



Kachri melon (a non-dessert form of *Cucumis melo*) diversity, germplasm utilization and varietal development under hot arid climate: Approaches and realization

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Summary

The native crop plants genetic resource is very essential for nature's resilient, region and season-specific varietal development and is also used in breeding programmes for resistance towards abiotic and biotic factors. Kachri and mat-kaachr or kachri melon (a non-dessert form of *Cucumis melo* var. *callosus* and *agrestis*) is an un-tapped arid zone cucurbit vegetable. Their vine plants are annual and short-duration in growth habit, and bearing 10.2–220.5 g weight fruits which are edible at maturity and unique in taste with ripening stages. It is wild and weedy types or semi-domesticated land-races and pre-dominantly grown mixed with the traditional farming in the north-western part of India. Intensive explorations and surveys were conducted in the state of Rajasthan from the year 1994 to 2001, and about 625 accessions were collected and studied over the period (1994 to 2012), and out of them, 68 germplasm lines were maintained for the conservation of regional diversity. The germplasm is evaluated repeatedly and characterized and categorized based on the plant morphology, maturity, utility of fruits and size, shape and skin colour of the mature fruits. On the basis of horticultural traits, fruit size, quality and yield components under the heat-stressed arid environment, the genotypes AHK-5, AHK-13, AHK-26, AHK-40, AHK-43, AHK-99, AHK-109, AHK-119, AHK-155, AHK-200, AHK-202, AHK-356, AHK-411, AHK-564 and AHK-572 were found the most promising and utilized in breeding programme. Unique quality, better fruit yielding, early harvesting and multiple stresses tolerating varieties, namely AHK-119 and AHK-200, developed for commercial cultivation. The development and recommendations of kachri melon production technology by ICAR-CIAH, Bikaner resulted in uniform and higher fruit yield (95–110 q/ha) as rainy and summer season harvest and now, its cultivation become much profit-making among the growers as a climate-smart crop. With the HBCPSMA concept, khejri and kachri technology exhibited high productivity of resources and family employment, and also returns @ Rs. 75,000–2,25,000 in comparison to the conventional cropping systems (Rs. 23,000–42,000) per ha/year under rainfed farming.

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Introduction

Indian sub-continent is an incredible region for the genetic diversity of the Cucurbitaceae family, and a wide range of wild and cultivated species crop-plant climatic adaptations exist from the tropical to desert ecology. Genus *Cucumis* and *Citrullus* species crop-plant diversity of India is well recognized worldwide, and the hot, arid and semi-arid zone of the north-western part of the country is considered the gold mine of non-dessert and dessert forms of *Cucumis* melon. Indigenous and non-dessert forms such as kachri, mat-kaachr, kaakdia, tar-kakdi, arya-kakdi and wangaa are the rescue vegetables of traditional cropping systems and provide nutritious food and income to the inhabitants, and fruits used in

culinary and salad (Chandra 1995; Pareek et al. 1999; Samadia & Pareek 2002)

Probably, India is the first to domesticate wild melons, and because of the selection pressure for a longer period of time by man and cross-pollination, it resulted in the establishment of cultivated non-dessert and dessert forms of *Cucumis* melon. In addition, regular gene flows resulted in the development of intermediate or recombinant types because the wild melons and cultivated ones grew close together for a long period in the country and were further utilized and stabilized as productive forms. Therefore, there is a fundamental need to utilize the adaptive and wild gene pool and maintenance of crop-specific regional diversity for developing breeding material of horticultural harnessing and multi-function use trait sources as concerned with climatic variability and food security (Samadia & Haldhar 2018 and More et al. 2018).

A path-breaking achievement of the long-term research at ICAR-CIAH, Bikaner (1994 to 2012) is morphological

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characterization of about 825 germplasm of *Cucumis* species as diversity of the arid and semi-arid areas of the north-western India and to understand the eco-adaptability of wild land-races, local types, botanical forms, variability in fruit bearing patterns, morphology and their stages of utility for use in the breeding programme and cultivar development under the defined climatic region. The *Cucumis melo* is polymorphic taxon and based on the evaluation of a large number of germplasms, it can be categorized into two botanical culti-groups viz., non-dessert forms (variety *callosus*, *agrestis*, *momordica*, *utilissimus*, *flexuosus*, *acidulus*, *alwarensis* and their cultures) and dessert forms (variety *cantalupensis*, *inodorus*, *reticulatus* and common types), and the studied germplasm accessions were predominantly monoecious and andro-monoecious sex-form, respectively.

The evaluation and characterization of native germplasm and their systematic purification and performance studies over the period under hyper-arid climate at Bikaner resulted in the selection of specific genotypes for further advancement as varieties of commercial significance were accomplished in kachri (AHK-119), mat-kaachr (AHK-200), kaakdia (ASH-10 & AHS-82), kakdi (AHC-1, AHC-2 & AHC-13) and muskmelon (CIAH-1). The developed phenotypes of non-dessert *Cucumis* melon are unique in quality, highly stable and viable for horticultural traits as targeted and found very promising for cultivation under a stressed climate. Now, some of the genotypes are commercialized and most popular among the farmers due to uniform harvest, earliness, short duration, and better horticultural traits, including a greater number of fruits/plants and quality yield (Samadia, 2003 and Samadia, 2007).

Kachri melon is an un-tapped cucurbit of the great Indian Thar desert, and its mature fruits are much liked for making chutneys, pickles, salad, culinary and dehydrated curry powder. Non-availability of the trait-specific and high yielding genotypes suited to abiotic stressed production sites was the most limiting factor for the systematic cultivation of kachri melon. Therefore, a long-term research work plan was taken with the prime objective of improving multiple stresses tolerant native landrace variability for the quality fruit yield and uniform harvest. For a collection of the regional diversity, intensive surveys in targeted areas and variability pockets were made during the 1994 to 2001 period by ICAR-CIAH, Bikaner and also in collaboration with NBPGR, RS (Jodhpur). Collected germplasm were evaluated repeatedly and the most promising ones were short-listed and utilized in the selection and combination breeding for the varietal development and also studied over the seasons and years to standardize nature's resilient crop production technology. The conclusion of the results of the strategic research programme is summarised in this paper.

Materials and Methods

Physiography and agro-climate

In India, Rajasthan (23° 3'–30° 12' N and 69° 3'–78° 17' E) is a geographically very large state, and 40 % area is hot

arid (19.6 million hectares) with desert ecology. The remaining area of the state is semi-arid plains and undulating drylands, and also the hilly and tribal belts with sub-humid climatic variability. Here, annual rainfall varies from 150 to 550 mm and is highly erratic. Out of 9–21 mean rainy days/annum, much of the rain often comes in a few (1–5) heavy events during the monsoon season (June–September), and it is uncertain. In the Kharif season, the high-temperature range of 35–42 °C causes panic during August–September and prolonged drought spells of 15–35 days. In-together the sandy soil creates an environment where very few native crop plants can survive well and find productive under the rainfed situations. All the collected *Cucumis* melon germplasm and breeding material were evaluated at the experimental farm of ICAR-CIAH, Beechwal, Bikaner (28° 6' N latitude and 73° 2' E longitude, and altitude 223 m) and it is in hyper-arid zone of Indian Thar desert.

