	0.058 mg
Fat	1.28%	Iron	0.182 mg	Vitamin C	29.81 mg

AHK-119: Fruits are small, egg shaped and unique in shape, size, taste, colour and very suitable for preparing *chutney*, dry powder, pickle, sauce and mixing with other vegetables for acidic taste. Average fruit weight is 50-60 g. The crop becomes ready for picking in 68-70 days after sowing. It bears about 22 fruits per vine and yield is 95-100 q/ha.

AHK-200: Fruits are 100-120 g in weight. Harvesting starts 65-76 days after sowing and continues up to 90-100 days. It produces 115-120 q/ha. Fruits are suitable for garnishing the vegetables and salad.

Kachri AHK-119 is drought hardy and high temperature tolerant

Snapmelon *(Cucumis melo* var. *momordica)*

Snapmelon is commonly grown as inter crop in maize. Its immature fruits are used as salad, vegetables and for other culinary preparations. Fruits at ripening stage develop suture. Its fruits are generally less sweet as compared to muskmelon; hence it is much liked by the people who are suffering sugar related disorders. Snapmelon pulp is suitable for preparation of jam by adding equal quantity of sugar to pulp. Good quality wine with excellent aroma and taste can be prepared with its pulp. It is a very popular vegetable of arid zone. It is commonly grown as a rainfed crop in Rajasthan and Gujarat. A great extent of genetic variability exists in India with respect to vegetative growth, quality attributes (Table 4) and resistance to biotic and abiotic stresses.

AHS-82, high temperature tolerant variety

Table 4. Nutritive value (per 100 g of edible part)

Moisture	95.7%	Fat	0.1%
Carbohydrate	3.0%	Vitamin A	265IU
Protein	0.3%	Minerals	0.4%

AHS-10: It is an early high yielding variety of snapmelon, selected from the local land race. The fruits are oblong and medium in size, 850-950 g in weight, 17-20 cm in length and 9.7-10.5 cm in diameter having 4.5-5%

Seed production of AHS-82

TSS. Edible flesh thickness is 2.1-2.6 cm and fruit cavity 5.5-6.1 cm wide. Its average yield is 225-230 q/ha.

AHS-82: This is also snapmelon variety, selected from the local genetic material. Plants are vigorous with average vine length of 2.25 m. Fruit harvest starts 67-70 days after sowing. Each vine bears 4.0-5.0 fruit giving yield of about 250 q/ha. The flesh is sweet (4.3-4.9% TSS), tasty and light pink in colour.

Mateera

Mateera is generally known as the poor man's vegetable and the common man's fruit in the desert. It is an indigenous type of drought hardy watermelon (*Citrullus lanatus*) and extensively grown on barren sand dunes of western Rajasthan. The immature green fruits at the tender stage are rich in protein, carbohydrate, crude fibre, calcium and phosphorus. The mateera fruits are sweet with refreshing edible flesh (pulp) and consumed fresh as dessert and have juicy properties. Besides, the tender fruits (*Loiya*) weighing 80-50 g are used extensively as fresh vegetable for making *rayta* and curries. The seeds are protein rich (25-32%) and are roasted, and eaten as snacks.

Seed production of Thar Manak–Drought hardy mateera

Thar Manak: It is a variety of mateera, developed through selection from the local land races found in arid zone. It is drought hardy and suitable for cultivation in arid zone during rainy season. Early and first fruit harvesting can be done in 75-80 days after sowing. Flesh is red, solid (firm) and granular, and has good taste and sweetness (9.5-11.2% TSS). The yield potential is about 400 q/ha.

Mateera diversity in arid zone

Bitter apple *(Citrullus colocynthis)*

Bitter apple is the probable ancestor of watermelon which is bitter in taste and known as *Tumba* or 'bitter apple'. It resembles a common watermelon vine, but bears small, hard fruits with a bitter pulp. Fruit contains 15% pulp, 62% seed and 23% rind. The mesocarp contains glucose (1.3% on flesh basis). The processed mesocarp may be good sources of pectin. The juice of the fruit contains citrullin, citrullene and citrullnic acid. The fruits of bitter apple also contain cucurbitacin B and its glycoside, cucurbitacin I. The peel free flesh of ripe fruits contains yellow bitter oil. The seeds are used for edible purposes as well as to extract oil. Seeds contain 16.7% yellow coloured semi-dry oil rich in linoleic acid. It is one of the most drought cucurbit showing maximum diversity in Thar Desert. It has been widely used in traditional medicines for centuries. Bitter apple can also be used in the preparation of biopesticide formulations.

