Mateera, watermelon (*Citrullus lanatus*) germplasm utilization for improving fruit quality and marketable harvest under hot arid climate of India: approaches and out-put

DK Samadia & SM Haldhar

Journal of Agriculture and Ecology

ISSN: 2456-9410

Volume: 10

Journal of Agriculture and Ecology (2020) 10: 1-21
<http://doi.org/10.53911/JAE.2020.10201>

Review Article

Open Access

Mateera, watermelon (*Citrullus lanatus*) germplasm utilization for improving fruit quality and marketable harvest under hot arid climate of India: approaches and out-put

DK Samadia¹✉ & SM Haldhar^{1,2}¹ICAR-Central Institute for Arid Horticulture, Beechwal, Bikaner-334006²Present: Associate Professor, Entomology, College of Agriculture CAU, Imphal✉ Corresponding author: DK Samadia, E-mail: samadiadk@yahoo.com

Article Info

Article history

Received: 22 September 2020

Accepted: 20 November 2020

Available online: 31 December 2020

Key Words: *Citrullus*, mateera, watermelon, tumba, tinda, drought tolerant germplasm, crop improvement, hot arid environment.

Abstract

Cucurbits, a big group of vegetable cultivated extensively in India. It consist wide-range of crops used in culinary, salad, dessert, pickling and processing. Indigenous cucurbits both fresh and dehydrated form ensuring nutritious food to inhabitants of tribal and desert areas. Kachri, kaakdia, mateera, tinda and tumba is grown under rainfed situations and its cultivation is admired with the traditional farming in north-western parts of Rajasthan. Mateera is under-utilized, drought tolerant and native form of watermelon. Its nutrition rich tender and ripen fruits and seed-kernel liked by desert dwellers and sold at high premium. For developing drought and heat tolerant genotypes in mateera, ICAR-CIAH initiated first-time intensive research and wide range of *Citrullus* germplasm collected, conserved and utilized in crop improvement work from 1994 to 2012. In past, absence of standard varieties in drought tolerant mateera, the arid zone farmers obliged to use heterozygous seed collected from fruits (based on taste) of own fields. This obviously results poor and no-insured quality. On evaluation of the *Citrullus* germplasm (254 entries) at Bikaner, watermelon genotypes failed to express their potentialities under high temperature and rainfed conditions. Therefore, use of indigenous and generated variability, and promotion of varieties from native germplasm is found to be beneficial. Mateera line AHW-18, AHW-19, AHW-65, AHW-108, AHW-140, AHW-RSS-1 and AHW-BSM-1 are promising for use in breeding or trait-specific selections. The developed mateera varieties *i.e.* AHW-19 and Thar Manak are early in harvesting, producing better quality fruits and multiple-use, and recommended for cultivation under resource constraints hot arid environment.

Copyright ©2020 Samadia & Haldhar, This is an open access article published under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Preferred citation: Samadia DK & Haldhar SM. 2020. Mateera, watermelon (*Citrullus lanatus*) germplasm utilization for improving fruit quality and marketable harvest under hot arid climate of India: approaches and out-put. *Journal of Agriculture and Ecology*, 10: 1-21; <http://doi.org/10.53911/JAE.2020.10201>.

Introduction

The Indian sub-continent is rich in cucurbitaceous crop-plants diversity. In vegetable group, both annual and perennial cucurbits play significant role and widely used for cooking, salad, dessert and processing. The arid and semi-arid region of north-western India is endowed with wide-range of genetic variability in particular to *Citrullus* and *Cucumis* having multiple-use and drought tolerant attributes. Indigenous cucurbits viz., kachri, kaakdia, mateera, tinda and tumba are component crops of traditional farming and playing vital role in providing nutritious food and income to inhabitants of desert ecosystem (Pareek & Samadia 2002; Pareek et al. 1999). Among *Citrullus*, mateera is native form of watermelon (*C. lanatus*) and is much useful to farmers for getting benefits from ripen fruits, loiya, seed, rainfed, organic, low-input and less-water requiring crop-commodity in the hot arid area of Rajasthan. Non-edible fruits bearing and perennial species, tumba or indrayan is bitter melon (*C. colocynthis*) and ripen fruits used for pickle making, medicine, seed-oil and bio-fuel. Third-one is seasonal and popular vegetable of dry-land i.e. tinda or round melon (*Praecitrullus fistulosus*; syn. *Citrullus vulgaris* var. *fistulosus*) and widely grown for its immature and dehydrated fruits (phophalia) for culinary. These rescue cucurbits predominantly grown on sand-dune landscape and desert sandy soil, rainfed and mixed-crop with bajra and legume (cluster bean, moth bean and cowpea) during the kharif season (Samadia & Pareek 1996; Haldhar et al. 2015).

Non-availability of trait-specific and

requisite genotype suited to abiotic stressed production sites of Indian arid zone is prime limiting factor in promoting native cucurbits. Therefore, long-term research work-plan was made at ICAR-CIAH, Bikaner with the objective to improve drought hardy *Citrullus* species variability for quality fruit yield under dry-land climate of Rajasthan. Owing to low moisture and heat stresses adaptability and also high fruit bearing capacity of native *Citrullus*, a wide-range of germplasm was assembled through explorations and augmentation (Samadia 2007). To collect the regional cucurbits genetic diversity, intensive surveys were conducted from 1994 to 2003, and evaluated and categorized for use in selection and hybridization breeding. In addition, a large number of generated progenies from germplasm and breeding material developed through identified parentage combinations were studied over the seasons and years to conclude the results of strategic research programme of varietal development, and elaborated in this paper.

Materials and Methods

Physiography and agro-climate: In India, Rajasthan ($23^{\circ} 3' - 30^{\circ} 12' \text{ N}$ and $69^{\circ} 3' - 78^{\circ} 17' \text{ E}$) is geographically big state and 40 % area is hot arid (19.6 million hectare) and remaining is semi-arid and dry-land climate. Here, annual rainfall varies from 150 to 550 mm and is erratic. Out of 9–21 mean rainy-days/annum, much of rain often comes in a few (1–5) heavy events during monsoon season (June–September) and is un-certain. In kharif, day-time high temperature range $35 - 42^{\circ}\text{C}$ and prolonged drought spells of 15–35 days in-together sandy soils creates an environment where very few native crops can

survive and viable under rainfed situations. The collected mateera germplasm, varieties and breeding material was evaluated at experimental farm of CIAH, Beechwal, Bikaner ($28^{\circ} 6' N$ latitude and $73^{\circ} 2' E$ longitudes and altitude 223 m) and this area is hyper-arid zone. In hot arid areas, winter is dry and minimum temperature fluctuates ($4-10^{\circ} C$) in December–January and some-times it prolonged to February. Most of years, low temperature dips-down below freezing (-1 to $-6^{\circ} C$) and frost is very common. Here, winter temperature variability determinates sowing-time and cropping period. In north-western part of the state, March–October months are hot, dry and sunny with continuity of high temperatures around $38^{\circ} C$ for prolonged period and results to excessive evapo-transpiration from crop-plants and soil-surface. In summer, maximum temperature in May–June is above $40^{\circ} C$ in east to $42^{\circ} C$ in the west zone. But it is very common to experiences extremes of temperature $42-47$ and $45-50^{\circ} C$ for the numbers of days (21–28 days), respectively and this period night temperature ($31-35^{\circ} C$) is also very high.