In this part of the country, winter is very dry and severe and the minimum temperature at night ranges between 4–10 °C in December–January and sometimes it is prolonged to February month. Most years, the low temperature dips down below freezing (–1 to –60 °C) and cold waves and frost occurrence are very common. Here, winter season temperature variability is very high and determines the seed sowing of cucurbits and cropping period. In north-western parts of the state, March–October months are hot, dry and sunny with a continuity of high-temperature range around 38 °C for prolonged periods, and it results in excessive evapotranspiration from the crop plants and soil surface. In the summer months, the maximum day temperature in May–June is above 40 °C in the east to 42 °C in the west zone. But it is very common to experience the extremes of high temperatures, 42–47 and 45–50 °C for the number of days (21–28 days), respectively, and during this period, night temperature (31–35 °C) is also very high.

The sand dunes or desert-field soil is coarse in texture and poor in organic matter, nutrients and water-holding capacity. Sand, fertile topsoil and fine particles continuing blow away due to strong wind thus affecting crop growth and production potentials. The crop plants get damaged through sandblasting on seedlings, leaves, stems, buds, flowers and tender fruits during heat waves and dusty wind storms (LOO and ANDHI). The young seedlings buried under sand and vine-plant disturbed badly. During the peak of summer, the adversity of heat stress is very high, and vine growth produces quality sunburns, and sometimes plants die due to heat strikes. To assess the crop-genotypes variability and performance, experiments were conducted over the seasons and years with normal dates of sowing, i.e., onset of monsoon rains in July month and mid-February with limited irrigations.

Germplasm collection

Realizing the importance of native and regional diversity of *Cucumis* species and the scope of cultivation under the resource constraints conditions of north-western parts of India, intensive explorations, short-trips and surveys were conducted in the hot spot areas and target variability pockets of arid and semi-arid, and tribal zone of Rajasthan from year 1994 to 2001 periods. The

germplasm was collected from a wide range of geographical landscapes and agro-fields. It was performed in the phase manner, both institutional and collaborative, and also the mission mode of NATP on sustainable management of plant bio-diversity by ICAR-CIAH, Bikaner and NBPGR (RS), Jodhpur. Passport information of the germplasm and basic seeds of the accessions were deposited to NBPGR, New Delhi and IC numbers were obtained by the collecting institute.

In totality, kachri melon diversity was collected from 27 districts of Rajasthan state and germplasm was sampled from a range of locations (about 1150 production sites) with arid to semi-arid climate, sandy desert landscape to farm-land soil and variable land-use systems. Open-pollinated fruits were collected both biased and random for making population samples (about 625 accessions of kachri and mat-kaachr) during the study. Passport data and short-notes were compiled to generate the variable information on specific collections, plant growth and fruiting behaviour, fruit variability patterns and cultivation practices at the production sites.

Germplasm evaluation and utilization

Over the years collected kachri melon diversity either through surveys or explorations and assembled at ICAR-CIAH, Bikaner were evaluated in the phase-manner and all together in the year 2001. The minimal descriptor of 35 attributes was defined for vegetative growth, flowering and fruiting, maturity, fruits and seed component observations on all the genotypes under study. Both kachri and mat-kaachr germplasm were categorized and grouped based on prioritized traits such as fruit size at maturity, skin spots, colour and thickness, flesh colour, thickness and seed cavity, bitterness and taste of fruits, bearing behaviour, number of fruits/plant and yield patterns.

Based on preliminary evaluation and prioritized traits, promising germplasm was short-listed for use in repeated evaluation and purification was done for uniformity and improvement under high temperature and abiotic stressed conditions. Purified material and isolated lines were evaluated over the seasons and also assessed to understand their potentialities for marketable fruit quality, processing values and suitability for two seasons of cultivation under the hot, arid climate. Therefore, each germplasm or breeding material was studied at least four times in rainy and summer and rainfed and irrigated situations. For evaluation of each germplasm or breeding line, the single-row plot of 25 metres in length was kept standard throughout the experimental trials, and 50 plants/genotype/row was maintained. With the initiation of flowering, twelve plants were tagged in each genotype, and four groups were made for recording observations.

For obtaining uniformity in kachri and mat-kaachr lines, promising material were purified based on fruit quality and prioritized traits. After purification, isolated selections were compared with the best-preferred genotypes for fruit quality and yield characters with varying production environments. Since, fruit size, edible quality, number of marketable fruits/plants and tolerant to the abiotic stresses of arid climate were the important

targets for kachri melon improvement, and therefore, long-term data were used with standard procedures to conclude the research work on varietal development and technology standardization.

A wide range of data was generated for each melon germplasm and breeding lines, and it was with seasons and production situations of the year 1995-1999, 2000, 2001, 2008-2010, 2011, 2012 and 2014-2016 at CIAH, Bikaner. After preliminary evaluation, data were compiled to assess the extent of genetic variability in the germplasm, and further the accessions short-listed based on prioritized traits and seasonal performance. Means of two-season data of short-listed and selected genotypes were used for the assessment of genetic variability component analysis, and means of four-season crop-genotype data was used for performance study.

Results and Discussions

Cucumis culti-group diversity study

The extremes of high and low-temperature conditions, scanty and uncertain rain patterns and drought-related stresses in the dry lands of north-western parts of India restrict intensive and high-yielding crop-genotypes cultivation. Therefore, vegetable farming with the native crop-plant species would be the best option under resource constraints hot climate. In this background, the available genetic diversity of the native cucurbits could play a greater role in making faster and easier crop improvement work, and also, utilizing the eco-adaptive variability, we can develop the need-based genotypes with desirable economic values and resource-based production systems (Samadia 2016; Samadia 2018; Samadia & Haldhar 2018).

Indian sub-continent is endowed with a wide range of cucurbitaceous crop-plant diversity, and their produce is used extensively in culinary preparations, dessert-salad and value-addition in respect of the seasons and regions. The north-western part of India is admired for the cultivation of kachri, kaakdia, mateera, tinda, kakdi, kheera-kakdi, kundru, kakoda and gourds with traditional practices. Both fresh and dehydrated products of these native cucurbits ensure nutrition-rich food and are relished by the inhabitants of the desert and tribal areas (Pareek et al. 1999; Dwivedi et al. 2003; Samadia & Haldhar 2020).

Out of six *Cucumis* species germplasm collected and reported (Chandra 1995), *C. sativus* and *C. melo* are available abundantly in Rajasthan, and variability in the landraces of variety *callosus*, *agrestis* and *momordica* under sand-dunes landscape of desert ecology is considered to be unique. In addition, the result of natural crossing among the different species and culti-groups of *Cucumis*, several intermediate types were stabilized that are quite different from the traditional forms. Based on surveys and explorations studies conducted under ICAR-CIAH projects over a decade period (1994 to 2004), it is accomplished that the types of cucurbits crop-plants found growing in the hot arid and semi-arid areas are distinctly different owing to the eco-adaptations and climatic variability of the regions as defined (Samadia 2007; Samadia & Haldhar 2019).

Maximum variability of *Cucumis* species germplasm was explored and collected (about 850 accessions) and several native forms were recorded with local names such as kachri, mat-kaachr, kaachra, kaakdia, kakdi, tar-kakri, aara-kakdi, aya-kakdi, wangaa, kir-kakdi, kheera-kakdi, balam-kakdi, chikan-kakdi, sawanariya and wild relatives. The germplasm availability was diverse and distinct with the zonal ecological and agronomic patterns of the state, and specific culti-group accessibility is also recorded with respect to the locations of western, northern, eastern, southern and central areas of Rajasthan. The ecological variability, rainfall patterns, land management systems and rainfed, irrigated, mixed or specific farming approaches with the rainy, winter and summer season crop cultivation provided an excellent opportunity to understand the range of *Cucumis* gene-pool and eco-type sources during the study period.

