

Probable Agricultural Biodiversity Heritage Sites in India: XIX. The Northwestern Deccan Plateau Region, the Leeward Side of the Western Ghats

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Abstract

Agriculture in the Northwestern Deccan Plateau region, the leeward side of northern Western Ghats, is quite ancient, involving the majority of the people. Being rich in granite, the region's hills offered hospitable caves for the early settlers from the Harappan civilization moving further southward. The semi-arid climate of the region, with its erratic rainfall and prolonged dry spells and the variation in edaphic factors, resulted in the adoption of a large number of drought-tolerant crops such as sorghum and millets. Being the central part of the Indian subcontinent, the region has been the meeting point of north and south Indian cultures/agriculture, and the center of exchange of knowledge and material, evolving a complex culture with components of North, South, and Central India. This is corroborated by the similarity recorded between this region and the Megalithic sites of the south-central region of the Eastern Ghats, and the remains discovered at various excavation sites of the region. The early use of cotton, flax, and goats suggests possible crop and animal domestication in the region. It is probable that the complex, north-south-central culture/agriculture of the subcontinent dispersed from here to other parts, particularly the southern regions of the continent with new settlements, leading to the region being termed Dakshinapatha (Dakshina = Deccan or Maharashtra and adjacent region) in Buddhist and Jain literature. This complexity led to the evolution and conservation of significant genetic diversity, particularly for various types of droughts, in a large number of economically important crops. For these significant contributions, the region is being proposed as another National Agricultural Biodiversity Heritage Site based on the indices proposed. This article discusses some of these contributions in brief.

The Northwestern Deccan Plateau, the leeward side of the northern Western Ghats was one of the many regions in India that offered favorable conditions for human settlement in ancient times: the granite hills of the Deccan Plateau provided perfect rock shelters and caves for human habitation.

Basically the region evolved as a southern expansion of the Harappan and Indus Valley culture, but with a difference. The evidences gathered from different lines of investigations about the origin and evolution of agriculture in the region, suggest that the Northwestern Deccan Plateau subsequently

probably became the meeting point or transitional zone or the center of exchange of products and technology of North Indian (Indus Valley and Indo-Gangetic Plains) and South Indian agriculture, from where or through which the products and practices of distinct cultures/agriculture spread all over the Indian subcontinent, particularly to southern India, promoting new settlements with components of North, South, and Central India. For these reasons, agriculture became the major profession of the local tribes and communities, involving more than 64 per cent of the population. In addition to the cultivation of crops that were brought and introduced by new settlers, new plant species – fiber crops such as diploid cotton and flax – were domesticated and spun into yarn (Gulati, 1961), and animals such as the Osmanabadi goat, suited to semi-arid conditions, were brought into domestication in the region. The diversity in agroclimate and edaphic factors, with soils from black basalt to saline and old crystalline rocks, resulted in dominance of diverse crops in the different areas of the region: for example, sugarcane in the northern high-rainfall areas; cotton in the central black soil areas; and sorghum in the southern semi-arid areas. The argoecological diversity provided opportunities to local tribes and communities to evolve and conserve useful genetic diversity in almost all crops and domesticated animals of the region, along with practices for their successful cultivation and rearing. For these contributions and documentation of the knowledge generated (in Sanskrit) for improved management and use of natural resources, cultivation of crops and rearing of animals that has been of significance

for national and global agriculture and livelihood support, the region is being proposed as another National Agricultural Biodiversity Heritage Site based on the indices illustrated by Singh and Varaprasad (2008).

Location and extent

The Northwestern Deccan Plateau, south of the Tapti River Basin, is a part of the hot semi-arid ecoregion situated on the leeward side of the Western Ghats. From the Satpura-Mahadeo hills in the north, the region extends up to Bellary-Dharwar in the south, encompassing the leeward districts of Maharashtra and the northern dry districts of Karnataka and Andhra Pradesh. On the west of the region lie the hills and ranges of the Western Ghats, on the east, the Bhamragad-Chiroli-Gaikhuri Ranges, Chhattisgarh, and the northeastern districts of Andhra Pradesh, and on the south, the dry districts of northern Karnataka. The terrain is undulating and the soil is generally medium blackish. Administratively, the region includes the semi-arid districts of Jalgaon, Dhule, Nandurbar, Aurangabad, Jalna, Hingoli, Parbhani, Beed, Nanded, Latur, Osmanabad (Dharashiv), Solapur, and parts of Pune, Nashik, Ahmednagar, Akola, Amravati, Nagpur, Gondia, and Sangli, in Maharashtra; the districts of Adilabad, Nizamabad, and Karimnagar in Andhra Pradesh; and the districts of Bidar and Gulbarga in Karnataka (Fig. 1).