Sand-dune or desert-field soil is coarse texture, poor in organic matter, nutrients and water holding capacity. Sand, fertile top-soil and fine particles continuing blow-away due to strong wind and thus affecting crop production potential. The crop-plants get damaged through sand blasting on seedlings, leaves, stem, 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 peak summer, adversity of heat stress is very high and vine growth and

produce quality sun-burns, and some-times plants dried due to heat-strokes. To assess the crop-genotypes, experiments were conducted over the seasons and year with normal sowing *i. e.* on-set of monsoon rains in July month and mid-February with limited irrigations. Germplasm collection and augmentation: Realizing the potentials of regional diversity and mateera cultivation in dry-lands of north-western parts of India, intensive surveys and explorations were organized in targeted variability pockets of arid, semi-arid and tribal areas of Rajasthan from 1994 and 2003 by CIAH, Bikaner. In addition, collaborative explorations were also made under the mission-mode of institute and NATP on plant bio-diversity programme with NBPGR (RS) Jodhpur for collection of dessert and non-dessert forms of *Citrullus* and *Cucumis* germplasm in Rajasthan. Maximum variability and native land-races of mateera, tumba and tinda was collected from north-western districts (Bikaner, Churu, Nagour, Jodhpur, Barmer, Jaisalmer, Pali and Hanumangarh) with desert ecology, rainfed and mixed cropping during the kharif.

Whereas, watermelon germplasm (28 entries) was explored from Sikar, Jaipur, Tonk, Ajmer, Kota, Chittorgarh, Udaipur, Sirohi and adjoining districts with the semi-arid climate and summer season cultivation. In addition, introduced and national watermelon genotypes (11 entries) were assembled from NBPGR, New Delhi, RARI, Durgapura (Jaipur), IIHR, Bengaluru and AICRP (vegetable crops) IIVR, Varanasi. In this way, a rich *Citrullus* diversity was collected through surveys and sampled from wide-range of locations having variable climate, soil,

topography and production systems (rainfed, irrigated and river-bed). Open-pollinated fruit / seed samples were collected, biased or randomly and passport information was compiled on area, growth, fruits, variability pattern and cultivation practices at the production sites. Germplasm evaluation and utilization: Over the years collected *Citrullus lanatus* diversity either through surveys and explorations or assembled from other organizations at CIAH Bikaner were evaluated and characterized systematically and it was in phase-manner. Minimal descriptor with 35 attributes was used for vegetative growth, flowering and fruiting behaviour, maturity, fruit yield, quality and seed characters studies for all the material under evaluation. Both mateera and watermelon germplasm were categorized based on prioritized traits such as earliness, number of fruits, fruit quality and marketable yield under high temperature and abiotic stressed conditions of hot arid environment.

The improved watermelon varieties, hybrids, purified mateera material and developed lines were evaluated over the seasons and assessed to understand their potentialities under arid climate and also suitability for two season cultivation. Therefore, each germplasm or breeding material was studied at least four times as rainy and summer and rainfed and irrigated situations. For evaluation of each germplasm or breeding line, single-row of 25 metre length was kept standard throughout the experimental trials and 50 plants/genotype/row maintained. With the starts of flowering, twelve plants were tagged in each genotype and four groups were made for recording observations. Thus,

collected *Citrullus* accessions (mateera-178, watermelon-39, tinda-32 and tumba-5) were evaluated in phase manner as well varying environments. A wide-range of data generated for mateera and watermelon germplasm and it was with seasons and production situations of 1995-1999 and 2000-2003 at CIAH, Bikaner. After evaluation, data were compiled to assess extent of genetic variability in germplasm, and genotypes short-listed based on performance and prioritized traits. Means of two season data of short-listed and selected genotypes were used for assessment of genetic variability components and means of four season crop data analyzed for comparative study. For purification of native mateera, promising germplasm lines were identified based on fruit quality trait and performance over the season. After purification, mateera selections were compared with standard watermelon varieties for fruit quality and yield component. Simultaneously, breeding for improvement of drought tolerant mateera through hybridization was initiated with the objectives to improve adaptive selections for acceptable flesh quality, higher sweetness and cultivation under water stress and high temperature conditions.

Here, the mateera selections (AHW-18, AHW-19 and AHW-65) and watermelon varieties (Sugar Baby, Durgapura Meetha, Charleston Local and Mahobobi) were selected for hybridization breeding (single and diallel). The developed F_1 , F_2 , BC_1 , BC_2 and parents and bi-parental material were studied for their performance as rainy and summer season crop during 1999-2003. Promising segregates selected in F_2 generation and breeding work advanced and emphasis was

given through individual plant selection based on fruit flesh quality traits and adaptability under dry-land climate. From 2004–2010, most promising lines, selections and varieties of mateera and watermelon were evaluated with varying season and situations. Since, fruit flesh quality, cracking-free, marketable yield and tolerant to prevailing climatic conditions of arid region were prioritized components for mateera, therefore, long-term data were assessed in various formats to conclude the research work.

Results and Discussions

Scanty rains, extremes of high and low temperatures in-together associated abiotic stresses in hot arid and semi-arid areas of north-western India limiting crop-genotypes choice and produce quality (Samadia 2016). Here, vegetable intensification with adaptive and native crop-plant species is in-general found to be the most appropriate and stable with dry-land climate. Genetic diversity has vital role in making rapid crop improvement, and utilizing available variability we can develop genotypes with greater economic values and cultivation under a set of environmental conditions. Indian sub-continent is primary and secondary or an area

of regional diversity for a large number of vegetable significant crop-plants. The dry-lands of north-western parts of country is also possesses good genetic diversity in most of cucurbits (Samadia 2018). Based on survey studies, it is come-up that the types of vegetable crop-plants found growing in arid and semi-arid area are distinctly different presumably due to the eco-adaptations and climatic variability. The north-western arid zone of Rajasthan grows some typical cucurbits and less-known vegetable significant crop-plants. The *Aravalli* range separates desert eco-system of the west zone from the eastern semi-arid zone, and here diverse vegetables are in traditional cropping. Under arid climate, rich genetic variability do exists in *Citrullus* and *Cucumis* group. In dry-lands, collection of native land-races, germplasm and varieties and their evaluation contributed maximum in vegetable diversification and production. Thus, collection, conservation and utilization would continue to be the best, dependable and desirable approach for crop improvement under abiotic stressed conditions of Rajasthan (Samadia 2007; Samadia & Haldhar 2017; Haldhar et al. 2016).

Table1. Agro-morphological variations for important characters in evaluated mateera germplasm

Character	Range
Vine length (m)	2.21 – 6.50
Number of branches/plant	3.12 – 6.45
Days to opening of first male flower (DAS)	24.5 – 45.2
Days to opening of first female flower (DAS)	40.2 – 55.5
Node number to appearance of first female flower	5.4 – 18.5
Number of fruits-set/plant	3.5 – 20.8
Days to first harvesting of ripen fruits (DAS)	72.5 – 110.5
Number of marketable fruits/plant	0.85 – 7.45
Fruit length (cm)	10.32 – 40.50
Fruit girth (cm)	25.91 – 73.54

Fruit weight (kg)	0.50 – 8.55
Edible flesh thickness (cm)	9.85 – 18.55
Non-edible flesh thickness (cm)	1.25 – 3.15
Number of seeds/fruit	280 – 840
TSS (⁰ Brix)	2.12 – 10.5
Fruit shape	Round, oblong-round, oblong and long
Fruit rind colour	Green-dark green clear stripes, green and dark green not clear stripes or light green with narrow lines and netting
Flesh colour and firmness	Whitish, light pink, pink to reddish in colour and loose to medium in firmness
Seed colour	Khaki, reddish, blackish, brownish, whitish and mottled

