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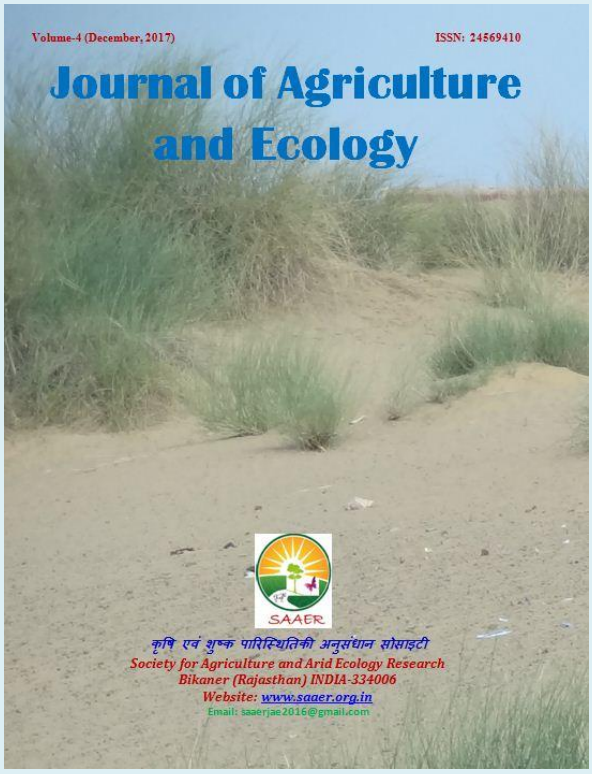

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Breeding strategies and scope of improvement in arid zone fruit crop-plants under abiotic stressed agro-climate: an analysis

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Abstract

Dry-land horticulture has immense potential in providing nutrition, social security and eco-restoration for the inhabitants of desert or rainfed and tribal land-areas of hot arid and semi-arid regions of the country. Realizing the importance and visionary support, Indian Council of Agricultural Research (ICAR) had prioritized research with few fruits in 1976 and then AICRP on arid zone fruits was started from 1978 with crop based centers in hot–spot region and this strengthen resulted to giving rise of Central Institute for Arid Horticulture in 1993 as national concern for conservation and use of arid crop-plant diversity and their promotion for horticultural exploitation. During 1985, commercial capacity of ber, pomegranate, aonla, bael, tamarind and custard apple was renowned. Indian sub-continent is one of recognized centre of origin or secondary areas of regional diversity for number of fruit crop-plant which are of native to arid and tribal areas, and not much attended for their potentiality *i.e.* ber, bordi, jharber, khejri, ker, lasora, gundi, pilu, phalsa, daasra, karonda, aonla, bael, wood apple, custard apple, tamarind, jamun, tendu, chironji, mahua, khirni, Palmyra palm, Indian dates, mulberry, fig and sehjan etc. There is ample scope for these drought tolerant and low input requiring crop-plant and for this there is rich reserve of considerable genetic variability is exists in species from *Thar* desert and tribal areas of the north-western India, which can yield fruits for fresh consumption, products of horticultural and nutraceutical values. Thus, their systematic exploitation and commercialization can not only provide food security but also ensure economic stability in rural masses in vast arid and semi-arid and/or tribal dominating sub-humid areas.

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Introduction

Most of the recent past advances in Indian Horticulture are with technology for favorable agro-climate. The vast and diverse land-scape of hot desert, arid, semi-arid and tribal area is not yet receiving logical thought for resource based horticultural development. The native crop–plants both annual and perennial are equally playing vital role for nutrition rich food, fodder as well income especially in hot arid and semi-arid areas of Rajasthan where animal husbandry is also an integral component of farming system. The monsoon supported arid zone crop-plants are drought tolerant and even the harvest failure in kharif season / conventional cropping is very high and it is estimated 50–60% in most of years only because of uncertainty in rain's pattern. Based on research experience and SWOT analysis over 25 years, it is accomplished that this hot arid zone has excellent agriculture production potential with wide and varied opportunities for crops, utilization of resource and ecological restoration (Haldhar 2012; Samadia 2016).