Tumba–Resistant to biotic and abiotic stresses

Khejri *(Prosopis cineraria)*

Khejri is a perennial plant belonging to family Leguminosae. It is called as *Kalpvriksh* of Thar Desert and drought hardy. It grows luxuriantly under the extremely adverse agro-climate in hot arid regions and that too without much cultural care. Khejri have multiple uses viz., nutritious rich pods, fodder and fuel, besides its favourable effects on ecology and soil fertility. It not only tolerates the extreme edapho-climatic conditions of Thar Desert but also has plentiful foliage, bears flowers and fruits during the driest period. Being leguminous species, it is compatible to almost all companion crops grown under the traditional cropping systems. The immature pods called as *sangri* are used as vegetable. It is a major source

Thornless variety – Thar Shobha

Red podded khejri

of leaf fodder (*loong*) in the arid zone. The pods and fodder is nutritious and high valued. About 10-15 kg tender pods and 25-30 kg *loong* can be harvested annually from a 20 years old tree. From wide genetic variability, some genotypes that produce high quality pods were collected for *ex situ* evaluation and conservation. Among them, Thar Shobha has been selected and recommended to develop systematic plantation for uniform *sangri* production. The fresh and dehydrated pods are sold at high prices in arid zone. It is propagated by patch budding.

Arya *(Cucumis melo* var. *chate)*

Arya is an annual plant and monoecious in nature. Tender fruits are generally used as salad and harvested before maturity. The fruit is climacteric. It is propagated by seeds. Fruit shape is long, skin colour light to dark green and smooth at tender stage. Fruit flesh is light orange at ripening without sugar and aroma. It is cultivated in several parts of arid zone.

Ripe fruit of Arya

Round melon *(Praecitrullus fistulolus pang. syn. Citrullus vulgaris* var. *fistulolus)*

Round melon is also known as round gourd, Indian squash, squash melon and *Tinda*. It is grown for small, tender fruits that are roughly spherical and about 5-8 cm in diameter. The fruits at cooking stage contain 1.4% protein, 1.4% fat, 3.4% carbohydrates, 1% fibre, 0.5% minerals, 13 mg carotene and 18 mg vitamin C/100 g of fresh weight. *Tinda* is extensively cultivated in North India, especially in Punjab, Uttar Pradesh and Rajasthan. It is believed to have originated in India and several landraces are prevalent in arid zone.

Spine gourd *(Kartoli)*

It is a perennial climbing plant. The spiny fruits are used as vegetable in all regions of India. They are quite palatable, rather sweet and entirely free from bitterness and good source of protein and iron (Table 5). Fruits, leaves and tuberous roots are used as a folk remedy for diabetes in India. It has small leaves and small yellow flowers. They are small, dark green, round or oval with spines. Fruits are available from July to October in North India which is rich source of protein and iron. Spine gourd is dioecious and propagated by underground tubers

Arya blooming in desert

Tender fruits of a local landrace of Tinda

and stem cuttings. Wide genetic variability exists in arid zone of Rajasthan particularly in natural habitats.

Spine gourd

Jhaar Karela *(Momordica balsamina)*

Jhaar karela is a wild climber containing wide spectrum of medicinal and nutritional value. The fruits are harvested from neglected places from July to October in arid zone. It is monoecious and propagated through seeds. Fruits are small and used as vegetable. The leaves, fruits, seeds and bark of the plant contain resins, alkaloids, flavonoids, glycosides, steroids, terpenes, cardiac glycoside, saponins having various medicinal importances. The therapeutic agent is '*Momordin*' which possess very good anti-diabetic activity. The commercial exploitation for biopharmaceuticals and nutraceuticals are some of the prospective future potential of Jhaar karela. It is found in natural habitats of arid zone particularly neglected places. It possesses resistance against biotic and abiotic stresses which may prove worth in utilizing in the breeding programmes.