In vast-spread traditional farming systems of arid and semi-arid farm-lands, mixed cropping of pearl-millet (bajra), cluster bean, moth bean, moong bean or cowpea is dominating in millions of hectare. Here, indigenous cucurbits such as kachri, kaakdia, mateera, tinda and arya-kakri are the rescue and underutilized vegetable crops. In addition, native perennial tree-plants such as khejri, ker, lasora, kumat, jharber, bordi, khimp, phog, guarpatha and tumba have horticultural attraction, ensuring nutrition rich food produce and providing subsistence income under rainfed conditions to the desert dwellers. Likewise in semi-arid and tribal area, mixed cropping with maize, urd bean, moong bean, cowpea, cluster bean or pigeon-pea is performed during the kharif and in which native forms / land-races of mat-kachar, phut, arya-kakri, wanga-kakri, chikan-kakri, kundru, kakoda, bhindi, bakala-phali, sem-phali, komba-phali and conch-phali are the supporting vegetables to the local inhabitants (Samadia & Haldhar 2019; Choudhary et al. 2015). Hence, there are specific areas with

multiple-stresses in the country like hot arid and unique forms in cucurbits are grown and on which not much research work is done for conserving diversity and its utilization. To fulfill vegetable and nutritious diet requirement, the best approach is to breed acceptable quality and high yielding varieties, and that should be superior to the existing ones and suited under extremes of climatic variability. By understanding the facts, systematic and intensive surveys in target variability pockets and crop-specific explorations in the arid, semi-arid and tribal dominating areas of Rajasthan and Gujarat were conducted for collection of wild, land-races and semi-cultivated germplasm of native cucurbits and un-exploited vegetable crop-plants. A rich variability in mateera, watermelon, tinda and tumba was collected, evaluated and utilized over the years (1994 to 2012) as *Citrullus* genetic resource (254 entries) and presently 75 germplasm/ breeding material is being maintained at CIAH (Dwivedi et al. 2003; Samadia 2003).

Fruit variability in indigenous mateera

Flesh and quality variations in F₂ generation

Fruits of mateera var. AHW-19

Fruit yielding mateera var. Thar Manak

Multiple-use mateera mutant AHW-BSM-1

High seed yielding mateera AHW-RSS-1

Fruits of multiple-use mateera Var. AHW-65

High protein and edible oil rich mateera seeds

Plate 1. Genetic variability and utilization studies in drought tolerant mateera germplasm at CIAH

Table 2. Growth, flowering, fruiting and quality characters of selected drought tolerant mateera genotypes (over the seasons)

Genotypes	Days to first female flower (DAS)	Number of fruit set / plant	Days to first harvest (DAS)	Number of marketable fruits / plant	Fruit weight (kg)	Fruit length (cm)	Fruit girth (cm)	Edible flesh thickness (cm)	Non-edible flesh thickness (cm)	TSS (^o Brix)	Vine length (m)	Number of branches /plant	Flesh Colour*	Flesh grade*
AHW- 01	49.78	6.86	93.35	2.63	5.23	40.83	61.68	16.32	2.36	7.22	4.20	6.46	LP	B
AHW-12	55.42	4.53	96.83	2.11	3.48	28.38	61.55	12.56	1.77	7.02	2.52	4.27	LP	B
AHW-16	53.42	7.76	90.54	3.70	4.23	28.72	58.42	14.38	2.05	7.51	2.55	4.52	P	A
AHW-18	48.46	8.83	82.37	4.84	4.16	30.52	61.65	14.51	1.82	8.04	4.52	6.24	DP	A
AHW- 19	47.87	8.60	80.50	4.59	3.93	35.65	59.58	12.46	1.60	8.44	3.01	5.55	DP	A
AHW-20	50.46	5.50	87.46	3.08	3.13	34.34	55.58	14.22	1.72	5.45	2.17	4.25	LP	A
AHW-65	44.15	9.91	78.05	5.26	2.83	28.97	55.55	13.23	1.73	8.22	2.56	5.61	P	A
AHW-73	45.16	7.63	88.44	4.57	3.75	31.77	55.44	10.64	2.24	6.41	3.56	5.46	LP	B
AHW-82	47.28	7.44	88.11	3.16	5.22	34.39	70.90	16.04	2.28	7.77	3.11	6.14	P	B
AHW-85	44.79	7.46	90.39	4.24	4.52	33.45	67.27	12.14	2.56	7.52	3.23	5.23	LP	B
AHW-108	46.47	8.36	86.96	4.12	3.48	28.71	55.38	12.81	1.63	8.06	4.13	6.19	DP	A
AHW-118	48.51	6.73	88.41	4.09	4.08	30.91	62.08	14.23	1.81	7.81	3.13	5.27	DP	A
AHW-120	48.91	6.60	88.12	4.44	4.23	34.09	64.24	15.18	1.80	7.63	3.24	6.20	P	A
AHW-123	49.36	6.77	86.55	4.07	4.84	33.40	68.00	12.44	2.83	6.08	2.84	6.35	LP	B
AHW-140	49.84	8.25	89.77	4.08	4.09	35.74	58.23	12.37	2.07	7.20	3.28	5.25	LP	B
Sugar Baby	74.20	5.19	103.70	1.14	2.83	25.41	61.05	15.61	1.47	9.24	3.22	5.21	R	AA
Durgapura Meetha	70.17	6.13	104.29	1.42	3.42	24.60	68.57	14.59	2.10	9.35	3.76	5.53	R	AA
Mean	51.43	7.21	89.64	3.62	3.97	31.70	61.48	13.75	1.99	7.58	3.24	5.51	-	-
CV (%)	1.8	4.9	1.3	4.2	3.8	1.7	1.1	2.0	4.2	1.2	4.1	1.9	-	-
CD (5 %)	1.57	0.59	1.88	0.25	0.25	0.90	1.12	0.44	0.13	0.14	0.22	0.17	-	-

* Light pink (LP), Pink (P), Dark pink (DP) and Red (R) colour; Very firm or solid (AA), Solid (A) and Semi-solid or loose (B) flesh.

Table 3. Mean performance of watermelon and mateera genotypes under hot arid conditions during 1996 and 1997 at CIAH, Bikaner

<i>Genotypes</i>	Days to first female flower (DAS)	Number of fruit set / plant	Days to first harvest (DAS)	Number of marketable fruits / plant	Fruit weight (kg)	TSS (⁰ Brix)	Vine length (m)	Number of branches /plant	Flesh Colour	Flesh firmness	Number of cracked fruits /plant
Durgapura Meetha	53.78	5.83	99.15	2.06	3.98	9.03	3.90	5.23	Red	Solid	1.42
Sugar Baby	57.40	5.60	98.61	1.50	2.53	9.46	3.05	4.20	Red	Solid	1.51
Arka Manik	58.37	6.73	88.15	1.85	4.04	8.30	3.34	6.00	Dark pink	Semi-solid	1.33
Arka Jyoti	51.68	8.53	86.38	1.86	4.12	8.96	3.07	5.97	Red	Solid	1.61
MHW-11	52.02	6.43	84.72	2.23	5.42	8.33	3.29	4.94	Dark pink	Solid	1.25
NHW-102	56.72	8.94	84.81	2.13	5.22	8.50	3.32	6.30	Dark pink	Solid	1.32
Mateera AHW-18	48.11	7.63	83.20	4.10	4.64	8.06	4.00	5.33	Pink	Semi-solid	0.00
Mateera AHW-19	44.08	8.86	79.91	4.30	3.93	8.33	3.35	5.46	Dark pink	Semi-solid	0.00
Mateera AHW-65	42.16	9.98	74.74	5.10	3.00	8.37	3.18	6.17	Pink	Semi-solid	0.00
Mean	51.59	7.61	86.63	2.79	4.10	8.59	3.39	5.51	--	--	--
CV (%)	1.9	5.2	1.5	6.4	3.9	2.3	5.5	3.2	--	--	--
CD (5 %)	1.71	0.68	2.27	0.31	0.28	0.34	0.32	0.30	--	--	--