Horticultural exploitation with native crop–plant species is found to be most appropriate, potential and stable under the restrictions from environmental conditions. Presently, systematic horticulture with native and potential perennial plant species is very negligible, and productivity and quality of produce from the existing production technology is marginal, scattered and unorganized. This situation is primarily because of unavailability of desirable crop–genotypes suited to prevailing agro-climatic conditions &/or environmentally stressed production sites of the define zones, unavailability of requisite quality planting material of recommended crop–genotypes and lack of apposite technology. Therefore, there are essentially two complementary requirements for enhancing productivity i.e. improvement in the genetic make-up as provisions for suitable crop-genotypes and development of favourable micro-climate at production sites of the specified zone to minimize the ill-effects of adversity (Pareek & Samadia 1999; Samadia 2014; Haldhar et al.; Samadia 2016) as technological tool for the crops under consideration.

Crop–genotype issue

In addition to very few popular fruit crops (mango, mandarin/sweet orange, lime/lemon, guava, papaya, grape, banana) in distinct agro-climatic zones of Rajasthan state, the perspective for multiple-use tree crop-plants promotion is also in order of recognition (ber, pomegranate, aonla, bael, custard apple, lasora, karonda, tamarind, jamun, etc.) with varying production approaches. There is ample scope for exploitation of a large number of native crop-plant species and for this there is rich reserve of considerable genetic variability is exists in species from *Thar* desert and tribal areas of western India, which can yield fruits for fresh consumption, products of horticultural and nutraceutical values. Thus, their systematic exploitation and commercialization can not only to availability of new food sources but also provides economic stability to rural masses/ local inhabitants in vast arid and semi-arid sub-tropic and/or tribal dominating

sub-humid areas of the state as Horticultural Flagship.

Now, it is also evident that there is limited scope for quantum jump in most of popular fruit crops in traditional growing areas having much favourable agro-climate, and this call for thrust to promote and enhance fruit production in un-utilized vast waste-lands spread over more than half of the geographical areas in the country of which Rajasthan state (arid, semi-arid & tribal area) forms a major share. Rajasthan state has vast un-tapped land and diverse resources where several well established and native horticultural crop-plants can be exploited for region specific commercial cultivation or trait specific production for processing industry (ber, bordi, jharber, khejri, ker, lasora, gundi, pilu, phalsa, daasra, karonda, aonla, bael, wood apple, custard apple, tamarind, jamun, tendu, chironji, mahua, kathal, khirni, Palmyra palm, Indian dates, mulberry, fig and sehjan *etc*).

On other side, scattered efforts and adoption of varieties and technologies from favourable region of crop production as recipe in the state resulted to very casual horticultural progress in last 25 years. Still, systematic, well planned or target oriented production of potential horticultural crops is quite negligible with three distinct zone in the state, and this is pre-dominantly because of unavailability of region specific suitable crop-genotypes and appropriate technologies with defined production sites having multiple stresses from abiotic and biotic factors, resources, awareness, marketing and industry. Therefore, assessment, selection and recommendation of most appropriate crops and their genotypes in respect to production sites of sub-zones (crop-genotype-environment) having variable resources and scope of production potential is first order requirement, and their regular and trustful supply of planting material is the primary responsibility.

Environmental issue

In India, Rajasthan is the largest state but a marginal zone for horticultural production. The extremes of high (March–October) and low (December–January) temperature conditions (-4^{o} C to 50^{o} C) and alongwith associated abiotic stresses in hot arid and semi-arid areas limiting the crop-genotype choice, quality of produce and productivity levels. Horticultural exploitation with native crop-plant species is generally found to be potential and stable under the sandy desert, dry-land and tribal land areas agro-climatic situation of the state that receiving 150–650 mm of rainfall and is mostly concentrated between June–September months. Out of 9–21 mean rainy days/annum in these zones, much of rain often comes only in a few (1–5) rainfall events during the monsoon season, and which is highly erratic and unpredictable.