Cultivation of kachri melon and snap melon is very popular with mixed cropping of the conventional farming systems of the arid region, and it is found growing in millions of hectares of farm-land area under rainfed conditions. Owing to their drought-hardy characteristics, these cult-groups are not only adapted but also exhibit high productivity under abiotic stressed conditions of arid environments. However, the quality of marketable fruits is highly variable and uncertainty in yield components was recorded at each production site during the explorations. Therefore, the existing problems of the poor-quality fruit harvest and non-availability of desirable genotypes in these underexploited cucurbits need holistic attentiveness, and it could be achieved very easily through the use of native genetic resources for developing trait-specific varieties and integration of appropriate agro-techniques in accordance to the production sites (Samadia & Pareek, 1999; Samadia 2018; Haldhar et al. 2018).

In this way, there are specific areas with resource-based variable cropping and multiple-stressed production sites that are cultivating and conserving primitive landraces of indigenous cucurbits and on which a strategic research work plan for germplasm collection and utilization is needed. With this understanding, intensive research work for utilizing the wild forms, landraces and semi-cultivated germplasm of kachri melon were taken-up and a total of 625 accessions (kachri, mat-kaachr and intermediates) were studied from 1994 to 2012, and diverse 68 germplasm / pre-breeding lines are being maintained at ICAR-CIAH, Bikaner for conservation of native genetic resources.

Surveys and preliminary evaluation

In several literatures, kachri is documented as a wild or weedy cucurbitaceous plant, annual or perennial, prostrate or climbing vines bearing small-sized bitter fruits or sweet-sour taste at maturity, and botanically as *Cucumis callosus* / *agrestis* or culture. This primitive form is also known as *kaachr*, *kachria*, *mat-kaachr*, *kaachra*, *sainda*, *goradi* and many more names in various parts of the country. In Sanskrit, it is defined as *chitra*, *chitrphala* and *mrigakshi* whereas mango melon in English. Prior to the development of ICAR-CIAH kachri technology, it was deep-rooted that the rural people used to collect fruits from non-cultivable areas and farmlands because of the

food values and income as a bonus. However, there were no standard genotypes and promotion mechanisms for this unique cucurbit, and thus fruit yield and quality were very poor and variable.

The primary survey work established the facts that kachri is a non-dessert form of *Cucumis* melon and underutilized cucurbits in India. So far, it is unexploited and considered a rescue vegetable crop of Kharif season. Its mature fruits are used extensively in the vegetable culinary and are much liked for the preparations of chutneys, pickles and garnishing salad. Fruits are peeled, dried whole or sliced and stored as such or in powder forms. It has industrial demand to manufacture ready-to-use curry-powders and base material of spices for sweet-sour taste (Samadia & Pareek 1999). With this background and to develop trait-specific varieties, a first-time in-depth research work plan was executed so that it can be promoted as profit-making a crop of the dry lands. To achieve this, about 625 collected kachri melon accessions were systematically evaluated and categorized for use in the crop improvement work at Bikaner.

In our survey studies, kachri is found to be the most drought-tolerant cucurbit vegetable and acquired much socio-economic value with the rural people. It is annual and naturally grown as a self-sown plant. Its vine plants are found in abundant either wild or weedy forms during the kharif season mixed cropping in the wide-spread farmlands of the arid and semi-arid regions of Rajasthan and also in nearby state districts. In crop fields of sand-dunes landscape and traditional mixed cropping areas, especially in the districts of Nagour, Churu, Bikaner, Jodhpur, Barmer, and Jaisalmer, the kachri plants were very high in numbers/ha, and much branched, prostrate and scattered. At full-grown stages, fruits were much variable in size, shape, and skin longitudinally variegated with 7-10 green strips. The flesh or pulp is bitter at tender stages, but it is edible at maturity, and ripened fruits are harvested during the September to November months.

During the surveys, it was recorded that the fruit variability showed two distinct groups that were harvested accordingly for their uses (kachri/kaachr and mat-kaachr/kaachra). Fruits used for the vegetable culinary and dessert salad at maturity were 8-12 cm in length (medium to big size) whereas, the small size fruits of 5-8 cm in length were liked for processing and value-addition. In the farm-lands, plants were very much variable with respect to growth habit and fruiting, and at each collection site kachri fruit material was highly heterozygous and this might be owing to cross-pollination and cross-ability behavior with other forms or species of *Cucumis melo*. The prime reason is that the plants were self-sown from seeds of open-pollinated fruits, and a mixer of culti-group melon seeds is being used for established production practices. Nevertheless, tremendous variability was recorded with regard to the growth of bearing plants (0.25–3.75 m), fruit size (1.5–15.8 cm length), fruit shape (round, oval, globose, oblong, ovate, obovate, spindle, long), skin thickness, colour and hairiness, seed content and pulp quality attributes, and thus the variations offering ample opportunity to the

breeder for genetic improvement in this culti-group crops.

The intensive surveys and explorations work undertaken for *Cucumis* melon diversity by NRCAH/CIAH, Bikaner and NBPGR, Regional Station, Jodhpur from the year 1994 to 2001 in the arid and semi-arid and also tribal dominating sub-humid areas of Rajasthan resulted into wide-range of kachri melon collections and a total 625 accessions were evaluated in a phase-manner and all-together for characterization of germplasm under hyper-arid climate. At Bikaner, evaluated germplasm recorded incredible variability with respect to growth, maturity, flowering, fruiting and quality attributes of fruits, besides a good number of accessions possessing traits of biotic and abiotic stresses tolerant (Samadia 2003; Samadia 2007; Samadia & Pareek 1999; Haldhar et al. 2017).

The results of the preliminary and repeated evaluation of a large number of kachri melon germplasm either in the phases of years and altogether using minimal descriptor of 35 attributes exhibited that the variations patterns in population samples of accessions are highly heterozygous and it is a mixer of kachri, mat-kaachr and intermediate forms of *Cucumis* melon. In totality, the collections exhibited a wide range of genetic variability in the important characters such as days to the opening of the first female flower (28.2-48.7 DAS), days to first fruit harvesting (54.5-80.2 DAS), number of marketable fruits/plant (4.2-102.4), vine length (0.94-2.57 m), number of branches/plant (3.1-14.5), mature fruit weight (10.2-220.5 g), fruit length (2.31-12.01 cm), fruit diameter (2.21-6.53 cm) and edible flesh thickness (0.11-1.64 cm). Many variations was recorded for fruit shape (oval, round, oblong, long, spindle or pear), size (very small, small, medium and large), skin colour (light green to green, light yellow or orange to whitish, yellow, striped or mottled), flesh colour (whitish to whitish yellow or light orange to yellowish orange), flavour and taste. A good amount of variation was measured for the seed cavity of fruits, seed content, size and numbers.