In Rajasthan, dessert and non-dessert forms of melon are cultivated extensively with varying seasons and production situations. Arid and semi-arid region of the north-western India is endowed with rich genetic diversity in most of melons and in particular to *Citrullus* group having drought tolerant and multiple-use attributes. Both *Citrullus lanatus* and *Praecitrullus fistulosus* have unique variability patterns. Owing to drought tolerating capacity, mateera is the specific land-race of desert eco-system. It is grown rainfed in the kharif and its seeds uniform and khaki in colour. Other-side, watermelon grown in the semi-arid region with irrigations during summer season and seeds much variable and it is mostly developed through introduced varieties. Similarly, tinda is in the same trends and semi-cultivated, tough and dark-green to whitish-green skin types is from the desert eco-system and grown in kharif season. The soft flesh and light-green skin type material grown irrigated during summer in semi-arid climate. Besides, bitter melon or tumba (*Citrullus colocynthis*) is perennial creeper, wild and found abundant in Thar desert and lesser variability exists. Mostly yellow colour and smooth rind fruits are 6–9 cm diameter, roundish, bitter flesh and lot of seeds. Mateera, tinda and tumba is grown widely on sand-dunes in mixed cropping, and also following a special **Bari** practices (micro-catchments) where about litre water is poured at each seed-sowing point and it is in March month to harvest rainfed produce. Thus, a good number of vegetable potential crop-plants are well adapted to dry-land climate. But the marketable quality and yield is

marginal in native genetic material and this is due to the problems from abiotic and biotic factors. However, the main cause is non-availability of desirable genotypes suited to the prevailing climatic conditions and cultivation under resource constraints arid environment. On other side, arid and semi-arid areas of Rajasthan (27.1 million ha & 79.08 % of the state) is best for quality mateera yield during rainy and summer, and it is due to high temperature, low humidity and plenty of sunshine conditions at fruiting period (Samadia 2007).

Drought tolerant mateera

Mateera is an indigenous form and drought tolerating watermelon (*Citrullus lanatus*). It is widely grown in north-western part of India in particular to arid region of Rajasthan during kharif. Mouth appeal of mateera fruit is attributed to sweet taste, aroma and refreshing edible pulp. Ripen fruits consumed fresh as dessert-salad and have juicy and cooling pulp. Tender fruits weighing 100 g (loiya) are used extensively for vegetable culinary and rayta. Loiya is rich in nutrition and 100 g fresh weight contains 96.3 % moisture and 3.7 % dry matter. On percent basis, dry matter contains carbohydrate (35.71), protein (12.15), fat (18.25), crude fibre (25.4), calcium (5.8), phosphorus (0.18) and trace elements (3.3). Seed are protein rich (25–32 %), roasted and eaten as snacks. Seed also yield nutritive oil (30–40 %). Seed kernels (magaz) is extracted on large-scale and used in sweets, bakery and ice-creams. Rind of ripen fruits is pickled or turned into sugar-candy (tuty-fruity), and is animal feed too.

Table 4. Performance of selected F₁ hybrids and their parents under hot arid conditions (mean of rainy & summer season) at Bikaner

Parents / hybrids	Days to first female flower (DAS)	Days to first harvest (DAS)	Number of marketable fruits/plant	Fruit weight (kg)	Fruit length (cm)	Fruit girth (cm)	TSS (^o Brix)	Flesh colour	Flesh firmness
Mateera AHW-19	46.02	77.00	3.82	3.84	27.86	67.31	8.06	Dark pink	Semi-solid
Mateera AHW-65	43.33	75.06	4.94	2.90	21.38	59.38	8.09	Pink	Semi-solid
Charleston Local	79.02	116.66	1.24	3.25	32.51	56.42	8.18	Red	Solid
Mahabobi	84.33	115.00	1.54	2.79	26.41	59.42	8.12	Dark pink	Solid
Sugar Baby	72.66	102.16	1.44	2.89	26.42	61.88	9.21	Red	Solid
Durgapura Meetha	69.05	101.20	1.69	3.44	28.54	69.32	9.45	Red	Solid
Mateera AHW-19 x Sugar Baby	54.25	95.66	5.04	3.86	29.29	60.45	5.13	Dark red	Solid
Mateera AHW-19 x Charleston Local	50.12	95.12	5.13	3.27	31.98	60.98	8.20	Red	Solid
Mateera AHW-65 x Sugar Baby	57.12	100.33	4.12	3.53	27.74	62.20	6.23	Red	Solid
Mateera AHW- 65 x Charleston Local	54.66	98.73	6.04	2.89	27.88	56.23	8.42	Red	Solid
Mean	61.03	97.67	3.50	3.26	28.02	61.36	7.91	-	-
CV (%)	1.9	1.5	1.9	2.3	1.6	1.2	0.9	-	-
CD (5 %)	2.02	2.54	0.11	0.13	0.77	1.25	0.13	-	-

Table 5. Genetic variability components for various characters from short-listed mateera/ watermelon germplasm at CIAH, Bikaner

Characters	Minimum	Maximum	Mean	CD (5%)	ECV (%)	GCV (%)	PCV (%)	h ² (%) (broad sense)	Genetic advance (GA)	Genetic gain (5%SI)
DFM	34.02	54.17	44.48	0.75	1.03	11.80	11.81	99.74	10.80	24.28
NMF	3.12	10.21	5.53	0.19	2.09	26.95	26.98	99.80	3.07	55.47
DFF	43.77	67.23	52.90	1.05	1.21	11.36	11.38	99.62	12.36	23.37
NFF	6.05	21.34	12.13	0.45	2.28	28.38	28.41	99.78	7.08	58.41
DFH	76.02	114.65	88.87	1.14	0.78	11.28	11.29	99.84	20.63	23.22
MF/P	1.03	5.45	1.90	0.09	3.06	69.67	69.69	99.94	2.73	143.47
FY/P	0.99	17.52	6.29	0.40	3.87	85.23	85.26	99.93	11.04	175.53
FW	0.78	6.81	3.10	0.10	1.98	47.89	47.91	99.94	3.06	98.64
FL	16.11	44.60	26.69	0.76	1.73	25.43	25.45	99.85	13.97	52.35
FG	35.58	70.87	53.93	1.26	1.42	16.47	16.49	99.75	18.28	33.89
EFT	8.15	17.68	13.79	0.39	1.73	15.26	15.30	99.57	4.32	31.38
NEF	0.74	2.78	1.74	0.07	2.55	28.61	28.65	99.74	1.02	58.87
TSS	5.14	10.92	8.32	0.27	1.99	17.77	17.81	99.58	3.04	36.54
VL	2.50	4.48	3.08	0.15	2.96	16.30	16.39	98.91	1.02	33.39