Beside appropriate genotype, productivity and quality of marketable produce of crops in these three distinct horticultural zone would also be depends upon availability and management of limited rain / irrigation water at the production sites of defined sub-zone as targeted for particular group of commodities under cultivation. Moreover, it can only be further reasonable when due considerations are given to

development of crop specific production sites with concept as integrated approach (HBCPSMA) for managing adverse effects from abiotic factors (drought, high and low temperatures, hot and cold winds, frost, high evapo-transpiration, high sunshine, low relative humidity and high wind speed) in particular.

Scope for crop production and potentiality

The enormous and un-tapped genetic resources in native crop-plants and to some extent the manageable climatic situations of the Rajasthan state, and potentialities for diversified fruit based production system under limited rains or irrigation in vast land-areas with distinct arid, semi-arid and sub-humid agro-climate, a careful identification of crops and their targeted or trait specific varietal selection / development could be a boon for success in dry-land horticulture. For this, however, there are essentially two complementary requirements in obtaining high quality yield and desire productivity i.e. improvement in genetic make-up of targeted fruit crop-plants intended for varietal development, and creation of favourable micro-climate for minimizing the ill-effects from abiotic and biotic factors at production sites of the defined sub-zones for their promotion.

Hence, to exploit the well-known fruit and native horticultural plant species, first of all, special attention on conservation and use of crop specific variability is required and for this systematic, innovative and long-term breeding approaches on targeted crops should be encouraged at high priority for developing better genotypes with multiple-use attribute including processing quality, wider adaptability and commercialization under the prevailing abiotic stressed situations of respective zone. The second tool is based R&D studies in arid zone horticulture from 1994–2016 by ICAR-CIAH, Bikaner and in which it is demonstrated that the quality yield and productivity in most of identified native crops can be enhanced manifold when due consideration is given on adoption of innovative and improved practices in an integrated manner under the recommended concept – Horticulture based crop production site management approach (HBCPSMA).

In this way, the foremost requirement is provision of most appropriate crop–genotype in popular as well native fruit crop-plants for distinct and resource based climatic zone, and then their promotion for systematic and integrated orcharding under khejri based crop production sites, and wide spacing planting model KM–9 (24x4x4m) or KM–11 (44x4x4m) would be practicable in arid and semi-arid areas. Similarly, mango based crop production sites and wide spacing planting model would be the best for fruit crop-plants cultivation and creation of favourable micro-climate under sub-humid and tribal dominating landscape.

To develop production site (1-4 ha size), the lay-out of paired rows of khejri/ mango should be east-west in direction and wider space between the rows (24 or 44 m) is developed field area for fruit or other sole crop cultivation. The four sides of production site is prepared and developed with multi-tier rows of seedling plantation (single or paired,

4mx4m) of native crop-plant species with the directions as khejri and lasora or rohida, kumat (south), khejri and ker or rohida (east), khejri and ker or lasora, rohida (west) and khejri and kumat or rohida, bordi (north), and in-addition desert shrubs (jharber and phog *etc.*) should be permitted all-around block for combating against hot and cold waves as micro-wind breaker and creation of favourable micro-climate under hot arid environment.

Under semi-arid to sub-humid and tribal areas, a large number of native crop-plants such as mango, jamun, lasora, tamarind, bordi, tendu, mahua, khirni, kathal, wood apple, Indian dates, Palmyra palm, teak and bamboo can be prioritized for single or paired row seedling plantation around production sites of 1–4 ha farm-land and this is for creation of favourable micro-climate. In addition, karonda, custard apple, jharber, ker, phalsa, daasra, sehjna, ratanjodh and sandheda can be promoted as crop-plants for field divider in the farm-lands. The above said native crop-plant species have tremendous economical significance and can be also promoted in the form of block plantation having less than one hectare farm-lands in tribal dominating zones for multiple-use crop production system under undulating land-scape, waste-land and rainfed situations adopting site management concept. Such production sites can be further exploited by incorporating under-exploited native vegetables and medicinal plants as inter-crops for nutritional security and continuous flow of income to the tribal people.