During the course of the preliminary evaluation of the basic germplasm of kachri melon, season-wise data was subjected to correlation studies so that useful traits could be prioritized for purification and repeated evaluation of the material. In this context, days to male flower opening showed highly positive and significant correlations with days to first female flowering which in turn also showed highly significant correlations with days to first harvesting of fruits. Fruit weight showed highly positive and significant correlations with the fruit length, fruit diameter, fruit yield/plant, weight of seeds/fruit and seed yield/plant. Similarly, fruit length and fruit diameter showed significant and positive correlations with fruit yield/plant. A number of fruits/plants exhibited a very high and significant positive correlation with fruit yield/plant and seed yield/plant. Thus, after ensuring the marketable fruit quality parameters of the specific germplasm and objectivity of the crop produce, the evaluated germplasm can be short-listed based on the few prioritized traits as defined for purification and obtaining uniformity of material in kachri melon.

Based on the preliminary data and seasonal evaluation with prioritized traits on fruit and quality parameters, all the kachri melon accessions (625) were categorized and three groups were formed i.e. kachri (325), mat-kaachr (105) and intermediate (195) so that the germplasm can be short-listed to use in the selection breeding and also conservation at ICAR-CIAH, Bikaner. In our study, it is recorded that plants producing smaller-sized fruits (1.15–125.7 g weight) were prolific in bearing habit, fruits uniform in size with acidic taste at maturity, and accessions were mostly drought tolerant. For market values, oblong-round shape fruits weighing 45–85 g at maturity were preferred more for sweet-sour taste, processing and value-addition, in particular to dehydration and, thus, classified as kachri (*Cucumis melo* var. *callosus*). At harvesting stages, kachri fruit skin is stiff (tight), thick, greenish background and depicted longer shelf-life.

On the other side, accessions bearing medium to big-sized fruits were 54 – 256 g weight at maturity and used at the start of ripening stages, and can be considered as mat-kaachr (*Cucumis melo* var. *agrestis*). In general, mat-kaachr fruits are preferred for vegetable culinary and garnishing salad. Plants are moderate in bearing and fruits size is uniform and the harvesting period is shorter. Fruits ease to divide; flesh is more and sour-sweet taste with peculiar flavour. Fruit skin is thin and soft at maturity, has a pale-yellow to light-saffron colour background and depicts a moderate shelf-life. The accessions belonging to the intermediate forms were diverse and mostly recombinants of kachri, mat-kaachr or kaakdia (snap melon) and fruit bearing is poor to moderate in numbers. A mixer of attributed fruits was 144 – 496 g weight at maturity, and ripened fruits recorded sweet-sour, sour-sweet, sour or taste-less edible pulp of variable colour, quality and utility. Plants were least branched and fruit maturity is not uniform.

Breeding for varietal development

The short-listed germplasm and selected lines were purified (two to four generations) and evaluated repeatedly for the important traits of plant growth, flowering, fruiting and maturity, marketable quality and utility of fruits and size, shape and skin of the mature fruits, and further advancement was also done to obtained uniformity and characterization. Three season data of 25 agro-morphological characters from 35 promising lines of kachri and mat-kaachr was used for comparative performance information. In addition, the prioritized characteristics such as marketable fruit quality, earliness, number of fruits/plants and yield attributes were also taken into consideration for selecting the genotypes for further advancement and obtaining uniformity in economic traits. Some of the most promising materials were found to be free from fruit-fly infestation in the field and also showed a tendency of tolerance towards normal drought and abiotic stressed situations of hot arid climate and, therefore, were used for purification.

Among the isolated material, the minimum days required for the opening of the first female flower were recorded in AHK-155-1 (28.2 DAS) followed by AHK-109-

1 (30.4 DAS). The AHK-200-1 exhibited earliness in the first harvesting of fruits (54.8 DAS), whereas AHK-175-1 took maximum days for maturity (72.4 DAS). A maximum number of fruit settings and fruits/plants were recorded in AHK-28-1 (140.5 and 102.4) and the minimum in AHK-127-1 (14.4 and 11.2). Average fruit weight was higher in AHK-19-1 (150.1 g) and minimum (10.5 g) in AHK-356-1. Fruit length was higher in AHK-109-1 (9.45 cm), and the shortest fruits were in AHK-43-1 (2.30 cm). The maximum fruit diameter was in AHK-44-1 (5.72 cm) and minimum (2.21 cm) in AHK-43-1. The flesh thickness was maximum in the fruits of AHK-127-1 (1.64 cm) followed by AHK-99-1 (1.02 cm). Maximum vine length was recorded in AHK-109-1 (2.55 m) and minimum (1.15 m) in AHK-40-1. Maximum number of branches/plant (11.4) was recorded in AHK-5-1 followed by AHK-152-1 (10.5).

With four generations of the election cycle, the promising genotypes exhibited earliness characteristics and the range for days to the opening of the first male and female flower was 30.4 - 39.2 and 35.2 - 45.4 DAS, respectively. The line AHK 200-4-1 (70.1 DAS) followed by AHK 119-4-1 (72.1 DAS) exhibited earliness for the first fruit harvesting. The maximum number of branches (10.54) was in line AHK 202-4-1 and minimum in AHK 40-4-1 (5.24). The range for a number of marketable quality fruits/plants was 4.5 - 36.8 (AHK 43-4-1). Fruit yield and quality component characters of commercial significance were quite different in the evaluated lines. Therefore, the most essential parameters such as fruit size, taste, quality acceptability at maturity and utility rating were taken into consideration with the fruit yield/plant for selection of desirable genotypes. The genotypes AHK-5-4-1, AHK-13-4-1, AHK-43-4-1, AHK-119-4-2, AHK-202-4-1 and AHK-356-4-1 were the most potential and bore smaller sized fruits that could be much liked for use in vegetable culinary and processing (dehydration). On the other side, fruits of genotype AHK-26-4-1, AHK-99-4-1, AHK-109-4-1, AHK-155-4-1 and AHK 200-4-1 were potential for use in vegetable cooking and garnishing salad.

Performance of promising genotypes

Sixteen selected genotypes were tested for fruit yield potential with varying production situations, such as rainfed during the kharif season and summer crops with limited irrigations. The genotypes AHK-5(a), AHK-13(b), AHK-43(a), AHK-119(a), AHK-119(b), AHK-202(a) and AHK 356(a) bearing smaller size fruits of sweet-sour or acidic taste at maturity and potential for processing (dehydration, pickles and chutney) and vegetable culinary. In this group, genotype AHK-119 recorded the mean maximum fruit yield (97.64 q/ha) and possessed all the desirable attributes of quality and crop growth characteristics for commercial promotion. The genotypes AHK-26(a), AHK-26(b), AHK-99(b), AHK-109(a), AHK-155(a), AHK-155(b), AHK-200(a), AHK-200(b) and AHK-200(c) bears moderate to big sized fruits of sour-sweet taste at the maturity and found to be the most potential for use as dessert-salad and vegetable cuisine. In this group, the genotype AHK-200 recorded mean maximum fruit yield (120.5 q/ha) and possessed all the desirable attributes of quality and crop

growth characteristics for commercial cultivation. Both the genotypes depicted field-level tolerance towards the normal drought (15-18 days dry spell) and free from fruit-fly infestation under the hot, arid climate of the northwestern part of India.