B/P	4.05	6.27	5.05	0.17	2.12	13.77	13.83	99.21	1.43	28.27
NS/F	63.32	418.55	201.90	4.23	1.27	52.24	52.25	99.98	217.29	107.62
STW	2.30	12.10	6.26	0.06	0.61	37.51	37.51	99.99	4.84	77.26
SL	0.72	1.35	1.04	0.02	1.66	17.26	17.29	99.69	0.37	35.50
SW	0.43	0.85	0.63	0.01	0.93	17.96	17.97	99.91	0.23	36.98

Where: DFM- Days to first male flower (DAS), NMF- Node to first male flower, DFF- Days to first female flower (DAS), NFF- Node to first female flower, DFH- Days to first harvest (DAS), MF/P- Marketable fruits/ plant (No.), FY/P- Fruit yield/plant (kg), FW- Fruit weight (kg), FL- Fruit length (cm), FG- Fruit girth (cm), EFT- Edible flesh thickness (cm), NEF- Non-edible flesh thickness (cm), TSS (⁰ Brix), VL-Vine length (m), B/P- Branches/plant (No.), NS/F- Number of seeds/fruit, STW- Seed test weight (g), SL- Seed length (cm) and SW- Seed width (cm).

Why mateera cultivation in arid region?

For production of mateera, farmer's broad-cast its seeds with mixed cropping of bajra or arid legumes. With good rains, farmer's collected mateera fruits during October-November and it is the period of harvesting kharif crops and fruits ensure income as bonus. In recent years, its cultivation is also popular as sole or inter-crop of orchards. Now, it is grown as irrigated crop in particular for loiya production under extremes of high temperature conditions (Samadia and More 2011). The non-availability of drought tolerant mateera varieties in the recent past, farmers used heterogeneous and mixed seed collected from cross-pollinated crop and it is based on sweetness of fruits. Intensive studies on flesh character of open-pollinated crops of mateera were done at farmer's fields, and it is concluded that hardly 10 % fruits are marketable quality. Hence, use of such seeds, there is no guarantee of fruit quality prior to cut it. Thus, absence of mateera varieties, productivity and quality is variable and poor. Consequently, it fetches low market price and returns to growers. Likewise, commercial watermelon varieties and hybrids (Durgapura Meetha, Arka Manik, Sugar Baby, Charleston, Mahobobi, Arka Jyoti, etc) needed high and

frequent irrigation water, poor yielding and suffer from fruit cracking under high temperature conditions in summers. In rainy season, these genotypes exhibited poor fruit quality and high level of viral complex in plants, and cannot grow under rainfed situation.

Breeding for marketable quality fruits in mateera

Realizing the importance of drought tolerant and multiple-use mateera in the Indian desert and potentialities to extent its period of fruits availability (April to November), it calls for concerted research. Looking this, systematic work-plan on mateera improvement was taken since 1994 with objectives to develop standard varieties for uniform and quality fruit production including dessert-salad, loiya and high seed content. To fulfill this, intensive surveys were conducted from 1994 to 2002 in arid and semi-arid areas of Rajasthan and wide range of genetic variability was collected in *Citrullus* species at CIAH. The collected germplasm was characterized, evaluated and utilized in improvement programme over the years (1995 to 2010) and also conserved at national gene-bank. On evaluation, the collected germplasm exhibited enough variations for agromorphological components of vine, fruit, flesh

quality and yield attributes. A wide range is recorded for important traits such as days to first male flower appearance (24.5-45.2 DAS), days to first female flower appearance (40.2-55.5 DAS), node to first female flower (5.4-18.5), number of fruit-set/plant (3.5-20.8), days to first harvest (72.5-110.5 DAS), number of fruits/plant (0.85-7.45), fruit length (10.32-40.50 cm), fruit girth (25.91-73.54 cm), fruit weight (0.50–8.55 kg), TSS (2.12-10.5⁰ Brix), vine length (2.21-6.50 m) and number of branches/plant (3.12-6.45). Much variability is also recorded for fruit rind, stripes pattern, flesh colour, content and seeds. Both collected and generated material was repeatedly studied for variability parameters and most of the attributes exhibited similar trends under investigation.

Thus, wide-range of variability exists in genotypes under utilization (tables) and it is with respect to growth, flowering, maturity, fruits, flesh quality and seediness besides tolerant to biotic and abiotic factors and which is required for crop improvement. During characterization, *Citrullus* germplasm were categorized based on economic traits and promising mateera lines viz., AHW-18, AHW-19, AHW-65, AHW-108, AHW-140,

AHW-RSS-1 and AHW-BSM-1 identified. Among watermelon, Sugar Baby, Durgapura Meetha and Charleston Local were potential for flesh firmness and colour under hot arid climate. First time, two high yielding mateera selections namely AHW-19 and AHW-65 developed, released for immediate gains in 1998 and growers accepted it for uniform harvest under rainfed conditions. However, two essential traits of commercial watermelon *i.e.* eye-appealing flesh quality and sweetness were not materialized in mateera varieties developed by the institute. Therefore, intensive breeding work was done involving AHW-19, AHW-65, Sugar Baby, Durgapura Meetha, Charleston and Mahobobi. First of all, a large number of progenies were generated using selected parentage in combinations (F_1 , F_2 , BC_1 , BC_2 and bi-parental) and evaluated. Simultaneously, requisite segregates isolated from F_2 to develop individual plant progeny and selfing precedes selection for generation advancement. Four prioritized traits such as flesh quality, earliness, tolerant to cracking and yield behaviour under high temperature and abiotic stressed situations were kept to screen the progenies.

Table 6. Path analysis (direct and indirect) for various characters in short-listed mateera / watermelon germplasm at CIAH, Bikaner