Scope of improvement and breeding strategies

The concerted germplasm utilization in improvement programmes of potential fruit crops over 50 years in India resulted to the development of good number of high yielding varieties suited to the different agro-climatic zones. The state of Rajasthan can grow a large number of fruit crops both native and introduced but it possesses environmental, bio-physical and resource constraints and thus limiting the extent and type of crop diversification, and distressing quality of produce and productivity levels irrespective of three distinct horticultural zones. The potential of several fruit crops (mango, guava, mandarins, sweet oranges, lime/ lemon, papaya, banana, grape, ber, aonla, pomegranate, bael, jamun, tamarind and custard apple *etc.*) have already been recognized in the state with varying climatic resilience and water resources.

The genetic resource is essential for crop improvement and variability provided by the germplasm is the basic material for developing varieties and value added / trait specific genotypes. The native crop-plants, local types and landraces are source of genes for environmental adaptability, stresses and quality of produce, and therefore, their systematic collection and *ex situ* evaluation is the pre-requisite for potentially utilization and

safe conservation of the genetic resources. Indian sub-continent is one of the recognized centre of origin or secondary areas of regional diversity for number of fruit crop-plants which are of native to arid, semi-arid and tribal areas, and yet not much attended for nutritional security, socio-heritage food values and their potentiality (ber, bordi, jharber, khejri, ker, lasora, gundi, pilu, phalsa, daasra, karonda, aonla, bael, wood apple, custard apple, tamarind, jamun, tendu, mahua, khirni, Palmyra palm, Indian dates, chironji, mulberry, fig and sehjna). These lesser attentive fruit crop-plants are pre-dominantly found growing under resource constraints and abiotic stressed conditions, and also with low priority in support for the research or commercial promotion and break through for market intelligence.

Prior to establishment of National Research Centre for Arid Horticulture, NRCAH in 1993 (later upgraded as Central Institute for Arid Horticulture) at Bikaner, the arid fruit crop germplasm collection, conservation and utilization work was executed and monitored through All India Coordinated Research Project on Arid Zone Fruits (AICRP on AZF) placed at Hissar (1978-1992) and its implementation was collaborative with crop specific and NBPGR centers located in hot-spot agro-climatic zones. The crop specific AICRP centres were under the control of ICAR institutions or state agricultural university and initial emphasis was mainly on ber, aonla, bael, pomegranate, date palm and custard apple, and further targeted crop-plants genetic resource management work was strengthen by ICAR, AICRP-AZF and NBPGR centres with regional and national perspective.

To promote profitable native crop-plant and un-exploited fruit culture in hot arid and semi-arid agro-climate, systematic germplasm augmentation, collection, conservation and utilization work programmes were formulated and implemented from 1994–2005 at Bikaner and it was deeply strengthened on ber, bordi, jharber, pomegranate, aonla, bael, khejri, ker, lasora, phalsa and sehjna (Samadia et al. 2002; Samadia 2003; Samadia 2005; Samadia 2006; Samadia & Pareek 2006; Samadia 2007; More & Samadia 2007). Like-wise, for semi-arid and sub-tropical fruit crops such as jamun, tamarind, karonda, khirni, wood apple, custard apple, chironji, mahua, ber, bael, aonla and pomegranate was prioritized and attended at CHES, Godhara (Gujarat). Similarly, research on conservation and use of regional diversity in well known fruits like mango, guava, grape, citrus and plantation crops is in way of strengthened with AICRP on sub-tropical and tropical crops at ICAR and NBPGR centres located in tribal and sub-humid zones of western India.

With the establishment of national centre at Bikaner, the mandate objectives of initial period was to assemble the scattered fruit crop germplasm and to conserve and utilize the genetic resources in improvement programme for developing genotypes with high quality yield potentials and suited to abiotic stressed environment. With mission mode approach of NRCAH during 1994-99, centre had made excellent growth in building-up of genetic resources and its utilization in

arid zone horticultural crops. The massive germplasm collection and augmentation programme up to 1999 at Bikaner resulted to the development of *ex situ* field repository in ber (300), pomegranate (150), date palm (47), aonla (19), bael (5) and lasora (2), and further this work was continued under NATP on sustainable management of plant bio-diversity (Samadia 2003).