Based on advanced varietal trial studies with the most essential horticultural traits such as fruit size, quality, maturity and yield characters for four seasons under drought and heat-stressed conditions, the genotype AHK-5, AHK-109, AHK-119, AHK-155, AHK-200, AHK-202, AHK-411, AHK-564 and AHK-572 were found to be the most superior for trait-specific selection and climate resilient or resource-based varietal development. The highest quality marketable fruit yielding, early harvesting, multiple utility and abiotic stresses tolerating varieties, namely AHK-119 and AHK-200, have been identified for commercial promotion (Samadia & Pareek 2000; Pareek & Samadia 2002; More et al. 2008). With varying production systems and seasons, the first harvesting of fruits was the earliest in AHK-200 (68.2 DAS), followed by 75.4 days after sowing in AHK-119. The mean yield of the kachri variety AHK-119 is 96.65 q/ha, and a vine bears 24.5 fruits (1.48 kg/plant). The mean yield of mat-kaachr variety AHK-200 is 109.52 q/ha, and a vine bears 19.4 fruits (1.90 kg/plant). Both varieties are tolerant of multiple-stresses, and thus, sowing can be done during the February-March and June-July months to harvest summer and rainy season crops under resource constraints and arid environments, respectively.

Kachri AHK-119: It is a high-quality fruit-yielding selection from the native landraces of Kachri and was identified in the year 1998 for commercial promotion by ICAR-CIAH, Bikaner. It is first developed for the systematic cultivation and promotion of kachri as a vegetable crop in hot, arid regions. It is drought and high-temperature tolerating selection (INGR number-98013) from the native germplasm and fruits much more suitable for processing (dehydration). It is very early in first harvesting (65 days after sowing), high yielding (95 q/ha) and short duration (115 days) variety. Mature fruits are oblong-round, small, sweet-sour taste and 50-60 g weight, 5-6 cm length and 4.0-4.5 cm diameter. Fruit flesh thickness is 0.4 cm, and the cavity is 3.04 cm wide, having too many seeds. Seed is small, soft and edible. It flowers very early, first male and female flower opening starts in 28 and 40 days after sowing, respectively. Vines are medium growth (1.7-2.5 m) with 5-7 primary branches. With the season's average, plants recorded 22 marketable fruits giving a yield of 94 - 99 q/ha.

Mat-kaachr AHK-200: It is high quality fruit yielding selection from the native landraces of mat-kaachr and identified in the year 1998 for commercial promotion by ICAR-CIAH, Bikaner. It is first developed for the systematic cultivation and promotion of multiple-use vegetable crops in hot, arid regions. It is drought and high temperature tolerating selection (INGR number-98014) from the native germplasm and mature fruits much suitable for garnishing vegetable salad and culinary. It is very early in first harvesting (65 days after sowing), high yielding (110 q/ha) and short duration (115 days) variety. Big-sized fruits are oblong in shape and light-yellow

colour with tight skin at maturity. Sour-sweet taste mature fruits are 100-120 g in weight, 7.5 cm in length and 5.1 cm in diameter. Fruit flesh thickness is 1.0 cm, and the cavity is 2.5 cm wide, and musky flavour at ripening. Seeds are few, small, soft and eaten with pulp. It flowers very early, first male and female flower opening starts in 26 and 32 days after sowing, respectively. Vines are medium in growth (1.75-2.51 m) with 5-7 primary branches. With the season's average, a vine produces 20 marketable fruits giving a yield of 100 - 113 q/ha.

Germplasm maintenance procedure and genetic variability

Kachri melon germplasm inventory, collection, conservation, utilization and maintenance is the curator's responsibility so that the native crop-plant species diversity can be promoted. The short-listed germplasm and selected lines were purified (two to four generations) and evaluated over the seasons, and the pre-breeding material seed was used for the preparation of composite samples for the medium-term storage studies on the conservation and maintenance cycle. This kachri melon germplasm lines seed was packed in gene-bank standard poly-bags and stored in deep-freeze (-20°C) facilities at Germplasm Conservation Laboratory of ICAR-CIAH, Bikaner. Random monitoring of seeds stored under refrigerator and deep-freeze conditions with variable packaging containers was done for viability studies through re-generation in the field at 5-, 10- and 15-years intervals and it has been concluded that stored germplasm seeds can be usable safely for cyclic maintenance of variety and breeding material at an interval of five and ten years, respectively.

Further, 68 germplasm lines seed was enhanced during the crop evaluation period of the year 2001 and freshly harvested seed material was stored using gene-bank standard poly-bags under deep-freeze (-20°C) facilities at ICAR-CIAH, Bikaner for conservation and breeding uses. During the kharif season of 2011 and 2012, the conserved 68 germplasm was used for studies on storage behaviour and maintenance and evaluated for trait-specific characterization. The kachri melon crop was raised both rainfed under a channel system of cultivation and drip technology with life-saving irrigations. With ten years of storage, germplasm seeds exhibited prompt germination (82–88 % within 4-5 days after sowing in the field) and good initial plant vigour was recorded. All the kachri melon germplasm exhibited normal growth and fruiting behavior, and evaluated with prioritized characters and seed enhancement was done for further conservation.

The evaluated germplasm lines recorded enough variations for the prioritized traits under investigation such as days to the appearance of first male flower (36.2–53.1 DAS), node number to first male flower (1.6–4.2), days to the appearance of the first female flower (41.5–60.4 DAS), node number to first female flower (2.9–5.2), days to the first harvest of mature fruits (74.3–88.6 DAS), fruit weight (15.7–138.3 g), fruit length (3.28–9.21 cm), fruit diameter (2.39–5.52 cm), number of fruits/plant (4.5–27.5), fruit yield/plant (0.097–2.026 kg), seed length (0.41–0.78 cm), seed width (0.17–0.38 cm),

the weight of seeds/fruit (0.502–3.897 g), seed yield/plant (3.291–52.993 g), the weight of 100 seeds (0.507–1.559 g), vine length (1.65–3.35 m) and number of branches/plant (5.6–14.5). The analysis of the variance of short-listed germplasm revealed the existence of highly significant genotypic differences for most of the quantitative traits, depicting greater variability in the material maintained.

For categorization, the germplasm lines were characterized on the basis of fruit size (very small, small, medium, large and very large), shape (oval, round, oblong-round, flat-round, oblong to long having obovate, ovate or pyriform) and utility at maturity and ripening stages. Mature fruit's rind or skin depicted high levels of variations (very tight and thick to very loose and thin) and also possess different patterns of dots either scattered or in rows; thus, this is a useful trait to screen material for shelf-life and tolerant to fruit-fly infestation. Variations in fruit rind colour were recorded, such as greenish-white, whitish-yellow, yellowish, saffron, blackish-green, greenish and mottled. Under absolute rainfed conditions of the arid climate, the short-listed germplasm lines exhibited a wide range of variations for the number of branches/plants, vine length and spreading behaviour and therefore, categorized for overall growth performance (poor, moderate, good and very good) so that suitability of the genotype with varying conditions can be understood. The germplasm was also screened for incidence of diseases and fruit-fly infestation, and in general, categorized as low, moderate, high and very high levels under the fields.