CHR	DFM	NMF	DFF	NFF	DFH	MF/P	FW	FL	FG	EFT	NEF	TSS	VL	B/P	NS/F	STW	SL	SW	FY/P (GR)
DFM	-	-	-	-	-	0.756	0.092	0.172	0.052	-	0.114	0.041	0.145	0.358	0.270	0.131	0.230	-	-
	0.923	0.704	0.827	0.675	0.759					0.044								0.009	0.713
NMF	0.326	0.427	0.326	0.332	0.313	-	-	-	-	-	-	-	-	-	-	0.043	-	0.010	-
						0.250	0.007	0.080	0.036	0.008	0.114	0.045	0.096	0.156	0.091		0.012		0.485
DFF	-	-	-	-	-	0.650	0.009	0.152	-	-	-	0.026	0.159	0.364	0.097	-	0.048	-	-
	0.820	0.697	0.915	0.704	0.845				0.052	0.073	0.015					0.074		0.142	0.601
NFF	0.943	1.003	0.994	1.290	0.867	-	-	-	0.015	0.104	-	-	-	-	-	0.208	-	0.089	-
						0.834	0.151	0.446			0.308	0.035	0.282	0.561	0.451		0.050		0.626
DFH	1.079	0.961	1.212	0.882	1.312	-	-	-	-	-	-	0.021	-	-	-	0.182	-	0.221	-
						0.739	0.110	0.313	0.069	0.044	0.173		0.121	0.411	0.123		0.034		0.516
MF/P	-	-	-	-	-	2.088	0.271	0.301	0.370	0.087	0.049	0.426	0.878	0.940	1.101	0.838	1.045	0.674	0.887
	1.711	1.222	1.483	1.350	1.176														
FW	0.002	0.000	0.000	0.003	0.002	-	-	-	-	-	-	-	-	-	-	0.004	0.002	0.005	0.491
						0.003	0.028	0.023	0.024	0.021	0.017	0.002	0.002	0.000	0.013				
FL	-	-	-	-	-	0.233	1.315	1.617	1.109	0.994	0.751	0.023	0.062	0.274	0.834	-	-	-	0.441
	0.301	0.304	0.268	0.560	0.386											0.368	0.200	0.335	
FG	-	-	0.039	0.008	-	0.120	0.578	0.464	0.677	0.549	0.352	0.135	0.256	0.035	0.375	0.018	0.050	0.038	0.473
	0.038	0.057			0.035														
EFT	-	0.029	-	-	0.051	-	-	-	-	-	-	-	-	0.315	-	-	-	0.035	0.398
	0.072		0.122	0.123		0.063	1.168	0.934	1.232	1.519	0.882	0.558	0.283		0.344	0.022	0.114		
NEF	-	-	0.011	-	-	0.016	0.418	0.320	0.359	0.401	0.690	-	0.092	-	0.197	0.031	0.058	0.064	0.344
	0.085	0.184		0.164	0.091							0.052		0.157					
TSS	-	-	-	-	0.004	0.058	0.029	0.004	0.057	0.105	-	0.287	0.060	0.030	0.016	0.011	0.048	0.002	0.254
	0.012	0.030	0.008	0.007						0.021									
VL	-	-	-	-	-	0.054	0.019	0.005	0.048	0.024	0.017	0.027	0.129	0.056	0.028	0.025	0.032	0.034	0.503
	0.020	0.029	0.022	0.028	0.012														
B/P	0.341	0.323	0.351	0.383	0.276	-	-	-	-	0.182	0.201	-	-	-	-	0.142	0.056	0.084	0.352
						0.396	0.021	0.149	0.045			0.094	0.384	0.880	0.064				
NS/F	0.470	0.344	0.170	0.562	0.151	-	-	-	-	-	-	-	-	-	-	-	-	-	0.596
						0.847	0.738	0.828	0.890	0.363	0.459	0.094	0.352	0.117	1.606	0.599	0.749	0.755	
STW	0.480	-	-	-	-	-	0.514	0.771	-	-	-	-	-	0.547	-	-	-	-	0.340
		0.342	0.274	0.546	0.471	1.359			0.091	0.050	0.151	0.132	0.662		1.263	3.387	3.128	3.017	
SL	-	-	-	-	-	0.784	-	-	0.117	0.118	0.132	0.264	0.391	-	0.730	1.447	1.566	1.341	0.492
	0.390	0.046	0.083	0.060	0.040		0.155	0.194						0.100					
SW	0.018	0.045	0.298	0.133	0.324	0.619	-	-	0.108	-	0.178	0.015	0.515	-	0.902	1.708	1.642	1.918	0.262
							0.376	0.397		0.044				0.184					

Table 7. Genotypic (above) and phenotypic (below) correlation co-efficient among various characters in short-listed mateera / watermelon

CHR	DFM	NMF	DFF	NFF	DFH	MF/P	FY/P	FW	FL	FG	EFT	NEF	TSS	VL	B/P	NS/F	STW	SL	SW
DFM	1.000	0.763	0.896	0.731	0.822	-	-	-	-	-	0.047	-	-	-	-	-	-	-	0.009
NMF	0.761	1.000	0.762	0.777	-	0.819	0.713	0.100	0.186	0.056	-	0.124	0.044	0.157	0.388	0.292	0.141	0.249	0.023
DFF	0.893	0.759	1.000	0.770	0.732	0.585	0.485	0.017	0.188	0.084	0.019	0.266	0.106	0.225	0.366	0.214	-	0.029	0.155
NFF	0.729	0.776	0.768	1.000	0.924	0.710	0.601	0.010	0.166	0.057	0.080	0.017	-	0.028	0.173	0.398	0.106	0.053	0.069
DFH	0.821	0.730	0.921	0.671	1.000	0.646	0.626	0.117	0.346	0.012	0.081	-	0.238	0.027	0.218	0.435	0.350	0.038	0.169
MF/P	-	-	-	-	-	0.563	0.516	0.084	0.238	0.053	0.033	0.132	0.016	0.092	0.313	0.094	0.139	0.025	0.323
FY/P	0.818	0.584	0.709	0.645	0.562	1.000	0.887	0.130	0.144	0.177	0.041	0.023	0.204	0.420	0.450	0.527	0.401	0.500	0.262
FW	-	-	-	-	-	0.129	0.490	1.000	0.813	0.854	0.769	0.605	0.102	0.149	0.024	0.459	-	-	-
FL	0.100	0.017	0.009	0.117	0.084	0.144	0.441	0.812	1.000	0.685	0.615	0.464	0.014	0.038	0.169	0.515	0.151	0.098	0.196
FG	0.186	0.187	0.165	0.345	0.238	0.177	0.472	0.853	0.684	1.000	0.811	0.520	0.200	0.378	0.052	0.554	0.227	0.124	0.207
EFT	0.056	0.084	0.058	0.012	0.053	0.041	0.397	0.767	0.612	0.808	1.000	0.580	0.367	0.186	-	0.226	0.014	0.075	-
NEF	0.048	-	0.079	0.081	0.034	0.023	0.344	0.604	0.463	0.519	0.578	1.000	-	0.133	0.207	0.285	0.044	0.084	0.023
TSS	-	-	0.016	-	0.132	0.203	0.253	0.101	0.014	0.200	0.366	-	0.075	0.209	0.228	0.058	0.039	0.168	0.007
VL	0.044	0.106	0.027	0.027	0.017	0.418	0.501	0.147	0.039	0.375	0.185	0.133	0.207	1.000	0.436	0.219	0.195	0.250	0.268
B/P	-	-	-	-	-	0.448	0.351	0.024	0.168	0.051	-	-	0.103	0.433	1.000	0.073	-	-	-
NS/F	0.386	0.365	0.396	0.432	0.312	0.527	0.595	0.459	0.515	0.553	0.206	0.225	0.058	0.218	0.072	1.000	0.161	0.064	0.096
STW	-	0.214	0.105	0.349	0.094	0.401	0.340	-	-	0.027	0.014	0.044	0.038	0.194	-	0.372	1.000	0.923	0.890
SL	0.141	-	0.101	0.080	0.138	0.500	0.492	0.151	0.227	0.073	0.074	0.085	0.167	0.249	0.160	0.465	0.921	1.000	0.856
SW	0.009	0.023	0.155	0.069	0.168	0.322	0.261	-	-	0.056	-	0.092	0.007	0.266	-	0.470	0.890	0.854	1.000
								0.195	0.207		0.023				0.095				

The desirable progenies and their derivatives were advanced over the years and evaluated both rainy and summer of 2000 to 2004. Fruit quality, fruiting behaviour, reaction to cracking, insects and diseases were taken into consideration to screen the developed progenies. In F_6 generation, few progenies of cross combination of AHW-19 x Sugar Baby exhibited desirable trends for fruit flesh (colour, firmness, content and TSS) and yield. After assessing fruit quality components among $F_{6/a}$ family, four blocks ($F_{6/a/3}$, $F_{6/a/7}$, $F_{6/a/9}$ and $F_{6/a/10}$) were developed and advanced for uniformity. On evaluation, these

showed desirable trends for earliness, number of marketable fruits/plant, fruit size, shape and flesh quality. The fruit quality and yield components of advanced family $F_{6/a/10}$ was much superior and highly acceptable depicting internally as good Sugar Baby and rind characters as mateera. This was further advanced in isolation and open-pollinated progeny named $F_{6/a}$ (Thar Manak) and released in 2007. The developed variety is devoid of cracking and suitable for spring-summer and rainy season cultivation under hot arid climate.