From 1999–2004, CIAH was co-operating centre under NATP–PBD of NBPGR, New Delhi for collection, evaluation and maintenance of arid horticultural crops, and is also one of identified National Active Germplasm Site (NAGS) for maintenance, multiplication and conservation in arid region (Anonymous – Annual reports of NRCAH / CIAH & NATP–PBD, 1995–2005). During the five year period of NATP–PBD (1999–2004), crop specific and multi-crop explorations were undertaken for intensive survey, identification and collection of horticultural plant diversity from parts of arid, semi-arid and tribal areas of Rajasthan and Gujarat, and resulted to identification of crop specific variability pockets and good number of elite germplasm were collected in ber (19), aonla (26), bael (7), phalsa (3), ker (64), lasora (65), date palm (46), khejri (15) and others (15) native fruit / tree crop-plants. Similarly, fruit crop-plants germplasm of jamun (68), tamarind (25), karonda (40), wood apple (10), custard apple (15), mahua (30), chironji (30), khirni (30), bael (120), aonla (15), ber (55), pomegranate (49), phalsa (25) and others trees-plants (40) are being maintained at CHES, Godhara and utilizing in improvement under semi-arid sub-tropic climatic conditions.

The need based varietal development in most of popular fruits is from favourable climatic zones in the country (1975–1995) and targeted fruit crop–genotypes were promotion for cultivation in the state of Rajasthan by various agencies, and however, their systematic production is yet not much popularized or commercialized. On appraisal and my experiences over 25 years in the field of horticulture at CIAH, it is comprehend that the environmental restrictions such as extremes of high and low temperature conditions for the prolonged period of time, and in-addition high aridity and drought situations due to low and erratic precipitation, and also unavailability of region specific appropriate crop–genotypes for cultivation under the prevailing climatic resilient are two well-built factors in limiting of fruit culture as industry in Rajasthan.

Most of the present day varieties of fruit crops are results of selections and are primarily based on fruit size and some quality attributes besides maturity period and yield under the most suitable agro-climate in the country. Systematic efforts to develop varieties in respect of precocity, dwarfism, short-duration for fruit development, specific quality (dessert, processing, export or diversified uses) and resistant / tolerant to need based abiotic stresses (extremes of high and low temperature, frost and drought), insect-pests (fruit fly and borers), diseases and suitability to specific agro-climatic zone are still lacking and now, it require attentiveness for enhancing yield potentials and bringing new area under cultivation (Haldhar et al., 2016a; 2016b; 2017). The varietal situation in

lesser–known and indigenous fruit crop–plant species is still quite unsatisfactory and their cultivation is not yet commercialised only because of lack of their named types/ cultivars/ value added genotypes with varying zones.

The recent past (1995–2015) and localized breeding work undertaken so far have resulted into development of few new genotypes in different part of the country as needed for the particular region, and further these are selections based on important attributes such as fruit size, quality, maturity and yield from native, exotic or generated variability, and identified for commercialization. The target oriented intensive breeding work on varietal and distant hybridization or combination, heterosis or resistant factors for developing trait or region specific superior genotypes for distinct climatic and resource variables zones of Rajasthan state is negligible. Therefore, as first order of work, the existing varieties/ genotypes of commercial significance must be utilized in breeding programmes as primary gene-pool to generate controlled seed progenies for large-scale field evaluation under the prevailing and abiotic stresses conditions of the zone in particular, and further segregating material be used in selection and/or combination breeding, and also for developing trait specific varieties/ value added genotypes adopting pre-breeding concept for generated material, and it should be with long-term strategies for conservation and re-utilization of the developed material.