Root of spine gourd–Propagating material

Table 5. Nutritive value (per 100 g of edible part)

Moisture	84.1 g	Phosphorus	42.0 mg
Protein	3.1 g	Carotene	2700 IU
Carbohydrate	7.7 g	Thiamine	45.2 µg
Fibre	2.97 g	Riboflavin	176.1 µg
Iron	4.6 g	Niacin	0.59 mg
Calcium	33.0 mg	Ascorbic acid	275.1 mg

Moth bean *(Vigna aconitifolia)*

Moth bean is an important crop of arid and semi-arid regions. It is a hot weather, drought resistant legume and can easily withstand the lack of water, dying hot winds and other climatic disasters. Being multi-purpose and higher adaptability to uncongenial ecological environments makes it a perfect choice for areas receiving lesser rainfall. Moth bean seeds are a good potential reservoir of proteins and other essential minerals and vitamins. Mature, raw seeds contain water 9.7 g, energy 1435 kJ (343 kcal), protein 22.9 g, fat 1.6 g, carbohydrate 61.5 g, Ca 150 mg, Mg 381 mg, P 489 mg, Fe 10.9 mg, Zn 1.9 mg, vitamin A 32 IU, thiamin 0.56 mg, riboflavin 0.09 mg, niacin 2.8 mg, vitamin B_6 0.37 mg, folate 649 µg, and ascorbic acid 4.0 mg per 100 g edible portion. Being pulse, it is a rich and cheap source of vegetable protein, but part of this protein is unavailable because of the presence of a trypsin inhibitor. The green pods are eaten as a vegetable and the ripe seeds, whole or split, are eaten cooked. Dry seeds of moth bean offers a variety of edible products; vegetable, fodder for animals, whole seed, *Papad, Bhujia, Dal, Mangori, Vada*, etc. It is also assimilated as a flour to prepare south Indian food delights like *Idli* and *Dosa*. India being the origin place has numerous landraces and cultivars of moth bean are available in arid zone.

Phog *(Calligonum polygonoides)*

It is locally known as phog, an endemic and threatened species reported from Thar Desert. It belongs to the family Polygonaceae and commonly grows on dry sandy soils and sand dunes. Its native habitat is hot arid region of Thar Desert of India however, it can flourish under such conditions without any impeded effected on growth and development. Phog is a perennial shrub, usually 4-6 feet in height but occasionally may reach even 15 feet height. It is drought hardy and capable of growing under adverse conditions of soil and moisture. It is not affected by frost. Phog has high economic values as its all plant parts are useful in one or other way. Its abortive flowers and succulent fruits are the most important

Fruits of Jhaar Karela

Seed of Jhaar Karela

Phog – A threatened species of Thar Desert

Khimpoli – Tender pods of khimp used as vegetable

source of food for sustenance during frequently occurring famines and also valued for medicinal properties. Flowers are known as phogla in Rajasthan and used to prepare *rayta*. The wood is used as raw materials in building huts/shelter and scaffolding of wells and other structures. The aqueous paste of plant acts as an antidote against snake bite. It is used for curing typhoid, asthma, cough and cold.

Khimp *(Leptadenia pyrotechnica)*

Khimp is a wonderful desert plant belongs to the family Apocynaceae. It is leafless, erect, evergreen perennial shrub and widespread in arid zone of India. Being highly drought resistant, it play an important role in afforestation of desert. Roots have a strong soil binding capacity and used in sand dune fixation. Khimp possesses antifungal, antibacterial, anticancer, antioxidant, wound healing, anthelmintic, antiatherosclerotic, hypolipidemic, antdiabetic and hepato protective activities coupled with other multifarious uses. Almost all plant parts are used in the traditional medicinal system to treat various disorders. It's flowering and fruiting time is August to January. The pods are known as *khimpoli* which ripe in the month of March. Pods are cooked as vegetable and possess medicinal value. The plant is used in thatching of huts and plant fiber for making ropes.

Long melon *(Cucumis melo var. utilissimus)*

Long melon is popularly known as *Kakri* or *Tar Kakri*. Tender fruits are delicious and used as salad, pickle and cooked as vegetable. Due to its cooling effect, it is very popular in most parts of the Thar Deserts during summers. It is a warm season crop and cultivated in tropical, subtropical and milder zones of India. It is very popular predominantly in Rajasthan, Punjab and Uttar Pradesh. India possesses considerable variability in long melon.

Thar Sheetal: Early variety of long melon and first harvesting took place after 45-50 days from sowing. The fruit length, number of marketable fruits per plant and marketable fruit yield varied from 25-30 cm, 18-22 and 132-142 q/ha, respectively. Bear light green coloured and tender fruits at edible stage which are free from bitterness. It set fruits at high temperature (up to 42°C) during summer under hot arid conditions of Rajasthan.