Out of 68 genotypes maintained, the material consisted about 48 % kachri, 28 % mat-kaachr and 24 % intermediates of non-dessert forms of *Cucumis* melon. Based on plant growth, maturity, fruit quality, uniformity, yield potential and overall performance, the genotype AHK-119 (oblong-round, mature fruits weighing 69.13 g and 22.16 fruits/plant), AHK-200 (oblong, mature fruits weighing 78.26 g and 14.63 fruits/plant), AHK-411 (oblong, mature fruits weighing 65.12 g and 15.53 fruits/plant), AHK-564 ((oblong, mature fruits weighing 95.22 g and 15.14 fruits/plant) and AHK-572 (oblong, mature fruits weighing 44.53 g and 13.53 fruits/plant) were found most superior for multi-location testing and also further use in breeding programmes. The maintained genotypes exhibit diverse attributes variability, and thus, there is ample scope for crop improvement for developing trait-specific and nature's resilient varieties of kachori melon, and similar results were also obtained in round melon and material germplasm under hot, arid climate (Samadia 2007; Samadia & Haldhar 2020).

Genetic variability component

In the short-listed germplasm study, the estimates of the genotypic and phenotypic coefficient of variation (GCV & PCV) indicated that there is enough scope for the improvement of kachri melon. In general, the estimates of PCV were higher than GCV for most of the characters except for the weight of the seed/fruit. The GCV, which gives a picture of the extent of genetic variability in the population, ranged from 2.81% (days to first harvest) to

52.18 (fruit yield/plant). The GCV estimates were higher for fruit weight (42.31%), number of fruits/plant (34.55%), fruit yield/plant (52.18%), weight of seeds/fruit (43.76%) and seed yield/plant (50.12%) whereas moderate for fruit length (22.62%) and weight of 100 seeds (20.53%) indicating better scope of improvement through selection. A close correspondence between PCV and GCV values with respect to all the characters indicated that the environment has very little influence on the expression of the characters under study. Under such a situation, selection can be effective on the basis of the phenotypic alone with equal chances of success.

With the help of GCV alone, it is not possible to determine the amount of variation that is heritable. Heritable variation can be worked out with a greater degree of accuracy when heritability (h^2 broad-sense) is taken into consideration along with genetic advance (GA). Hence, both heritability and genetic advancement were determined to understand the picture for the scope of improvement in various characters through selection. Very high heritability estimate values were obtained for most of the characters. Moderate values of heritability estimate were found for days to first harvest and seed length where as low values were recorded for node to male flower, node to female flower and seed width.

The genetic advance ranged from 4.66 to 104.18% of the mean (genetic gain). The investigation revealed that the economic trait, i.e. fruit yield/plant, could be improved by 0.74 units under 5% selection intensity (SI), which could be 104.18% higher than the mean. The high heritability value coupled with high genetic advance was for fruit yield/plant, seed yield/plant, weight of seeds/fruit, fruit weight and number of fruits/plants, and moderate for fruit length and weight of 100 seeds. Therefore, simple selection could be effective for the improvement of these traits due to additive type of gene action. High heritability estimates, along with low genetic gain with respect to days to the appearance of the first male and female flowers, were probably due to a non-additive type of gene action, and thus, direct selection for these traits will be less effective.

It is very clear from the data that traits like fruit yield/plant, seed yield/plant, weight of seeds/fruit, fruit weight and number of fruits/plants possessing high GCV, heritability and genetic gain could effectively be used in selection. It has been suggested that characters with high heritability and high genetic gain would respond to selection better than those with high heritability and low genetic gain. The high variability and heritability, along with high genetic advance as a percentage of the mean expressed by the above-mentioned characters, indicated that the genotypes could be tested in multi-location for performance and selected as donors for the characters or used as parents in a hybridization programme.

Correlation coefficients

In general, the magnitude of genotypic correlation coefficients was slightly higher than their corresponding phenotypic correlation coefficients for all the characters indicating thereby a strong inherent association between various traits under study. Fruit yield is a dependent character and is highly influenced by environmental factors, and for improvement, information on its

association with main components is beneficial. A strong, positive and significant correlation was recorded between fruit yield/plant with fruit weight (0.748), seed yield/plant (0.716), fruit diameter (0.599), fruit length (0.553), number of fruits/plant (0.549), test weight (0.385), the weight of seeds/fruit (0.417), seed weight (0.270) and seed length (0.259) indicating effective improvement through these characters could be achieved in kachri melon.

Days to first male and female flower appearance and days to first harvest had shown negative and non-significant correlations with fruit yield/plant. Days taken to first harvesting, which is a character of earliness or late, had a positive and significant association with days to first male and female flower appearance, which is clearly an indication of the mutual association of these traits for their expression. Fruit diameter showed positive and significant correlations with fruit weight, fruit length, weight of seeds/fruit, test weight, seed length, seed weight and seed yield/plant. Seed yield/plant showed positive and significant association with weight of seeds/fruit, number of fruits/plant, fruit weight, fruit diameter, fruit length, test weight and seed weight. Negative and non-significant association of days to the appearance of female flower and days to first harvest with a number of fruits/plant, which clearly indicated that early genotypes bear more number of fruits/plant. For effective selection and higher yields, a number of fruits/plant is an important character, but it may slightly affect the weight and size of fruits. therefore, a moderate balance has to be made for a medium number of fruits, weight and size to achieve better results in kachri melon in dry-land climate.

Products and uses

Mature and ripened fruits of kachri melon are nutritionally rich and relished both fresh and dehydrated. Fruits are usually cooked for making different vegetable cuisines and used to prepare the chutneys, pickles and salad. Kachri fruits are dehydrated on a large scale for off-season uses and are also unique ingredients of curry-power. Kachri fruits have a great impact on the social, cultural and religious occasions of desert dwellers. Fresh fruits used in *Diwali Pooja* and an extraordinary gift pack "*Dibadi*" is sent to kith and kin which contains dehydrated forms of traditional vegetables and fruits of arid region such as kachri, khelra, phopalia, ker, sangri, guarphali and many more. Kachri is one of the ingredients of the delicious vegetable popularly known as "*Panchkutta*" in the desert districts of northern-western India.

Mature fruits are peeled, dried whole or sliced and can be stored as such or in powder form. The dehydrated fruits sold @ 120-150 Rs/kg and have great potential in the ready-to-use spice manufacturing industry. Kachri powder is used as a souring agent in combination with chillies, coriander, turmeric, cumin, paan-methi and other condiments to manufacture various tastes of curry powder. In addition, kachri powder is also used to prepare "*Kach-churan*" in combination with black pepper, cumin, ginger, sugar and salts, and it is commonly used for therapeutical properties to cure stomach pain, nausea, vomiting and constipation.

Nutritional values

The diverse kachri melon genotype fruits were harvested at maturity stages, and the composite sample was formulated for food value analysis. The fresh fruit on 100 g weight basis contains 88.2 % water, 7.45 % carbohydrate, 0.28 % crude protein, 1.28 % fat, 1.21 % crude fibre, 1.46 % total nutrient elements, 0.09 mg calcium, 0.0029 mg phosphorus, 0.182 mg iron, 0.0046 mg copper, 0.052 mg zinc, 0.058 mg manganese and 29.81 mg vitamin C. The fresh fruit provides 47.24 K calories. Likewise, a composite sample of dehydrated fruits on 100 g weight basis contains 63.68 % carbohydrate, 2.41 % crude protein, 11.01 % fat, 10.41 % crude fibre and 12.51 mg total nutrient elements, 0.82 mg calcium, 0.025 mg phosphorus, 1.56 mg iron, 0.04 mg copper, 0.45 mg zinc, 0.495 mg manganese and 17.02 mg vitamin C. For value addition and processing promotion, kachri AHK-119 fruit samples were also assessed at marketable harvest stages. On a fresh weight basis, its mature fruits contain 89.32 % moisture and 10.68 % dry matter. On a dry-weight basis, total dry matter contains 61.5 % carbohydrate, 1.9 % protein, 12.3 % fat, 10.2 % crude fibre, 0.9 % calcium, 0.007 % phosphorus and 10.8 % trace ash.