In native crop-plants, very little attempts have been made towards systematic breeding and genetic improvement studies. For systematic genetic resource utilization and management, first of all, the native crop specific genetic wealth should be assembled in field repositories and it should be both in the form of seed progenies for large-scale population studies and selective genotypes have to be spotted, identified and collected for *ex–situ* evaluation through multidisciplinary approaches including vegetative form, and it should be considered as immediate gains for varietal selections or value added genotype. At the same time, long–term strategies through combination and segregating breeding for trait specific improvement as well as conservation of pre-breeding material need to be formulated with prime objectives of desirable genotypes in the targeted crops and also to solve the long–standing problems related to fruit quality, uniformity and biotic and abiotic stresses tolerant genotype for varied eco-regions.

The utilization of native and introduced genetic material for breeding varieties over the long period of time in the country resulted into generation of many new genotypes / lines in the form of selections and to some extent through hybridization. Thereby, considerable generated material / variations may have exists in targeted species with regards to the plant type, flowering-fruiting, morphological and physiological of fruits, reaction to biotic and abiotic factors and eco-adaptations. Therefore, in primary step of characterization/ categorization of evolved/ generated material of crops, trait based genotypes should be marked/ identified for advantageous attributes as needed for long-

term considerations. Since, detailed evaluation of identified genotype is essential for further breeding programme and to incorporate desirable gene(s) through combination breeding. Wild and relative species gene-pool possesses unique traits and that can be exploited both by direct selection for use in combination breeding or improvement through advanced approaches. They also constitute priceless reservoir that contain gene (s) conferring better adaptations to stressed environment and also resistant to diseases and insects or have more nutritional and medicinal properties. Therefore, there is urgent need to promote systematic utilization of wild gene-pool in strategic breeding work for developing genotypes having biotic and abiotic stress resistant or tolerant, and their conservation as relative species.

Different approaches are required that can promote strategic breeding in priority fruit and native crop-plant species and it should be on time–scale but in phased manner. Most of the priority crops have wild species or relatives too. The utilization of wild species or relatives of the targeted species not only depend on their crossability and re-combination with cultivated species, but also on the extent of presence of undesirable traits in a particular species under consideration. Further, utilization of generated gene-pool for characterization and use in breeding particularly at intra or inter species level needs competency, continuity, much more time, expertise support, human resources and infrastructures at field level. In this way, development and utilization of pre-breeding lines and genetic material can serve the breeder's purpose more efficiently and effectively under national perspective. In this context, pre-breeding lines are advanced or trait specific generated lines, which are derivatives of cross between cultivated species and priority species identified for specific purpose, or evolved genetic material identified for the specific traits from the native variability or variability created adopting hybridization within the cultivated species / varieties.

Thus, newly evolved and conserved generated lines or material can directly be utilized for improvement without need of much time and expertise every time to run the breeding programmes in fruit / perennial crops, and anywhere in the country too. The availability of pre-breeding lines or genetic stocks to the present breeders can ensure fast progress of varietal development process for the specific objectives or targets to solve the particular problem. The execution of such concept may have prompt benefits in the priority crops and can be exploited even at those research centers / regions where adequate facilities are not available, since the ultimate aim of identification and development of pre-breeding lines or genetic stocks is its utilization in crop improvement based on basic information gathered over the period with systematic screening and characterization at lead institutions. The development of need based trait specific and value added genotype should be the utmost priority to solve the problems in native crops as required for particular region, stresses, quality or commercialization of crop-plant for food and nutraceutical values.