Table 8. Range values of characters in advanced progenies from cross combination of AHW-19 x Sugar Baby selected for fruit quality improvement in drought tolerant mateera at CIAH, Bikaner

Generation	F ₂	F ₃	F ₄	F ₅	F ₆	F ₆
Season/year	Rainy	Summer	Rainy	Summer	Rainy	Summer
Character	1999	2000	2000	2001	2001	2002
Days to first female flower (DAS)	41.2-51.5	40.2-55.1	41.7-57.2	46.2-58.6	32.5-38.9	40.1-44.2
Days to first harvest (DAS)	75.5-95.2	75.4-92.1	72.4-98.6	75.4-94.2	70.4-74.6	74.1-76.2
Number of fruits-set/plant	8.5-11.4	7.3-13.2	6.5-13.2	6.2-14.0	10.5-16.4	11.1-14.2
No. of marketable fruits/ plant	2.1-4.2	1.5-5.6	2.5-5.1	3.2-5.0	3.5-5.0	3.6-4.6
Vine length (m)	2.5-3.5	2.4-3.8	2.5-3.2	2.1-2.9	3.1-3.9	3.1-3.6
Number of branches/plant	4.2-6.4	4.1-6.5	4.2-6.2	4.2-5.8	5.5-6.2	5.4-6.0
Fruit weight (kg)	1.5-4.5	2.5-5.6	1.8-5.7	2.0-3.9	4.9-5.2	4.5-5.2
Fruit length (cm)	13.4-28.5	20.1-28.3	19.4-29.6	12.9-24.5	20.1-24.5	20.3-25.1
Fruit girth (cm)	48.5-64.5	52.4-68.4	54.2-66.1	50.2-63.4	62.4-66.8	57.2-68.4
Edible flesh thickness (cm)	11.5-16.4	12.2-19.4	12.8-20.4	13.7-17.4	16.5-18.4	16.5-19.2
Non-edible flesh thickness (cm)	1.1-2.4	1.2-2.3	1.1-2.3	1.1-2.2	1.5-1.8	1.9-2.1
TSS (⁰ Brix)	10.2-13.5	7.0-12.8	7.8-13.2	10.1-12.8	10.5-11.8	10.2-12.8
Fruit shape	Round,	Round,	Round,	Round,	Oblong	Oblong

Flesh colour	Oblong Red, deep pink, pink, yellow, saffron, whitish	Oblong Red, deep pink, pink, yellowish- white	Oblong Red, deep pink, pink, yellowish- white	Oblong Red, deep pink, pink	Red, deep pink, pink	Red, deep pink
Seed colour	Black, brown, mottled	Black, brown, mottled	Black, brown, mottled	Black, brown, mottled	Black, brown, mottled	Black, brown
Seed size	Big, medium, small	Big, medium, small	Big, medium, small	Big, medium, small	Big, medium	Big, medium
Seed quantity	Few to many	Few to many	Few to many	Few to many	Moderate	Moderate

Table 9. Mean performance of drought tolerant mateera variety Thar Manak with channel and drip technology of crop production under hot arid conditions (average of summer and rainy season crops from 2008 to 2010) at CIAH, Bikaner

Characters	Channel technology	Drip technology
Days to appearance of first male flower (DAS)	33.5	35.5
Node number to first male flower	5.5	5.7
Days to appearance of first female flower (DAS)	41.5	43.7
Node number to first female flower	9.8	10.2
Days to first harvest (DAS)	72.5	78.5
Vine length (m)	2.2	2.54
Number of marketable fruits/plant	3.7	4.24
Marketable fruits yield/plant (kg)	12.33	15.58
Fruit weight (kg)	3.12	3.54
Fruit length (cm)	21.0	23.5
Fruit girth (cm)	54.0	58.2
Edible flesh thickness (cm)	13.8	14.9
Non-edible flesh thickness (cm)	1.48	1.52
TSS (⁰ Brix)	9.8	10.2
Number of seeds/fruit	319.5	335.5
Weight of seeds/fruit (g)	39.3	42.2
Seed yield/plant (g)	108.4	122.2
Weight of 100 seeds (g)	11.8	12.5
Seed length (cm)	1.31	1.32
Seed width (cm)	0.74	0.75
Seed thickness (cm)	0.29	0.30
Flesh colour	Red	Red
Flesh firmness grade	A	A
Seed colour	Black	Black

AHW-19

It is multiple-use selection and rainfed cultivation. Appearance of first female flower starts at 45 days and tender fruits (loiya) ready for harvesting from 58 days of sowing. Ripen fruits ready for first harvesting at 75-77 DAS, and are 3.8-4.1 kg weight, 30-33 cm length and 60-65 cm girth. Oblong shape fruits have dark green-green clear stripes on the smooth rind. It bears 3.1-3.4 ripen fruits/ plant and yielded 192–386 q/ha. Flesh pink, firm, good taste and 8.0-8.4 % sweetness. High in seeds, 489-527 number/ fruit and weight of 100 seeds is 9.12-9.27 g. Seed bold and khaki in colour.

AHW-65

It is dual-purpose selection and early in fruit harvesting under rainfed conditions. Medium growth vines 3.1 m length and producing andromonoecious flowers resulting to higher fruit setting. Tender loiya harvesting starts at 55 days and ripen fruits from 72 days after sowing. It bears 3.7-4.2 fruits/ plant and yields 182-341 q/ha. Mature fruits are round, green stripes on smooth rind, medium sized and 2.8 kg weight, 25-29 cm length and 58-61 cm girth. Ripen fruits have 14-15 cm edible flesh and 1.5-1.7 cm non-edible flesh. Flesh is pink, firm, sweet and 8.0-8.5 % TSS. The fruit have excellent keeping and transport quality

Thar Manak

It is wider acceptable fruit quality selection and tolerant to drought, high temperature and abiotic stressed conditions. It is through hybridization from cross combination of AHW-19 x Sugar Baby. It is early in first harvesting (75 DAS) and high yielding (185–355 q/ ha). Ripen fruits are oblong-round with dark green-green stripes on

smooth rind. Fruits weighing 2.65-4.21 kg are 20-22 cm length and 58-62 cm girth, and free from cracking. Flesh is attractive, reddish, firm, granular and 9.5-11.2 % TSS. Seeds very big, bold, black and low (160-266 number/ fruit). It is suitable for summer and rainy season irrigated crop and also rainfed cultivation during kharif.

AHW-RSS-1

It is trait specific selection from native germplasm and stabilized in 2012 for high seed yield under rainfed conditions. It is short duration, harvesting starts at 80 days and vine bears 3.2 mature fruits. Fruit is big and oblong shape with non-stripe light green and smooth rind. Ripen fruits 7.9 kg weight, 32 cm length and 68 cm girth. Edible flesh firm but white in colour, 15.5 cm thick and non-edible is 2.5 cm wide. Fruit very high in seeds (950-1120 number), weight of 100 seeds is 9.8 g and yield 295-335 g/plant. Seed big, bold and reddish in colour.

AHW-BSM-1

It is black seeded mutant spotted in 2005 from AHW-19 crop and selected in 2012 for multiple-use, high seed-yield and rainfed cultivation. Harvesting starts from 80 days and vine bears 2.5 fruits and yield is 11.0 kg/plant. Fruits medium sized, oblong with green-dark green stripes and smooth rind. Ripen fruits 4.4 kg weight, 22.4 cm length and 61.6 cm girth. Edible flesh is firm, pink, 16.8 cm thick and non-edible 1.2 cm wide. Fruits high in seed (891 numbers) and 214 g/plant yield. Seed is big, bold and black in colour.