Ridge gourd *(Luffa acutangula)*

Ridge gourd is an important warm season vegetable crop widely cultivated in tropical and sub-tropical parts of India. The immature tender green fruits are cooked as vegetable. It is a good source of carbohydrates, vitamin C and minerals. Warm and humid climate is favourable for its growth and development. The optimum temperature for its growth and development is 25-30°C. Wide variation

Khipi – highly drought resistant plant

Thar Sheetal – Tolerant to high temperature

Seed production of Thar Sheetal

exists in ridge gourd in arid zone with respect to shape and length of fruits.

Thar Karni: It is important variety of ridge gourds. Fruits are 20-25 cm long weighing 90-110 g and cylindrical with 10 longitudinal shallow ridges. It is tolerant to high temperature (up to 42°C) and disease under field conditions. First picking of fruits can be done in 51-55 days after sowing. It can give 130-140 q/ha fruit yield under hot arid agro-climate.

Sponge gourd *(Luffa cylindrica)*

The tender fruits are used as vegetable which are easily digestible. Besides being a vegetable, the mature dry fruits are used in industries for filter and cleaning the motor car, glass wares, kitchen utensil, bath and body bathing accessories. Several landraces are found in North India and arid zone having wide variability in leaf shape, size of fruit (ranging from a few centimeters to one meter), fruit shape, fruit colour and seed colour (white and black).

Thar Tapish: It is a short duration (110-115 days) variety of sponge gourd. It took 49.2-52.4 days to first harvesting of tender fruits. It is suitable both for rainy and summer season cultivation. Average fruit weight is 116.0 g and produced 11 fruits/plant. It is multiple-stress tolerant/ heat tolerant variety and fruit yield is about 145.80 q/ha.

Ivy gourd (*Coccinia grandis* syn. *C. indica*)

Ivy gourd or *kundru* is perennial climber and dioecious plant. Being perennial in nature it continues up to 2-3 years in same field. It is native of India. Fruits are smooth, small (5-6 cm long) and cooked as vegetable (Table 6). Propagated through stem cuttings. Parthenocarpic germplasm is also found in nature which does not require pollination for fruit set.

Table 6. Nutritive value (per 100 g of edible part)

Moisture	93.5 g	Energy	18 kcal	Thiamine	0.07 mg
Protein	1.2 g	Calcium	40 mg	Riboflavin	0.08 mg
Fat	0.1 g	Phosphorus	30 mg	Niacin	0.7 mg
Mineral	0.5 g	Iron	0.38 mg	Folic acid	18 µg
Carbohydrate	3.1 g	Carotene	156 µmg	Vitamin C	15 mg

Seed production of Thar Karni

Field view of sponge gourd

Thar Karni – Tolerant to high temperature and mosaic disease

Thar Tapish – High temperature tolerant

Thar Sundari

Thar Rachit – High temperature tolerant variety

Thar Sundari – a parthenocarpic variety

ICAR dignitaries testing the ICAR-CIAH developed varieties

Thar Sundari: It is a stable variety of sponge for sequential female flowering and fruiting. It is short-perennial (4-5 years), gynoecious and produced good quality parthenocarpic fruits. Tender fruits for vegetable culinary are ready within 6.28-8.42 days from opening of female flowers. The elongated-long shape tender fruits are light green-green-dark green in colour with non-clear white strips and soft. It is suitable for harvesting both as rainy and spring-summer crop with yield of 2.85-3.48 kg/plant/season.

Brinjal *(Solanum melongena)*

The intensive germplasm evaluation and systematic utilization in brinjal breeding programme has been done with the core objective of developing varieties having better marketable quality fruit yield. Crop has potential to tolerate high temperature and abiotic stresses of hot arid agro-climate. ICAR-Central Institute of Arid Horticulture has developed Thar Rachit variety which is suitable for high temperature and abiotic stress conditions of hot arid environment.

Thar Rachit: It is an early variety (45 days after transplanting) of brinjal suitable for both rainy-winter and spring-summer cultivation. Plants are short stature (50-65 cm height at 90 days) and semi-erect. Fruits are oblong-round, dark purple colour and small sized. Fruit weight is 40-45 g and number of fruit per plant varies from 80-90. Yields about 3-4 kg/plant under high temperature and abiotic stress conditions of hot arid environment.

SUMMARY

The hot arid zone possesses wide range of genetic diversity among several annual and perennial vegetables. The crops indigenous to arid region are capable to withstand biotic stresses and possess several medicinal properties. The ICAR-Central Institute of Arid Horticulture, Bikaner, Rajasthan is continuously making the efforts for collection, evaluation, maintenance, conservation and utilization of germplasm available in arid zone. Being drought and high temperature tolerant, the varieties developed by the institute are popular among the farmers of arid zone and making strident.

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