Production technology

Systematic experimentation on kachori melon varieties adopting channel and drip systems of crop production under sandy soils of the arid regions resulted in the standardization of agro-techniques as a package of practices (Samadia 2016; Samadia 2018; More et al. 2018; Samadia et al. 2021). For normal sowing, on-set of monsoons in July and February is the best time to raise rainy-winter and spring-summer season crops, respectively. Surface-channel, arch or tent-type structure covering technology developed at ICAR-CIAH for protected cucurbits sowing in the first week of January is an excellent mechanism to minimize the ill-effects winter severity and results in early crop harvest, and higher income is obtained under climatic adversity.

After selecting the proper plot, the marked area should be cross-ploughed, followed by planking or the using a rotavator, and field preparation should be started 10–15 days prior to the sowing. About 50–60 cm wide and 20–25 cm deep channels (furrows) are made at 2.0 m distances for kachri cultivation. For uniform water distribution, crop-sown channels should be 25m in length on one side of the delivery line, and a 50x50m plot size is appropriate. Similarly, the side length of lateral pipes should not exceed 25m, and the unit plot should be 50x50 m in size with control valves. Four-hectare vegetable block can be managed with a drip unit through a digging-based water supply system of PVC pipe-line net-working of main (110mm), sub-main (75mm) and plot-line (63 mm) for pressurized irrigation as projected at CIAH. In addition, the integration of an overhead water storage reservoir and the solar-pumping system is a no-pole electricity water resource utilization concept that is much more practical for high resource productivity and insured crop production.

Based on soil fertility building-up studies at 0, 3, 6 & 9 years of vegetable cultivation fields, it is established

that only channels as seedbeds need to be fertilized and mixed thoroughly. Basal dose of FYM (50q), vermin-compost (5q), DAP (100kg), SSP (100kg), urea (50kg), MOP (50kg) and neem-leaf powder (10kg) is enough per hectare for maintaining field productivity. For drip technology, here, the manure-fertilized channels are converted into seedbeds on which laterals are laid down. Kachri melon seeds are sown at 50 cm distances, and sowing should be done only at the inner down-side of the northern slope of channels or near the drippers of lateral lines.

For hectare sowing, about 1.0 kg of seed is enough. Prior to sowing, seed should be soaked in water for 2–6 hours and also treated with fungicide. At each sowing point, 2–3 seeds are sown. After good germination and when the seedling attains 8–10 cm height or is 18-21 days old, thinning is done, keeping one or two healthy plants at each point. The crop should be irrigated at intervals of 7-9 days by flood method only in the channels or 3-4 days for 1.5-2.0 hours with drip technology (laterals 16 mm and 4 lph in-line emitters) under the sandy soils. Manual hoeing and weeding in channels and seedbed is done at 18-21, 30-35 and 45-55 days after sowing. A similar schedule is recommended for the application of urea (50 kg/ha) in 2-3 split doses as early plant growth, flowering and fruit setting stages and spraying of insecticides to manage minor insect pests.

For improving marketable fruits and quality seed yield in kachri var. AHK-119, a series of treatment combinations, were studied as experimental trials with channel and drip technology of crop cultivation during the rainy season of 2008 to 2010 (three years) at ICAR-CIAH, Bikaner, adopting khejri-based production site management approaches. The drip technology of crop production (laterals at 2.0 m distances and in-line emitters at 0.50 m apart & 4lph) with limited water as protective irrigations (1 to 3) during the long dry-spells improved the fruit yield potentials of about 22.5% as compared to channel system of cultivation.

Prospects and commercial harnessing

Realizing the significance of the drought-tolerating native cucurbits in the Indian Thar desert, the potentialities to extend the period of their fresh fruits' availability (April to November), considerable market demand and diversified utilities and therefore, strategic research work was undertaken at ICAR-CIAH, Bikaner for developing nature's resilient technologies. With the prime objective to utilize the native *Cucumis* diversity for developing the genotypes of different purposes such as culinary, salad, dehydration, and value-addition, it is recognized that the present research out-put on kachri melon could support promoting it as a profit-making commodity. In conclusion, the developed varieties of seeds and technology of kachri melon are cost-efficient and worthy of commercialization under resource constraints in arid regions.

The development of the kachri melon variety AHK-119 and production methods such as deep-furrow, channel and drip technology at ICAR-CIAH, Bikaner, resulted in better fruit yield and uniform harvest @ 95–110 q/ha as rainy and summer season crop. Now, the

newer technology of kachri melon is much more popular among growers and converted it as a sole vegetable crop. With the HBCPSMA concept, khejri-based crop production models KM-1, KM-3, KM-9 and KM-11 exhibited higher resource productivity, *i.e.*, khejri var. Thar Shobha (fresh sangri yield of 6.58 kg/plant) and kachri var. AHK-119 (fruit yield of 56.58 q/ha). This approach documented higher family employment and annual income @ Rs 75,000–2,25,000 in comparison to conventional crop cultivation (Rs. 23,000–42,000) per ha/year under absolute rainfed conditions.

The technological advancement and seed promotion chain in kachri melon resulted into its wide-spread

popularization not only in arid and semi-arid areas of Rajasthan but also in the drier parts of Punjab, Haryana, Gujarat, Madhya Pradesh and Maharashtra. Annually, 3-4 q truth-fully labelled seed of kachri-AHK-119 is being made available to the farmers through various institutions and related agencies, and further, it is multiplied by the progressive growers for their own and associated users. About 6000 hectares/year area is with ICAR-CIAH technology, and farmers are getting many benefits from the kachri cultivation as two seasons, off-season, inter-crop, low-input and less-water requiring crop-commodity.

Table 1. Average fruit yield potential of kachri melon varieties with varying production situations (mean of summer and rainy season of each year) at Bikaner

Fruit yield (q/ha)	1996	1997	1998	1999	2000	2001	Mean
Kachri AHK-119	94	99	96	96	95	95	95
Mat-kaachr AHK-200	106	113	109	109	100	112	109
Best control (AHK-5)	--	--	54	48	52	51	51

Table 2. Performance of kachri variety AHK-119 under absolute rainfed conditions and channel and drip technology with Khejri based crop production site (mean of 2010 to 2016) at Bikaner

Characters	Rainfed technology	Channel technology	Drip technology
Days to first male flower (DAS)	30.8	29.2	31.5
Days to first female flower (DAS)	34.7	32.5	34.1
Days to first harvest (DAS)	70.4	68.4	72.2
Fruit weight (g)	65.8	62.2	67.5
Fruit length (cm)	5.63	5.22	5.75
Fruit diameter (cm)	4.29	4.17	4.46
Number of marketable fruits/ plant	19.8	18.6	24.5
Fruit yield/ plant (kg)	1.43	1.15	1.65
Fruit yield/ ha (q)	98.84	95.4	129.5
Number of seeds/ fruit	304.6	279.5	355.8
Seed yield/ plant (g)	61.88	52.55	71.25
Seed yield/ ha (q)	3.82	3.56	4.25