Future strategies

Breeding for improvement in fruit quality and productivity is a continuous nature of work to ensure genotypes for cultivation

under high temperature, drought, low-rains / water and suitability to organic, off-season or prolonged period of harvesting. In addition, increased *Citrullus* demand invites timely re-setting of priority and the breeding programmes should be focused through use of native germplasm and value-added genotypes developed else-where. Since, the existing genotypes are susceptible to virus complexes, temperature and abiotic stresses of hot arid conditions. Based on gap analysis in germplasm utilization over 25 years at CIAH, some issues have been identified for in-depth analysis and strengthening the activities:-

- a) Utilization of regional and national genetic resources of mateera/ watermelon for breeding high temperature stresses tolerant genotypes with better quality marketable fruit yield under varying production environment,
- b) Utilization of indigenous mateera germplasm to develop trait-specific/ value-added genotypes such as loiya and seed-kernels for production under rainfed and abiotic stresses conditions, and its promotion through seed-chain due to their regional preferences,
- c) Distant hybridization and combination breeding using mateera and tumba gene-pool to develop viruses tolerant watermelon genotypes for cultivation under abiotic and biotic stresses areas,
- d) Conservation and use of native *Citrullus* germplasm for breeding varieties and cultivation under low-input, organic, rainfed, surface-covering protective technique as mechanism of escaping severity of winter for short-period and vertical harvesting under hot arid climate.

References

- Anonymous. 1994–2019. Annual reports. National Research Centre for Arid Horticulture / Central Institute for Arid Horticulture (ICAR), Bikaner (Rajasthan) India.
- Anonymous. 2005. Final report - NATP on sustainable management of plant biodiversity - Collection, evaluation and maintenance of arid horticultural crops. Co-operating centre of NBPGR, Central Institute for Arid Horticulture (ICAR), Bikaner (Rajasthan) India.
- Choudhary BR, Haldhar SM, Maheshwari SK, Bhargava R & Sharma SK. 2015. Phytochemicals and antioxidants in watermelon (*Citrullus lanatus*) genotypes under hot arid region. *Indian Journal of Agricultural Sciences* 85 (3): 414–417.
- Dwivedi NK, Bhandari DC, Bhatnagar N & Samadia DK. 2003. Diversity of kachri and mateera in arid region of Rajasthan. In: Human impact on desert environment (eds. Naraian, Pratap, S. Kathju, Amar Kar, M. P. Singh and Praveen Kumar). Arid Zone Research Association of India and Scientific Publishers (India) Jodhpur (India). pp478–482.
- Haldhar SM, Choudhary BR & Bhargava R. 2016. Susceptibility of watermelon genotypes to fruit fly *bactrocera cucurbitae* (coquillett). *Indian Journal of Entomology*, 78(2): 170-173.
- Haldhar SM, Choudhary BR, Bhargava R & Meena SR. 2015. Antixenotic and allelochemical resistance traits of watermelon against *Bactrocera*

- cucurbitae* in a hot arid region of India. *Florida Entomologist*, 98(3): 827-834.
- Pareek OP & Samadia DK. 1999. Watermelon (mateera) varieties developed by NRCAH. ICAR NEWS, 5 (2): 14-15.
- Pareek OP, Vashishtha BB & Samadia DK. 1999. Genetic diversity in drought hardy cucurbits from hot arid zone of India. IPGRI-APO Regional Newsletter for Asia, the Pacific and Oceania, 28: 22-23.
- Pareek OP, Vashishtha BB, Vishalnath, Samadia DK & Singh RS. 1999. Horticultural resources in Thar dessert. In: Natural resources in Rajasthan (eds. Anil Kumar, Rajesh Sharma and Madhu Sharma), SKRAU, Bikaner. pp4-9.
- Pareek, O.P. and Samadia, D.K. (2002). Promising indigenous cucurbit varieties. *Indian Horticulture*, 47 (2): 15-18.
- Samadia DK & Haldhar SM. 2017. Breeding strategies and scope of improvement in arid zone fruit crop-plant under abiotic stressed agro-climate: an analysis. *Journal of Agriculture and Ecology*, 4: 1-13.
- Samadia DK & Haldhar SM. 2019. Scope and strategies for genetic improvement in vegetable crop-plants under high temperature and abiotic stressed climate of Rajasthan: A gap analysis. *Journal of Agriculture and Ecology*, 8: 1-18.
- Samadia DK & Pareek OP. 1996. Variability in drought hardy watermelon (*Citrullus lanatus*) type mateera in arid eco-system. Abstract of paper In: Second International Crop Science Congress. November 17-24, 1996. New Delhi. P9-015:p278.
- Samadia DK & Pareek OP. 1998. Genetic diversity in watermelon type "Mateera" (*Citrullus lanatus*) in hot arid environment. Abstract of paper In: XVIIIth International Congress of Genetics. August 10-15, 1998. Beijing, China. 8P64:p147.
- Samadia DK & Pareek OP. 2001. AHW-19 and AHW-65: New mateera varieties. *Indian Horticulture*, 46 (2): 8-9 & 21.
- Samadia DK and More TA. 2011. Thar Manak to quench thirst in desert. *Indian Horticulture*, 56 (5): 14-15.
- Samadia DK, Nallathambi P, Vashishtha BB & Dhandar DG. 2002. Quality improvement in drought hardy mateera (*Citrullus lanatus*) under hot arid conditions. Abstract of paper In: International Conference on Vegetables. November 10-14, 2002. Bangalore, India. II-86P:pp84-85.
- Samadia DK, Pareek OP & Vashishtha, BB. 2000. AHW-19 and AHW-65: Watermelon type mateera selections for the hot arid eco-system. Abstract of paper In: Third International Crop Science Congress-2000, August 17-22, 2000. Hamburg, Germany.
- Samadia DK. 2003. Genetic resource management for sustainable horticultural development in arid regions of India. In: Sustainable Resource Management (eds. B.B.S. Kapoor and Ali Ahemad), Madhu Publications, Bikaner (India). pp163-173.
- Samadia DK. 2006. Mateera. In: Prospects and dimension for utilization of arid

- foods (eds. Goyal, M. and S.K. Sharma), Yash Publishing House, Bikaner. pp79-83.
- Samadia DK. 2007. Arid Vegetables. In: Underutilized and under exploited horticultural crops. Peter, K.V. (ed.), Vol. 2 New India publishing agency, New Delhi (India), pp153-174.
- Samadia DK. 2007. Studies on genetic variability and scope of improvement in round melon under hot arid conditions. *Indian Journal of Horticulture*, 64 (1): 58-62.
- Samadia DK. 2014. Mateera: Research and development in arid region (Hindi), Technical bulletin - 45, ICAR-CIAH, Bikaner. 44p.
- Samadia DK. 2015. Mateera – Thar Manak: Grow with innovative technological advancement. Technical Folder, CIAH, Bikaner, 6p.
- Samadia DK. 2016. Horticulture based crop production site management approach (HBCPSMA) - an innovative concept for doubling farm income under dry-lands. *Journal of Agriculture and Ecology*, 1: 1–9.
- Samadia DK. 2018. Cultivating underutilized vegetables in arid region. *Indian Horticulture*, 63 (4): 34-39.