Table 1. Primary varieties from the germplasm of crop cultivation areas

Crop	Initial varieties of commercial significance in India and most potential for use in breeding as basic gene-pool adopting pre-breeding concept
Ber	Gola, Seb, Umran, Mundia, Kaithli, Banarasi Karaka, Mehrun, Reshmi, Illachi, Kakrola Gola, Katha, Ponda, Tikdi, Sukhawani and Chomu Local.
Aonla	Banarasi, Chakaiya, Hathijool, Kanchan, Krishna and Balwant.
Bael	Mirzapuri, Kaghji, Gonda, Basti No-1 and Dhara Road.
Pomegranate	Dholka, Kandhari, Jalore Seedless, Jodhpur Red, Ganesh, Musket, CO-1, Alandi, GR, GRP, Bassen Seedless, Yercaud, Wonderful, Paper Shell, Kabul and Anardana.
Custard apple	Balanagar, Red Sitaphal, Mamaonth, Washington and Local Sitaphal.
Date palm	Halawy, Barhee, Khalas, Medjool, Khadrawi and Zahidi.
Fig	Poona Fig and Local types of Bangalore, Bellary, Coimbatore, Daulatabad, Dindigul, Ganzam, Hindupur and Saharanpur.

Table 2. Promising varieties / selections / lines / value added genotypes in fruit crop-plants

Crop	Genotypes under commercial promotion and useful for region specific performance trials & combination / segregation breeding as new gene-pool adopting pre-breeding concept
Ber	Goma Kirti, Thar Sevika, Thar Bhubharaj, BS-75-1, Hybrid-1 and Hybrid-10 (Bawal), Narendra Ber Selection-1 and Local types of the region.
Aonla	Neelum (NA-7), Amrit (NA-6), Anand-2, Laxmi-52, Goma Aishavarya, BSR-1, ATPS-1, NA-20, NA-25, NA-26, CHES-1, Gujarat Aonla-1, CIAH/EO-24.
Bael	NB-5, NB-9, NB-16, NB-17, Pant Urvashi, Pant Sujata, Pant Aparna, CISH-B-1, CISH-B-2, Goma Yashi, Goma Divya and Goma Neelkanth.
Pomegranate	G-137, P-26, P-23, Mridula, Phule Arakta, Bhagawa, Bhagawa-Selection-4, Kesar (Sindhuri), Rubi, Nana, Daru, Goma Khatta and CIAH-DKS/H/97/003.
Custard apple	Arka Sahan, Hybrid No.-6, 13 & 22 (MPKV, Rahuri), APK-CA-1, Selection-9 (SK Nagar), Washington-07005, Washington-98797, Raidurg, Ramsita, Sinhan Local, Local types form Chittorgarh and Rajsamand area of Rajasthan
Date palm	Khuneji, Chipchap, Braim, Selection-9, Selction-13, Yaqubi, Khedoi-7, Madhepura and Mundra Selection-3.
Fig	Deanna, Conadria, Excel, Dinkar, Black Ischia, Shahi and Maisram.
Tamarind	Pratisthan, No-263, Yogeshwari, PKM-1, Urigam, Cumbum, DT-1 & DT-28 (Dharwad), Goma Prateek, Ajanta, T-1, 16, 22, 28, 29 &TR-1, TS-1&2 and Vellore-2.
Jamun	Goma Priyanka, Rahuri Selection-1, Rahuri Selection-2, AJG-85, CISH-J-39, CISH-J-42, GJ-2, GJ-8 and GJ-30.

Wood apple	CHES-2, CHES-10 and CHES-11.
Chironji	CHES-C-7, CHES-C-2 and Thar Priya.
Karonda	K-1, K-2 & K-3 (Maharashtra), Selection No.-3, 12, 13 & 16 (MPKV, Rahuri), Pant Manohar, Pant Sudarshan, Pant Suwarna, Thar Kamal, CHES-K-1, CHES-K-2 and CHES-K-3 (Godhara) and Pushkar Local.
Mahua	Thar Madhu, MH-10, MH-14 and MH-18(Godhara).
Mulberry	Thar Lohit, Thar Harit, BM-27, 31, 60, 91 and 100 (Bawal).
Khirni	Thar Rituraj
Phalsa	CIAH-P-1, CIAH-P-2, CIAH-P-3 and Thar Pragati.
Lasora	CIAH-Selection-1, CIAH-Selection-2 and JL-07 (Jobner).
Khejri	Thar Shobha and CIAH-Selection-2.
Ker	CIAH-Thornless-1
Sehjna	CIAH-AHMO-1, PKM-1, PKM-2 and Thar Harsa.

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