Fruit variability in kachri melon germplasm



Fruit variability in kachri melon lines



Promising breeding lines



Flower and fruit growth stages



Bearing in kachri



Maturity in kachri



Mat-kaachar AHK-200



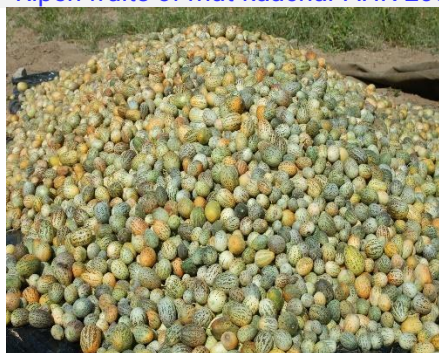
Ripen fruits of mat-kaachar AHK-200



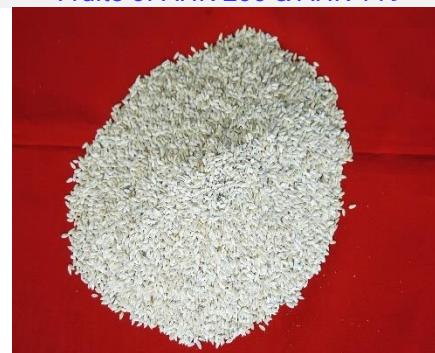
Fruits of AHK-200 & AHK-119



Fruits of kachri AHK-119



Fruits for fresh marketing



Kachri melon seeds



Field view of kachri technology



Kachri production technology



Khejri and kachri technology

Plates: Kachri melon diversity, potential lines, varieties and production technology

Table 3. Genetic variability component studies on kachri melon germplasm lines at CIAH, Bikaner

Characters	Min.	Max.	Mean	CD at 5%	ECV %	GCV %	PCV %	h ² % (broad sense)	Genetic advance (GA)	Genetic gain (5% SI)
Days to male flower (DAS)	36.2	53.1	41.81	0.73	1.09	7.87	7.95	98.10	6.72	16.07
Node to male flower	1.6	4.2	2.77	0.53	11.94	10.67	16.02	44.41	0.40	14.65
Days to female flower (DAS)	41.5	60.4	49.22	0.70	0.88	7.03	7.09	98.44	7.07	14.37
Node to female flower	2.9	5.2	3.99	0.52	8.18	7.93	11.40	48.47	0.45	11.38
Days to first harvest (DAS)	74.3	88.6	79.59	2.65	2.06	2.81	3.49	64.94	3.71	4.66
Fruit weight (g)	15.7	138.3	59.91	7.06	7.30	42.31	42.94	97.11	51.47	85.90
Fruit length (cm)	3.28	9.21	6.04	0.26	2.72	22.62	22.79	98.57	2.79	46.28
Fruit diameter (cm)	2.39	5.52	4.12	0.21	3.27	14.56	14.93	95.19	1.20	29.28
Number of fruits/plant	4.5	27.5	12.00	1.91	9.88	34.35	35.74	92.35	8.16	67.99
Fruit yield/plant (kg)	0.097	2.026	0.713	152.77	13.26	52.18	53.84	93.93	743.25	104.18
Seed length (cm)	0.41	0.78	0.56	0.05	6.14	8.65	10.61	66.49	0.08	14.53
Seed width (cm)	0.17	0.38	0.26	0.04	10.06	9.61	13.92	47.72	0.03	13.68
Weight of seeds/fruit (g)	0.502	3.897	1.718	0.01	0.64	43.76	43.76	99.98	1.54	90.14
Seed yield/plant (g)	3.291	52.993	20.415	3.22	9.77	50.12	51.07	96.34	20.69	101.35
Weight of 100 seeds (g)	0.507	1.559	0.895	0.02	1.75	20.53	20.60	99.27	0.37	42.14

Table 4. Genotypic (above) and phenotypic (below) correlation coefficients studies on kachri melon germplasm lines at CIAH, Bikaner

Traits	DMF	NMF	DFF	NFF	DFH	FW	FL	FD	NF/P	FY/P	SL	SW	WS/F	SY/P	W100S
DMF	1.000	-0.146	0.968	-0.003	0.615	-0.174	-0.119	-0.169	-0.043	-0.126	-0.147	0.071	-0.183	-0.149	-0.014
NMF	-0.108	1.000	-0.116	0.654	-0.198	-0.048	-0.088	0.001	-0.046	-0.073	0.092	0.088	-0.099	-0.106	0.168
DFF	0.965	-0.086	1.000	-0.016	0.639	-0.202	-0.131	-0.220	-0.055	-0.161	-0.154	0.039	-0.216	-0.191	-0.068
NFF	-0.003	0.331	-0.015	1.000	-0.101	-0.039	-0.081	0.060	0.008	-0.097	0.293	0.239	-0.067	-0.065	0.300
DFH	0.495	-0.153	0.522	-0.106	1.000	-0.302	-0.138	-0.307	-0.088	-0.249	0.035	0.007	-0.221	-0.195	-0.095
FW	-0.171	-0.036	-0.199	-0.013	-0.250	1.000	0.857	0.880	-0.066	0.754	0.578	0.445	0.621	0.469	0.639
FL	-0.118	-0.066	-0.131	-0.049	-0.124	0.843	1.000	0.661	-0.189	0.569	0.561	0.398	0.532	0.325	0.582
FD	-0.166	0.019	-0.218	0.051	-0.245	0.848	0.643	1.000	-0.088	0.637	0.537	0.372	0.557	0.405	0.699
NF/P	-0.036	-0.018	-0.049	0.001	-0.069	-0.057	-0.180	-0.093	1.000	0.536	-0.101	0.102	-0.070	0.539	-0.133
FY/P	-0.118	-0.037	-0.154	-0.071	-0.205	0.748	0.553	0.599	0.549	1.000	0.370	0.435	0.431	0.717	0.395
SL	-0.123	0.061	-0.128	0.053	0.018	0.439	0.454	0.423	-0.101	0.259	1.000	0.426	0.398	0.253	0.708
SW	0.062	-0.019	0.033	0.076	-0.047	0.273	0.271	0.251	0.089	0.270	0.379	1.000	0.402	0.399	0.548
WS/F	-0.181	-0.068	-0.214	-0.048	-0.178	0.612	0.528	0.543	-0.068	0.417	0.324	0.279	1.000	0.769	0.566
SY/P	-0.142	-0.054	-0.185	-0.046	-0.153	0.457	0.318	0.381	0.556	0.716	0.189	0.277	0.755	1.000	0.394
W100S	-0.013	0.113	-0.066	0.198	-0.087	0.628	0.576	0.678	-0.122	0.385	0.578	0.385	0.564	0.389	1.000

*Traits: DMF–Days to appearance first male flower (DAS), NMF–Node number to first male flower, DFF–Days to appearance first female flower (DAS), NFF–Node number to first female flower, DFH–Days to first harvest (DAS), FW–Fruit weight (g), FL–Fruit length (cm), FD–Fruit diameter (cm), NF/P–Number of fruits/plant, FY/P–Fruit yield/ plant (kg), SL–Seed length (cm), SW–Seed width (cm), WS/F–Weight of seeds/ fruit (g), SY/P–Seed yield/plant (g), W100S–Weight of 100 seeds (g).

Declaration of Interests

The authors have no conflict of interest to declare.

Data Sharing

All relevant data are within the manuscript.

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