Landscape

The average elevation of the Deccan Plateau is about 600 m, sloping generally eastward.



Figure 1. Extent and location of the Northwestern Deccan Plateau region (the leeward side of the Western Ghats).

The northwestern part of the Deccan Plateau is typified by stepped plateau denudational structures in the relief. It houses a variety of habitats, with the Western Ghats forming the western boundary, while Chhattisgarh, and in the larger sense, the Eastern Ghats form the eastern boundary. The landscape of the region consists of plateaus and hills formed as a result of volcanic activity and the subsequent cooling down of the lava, which resulted in the formation of a basaltic base that is more than 2,000 m thick. The western margin of the plateau consists of surfaces of erosion, called the Sahyadri Hills (Western Ghats), whose peaks are covered with lateritic red soil with localized patches of dense forest. Eastward from the

Western Ghats (saddle or hill), the river system of the region consists of the rivers Godavari, Krishna, Bhima, Tapi-Purna and Wardha-Wainganga, which flow towards the Bay of Bengal, cutting through the plateau and converting it into a land of well-defined river valleys, characterizing the landscape into broad valleys divided by flat-topped interfluvies (higher lands between two rivers), mesas (tablelands), and rectilinear escarpments (steep slopes). Further eastward, the reduction in the amount of rainfall has caused aridity and the development of an inselberg (isolated hill) type of landscape. Finally, the interfluvies disappear giving rise to broad alluvial plains covered with the rigor sods (turf of

grass). In Maharashtra, the plateau can be further subdivided into five micro-units: (i) the Ajanta Hills; (ii) the Godavari Valley; (iii) the Ahmednagar-Balaghat Plateau; (iv) the Bhima Basin; and (v) the Mahadeo Upland.

The main mountainous regions and hills are the Satpura Range and the Varandha, Sawantwadi, and Tamhini Ghats. The Satpura and the Gaikhuri Bhamragad Chiroli ranges are the chain of mountain ranges in the eastern part of Maharashtra. The region has a few lakes: the Ramkund Lake (Nashik), the Lonar Lake (Buldhana), the Pashan Lake (Pune), and the Ambazari Lake (Nagpur).

Agroclimate

The climate of the region is characterized by hot summers and mild winters. The mean annual rainfall ranges from 600 to 1,000 mm, which covers about 40 per cent of the annual potential evapotranspiration. The climate can be divided into three basic seasons: the dry and cool winter (November to February); the hot and dry summer (March and May); and the hot rainy season (June to October). East of the Sahyadri (Western Ghats) in the Deccan

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plateau the average rainfall diminishes to a meager 700 mm, because the region lies in the rainshadow zone of the Western Ghats. Among the western plateau districts, Solapur and Ahmednagar are in the heart of the dry zone. The rainfall increases slightly, later in the season, eastwards in the Marathwada and Vidarbha regions. The moisture availability period for crop cultivation ranges from 90 to 150 days. However, the highly unpredictable character of the monsoon, with short spells of rains, floods, and long, dry breaks, as well as droughts, add much to the discomfort of agriculture and the rural economy.

The region is characterized by shallow and medium black soils, followed by lateritic soils. The common landscape of the region is moderate to gentle slopes. Most soils belong to the Pargaon, Sawargaon, and Barsi series. The Pargaon soils are shallow, loamy skeletal, and highly calcareous in nature. The Sawargaon and Barsi soils are clayey, calcareous, and moderately alkaline, and show marked swell-shrink properties (Sehgal *et al.*, 1992).

Floristic diversity

The region is not very rich in biological diversity, but being a contiguous land mass with the moist deciduous forests that lie along the foothills of the Western Ghats, the region does show the heterogeneous nature of diversity. Less than 500 species of angiosperms have been recorded from the region. As the Northwestern Deccan Plateau lies in the rainshadow of the Western Ghats, it is a semi-arid region with vegetation consisting largely of the

dry thorn and deciduous forests, dominated by *Acacia* Mill., *Anogeissus* Wall., *Tectona* L.f., *Hardwickia* Roxb. (*anjan*), and *Albizia* Benth. species. Thus, the main forest types in the region are dry deciduous forests, thorn forests, and scrub jungles. Certain hills associated with the plateau to the east may have patches of moist deciduous forest. The climax vegetation in the Deccan has almost completely disappeared. Nevertheless, the region has a high diversity of grass flora. The dry deciduous forests are represented by some of the following large evergreen to medium-sized tree species: *Aegle marmelos* (L.) Correa ex Roxb., *Anogeissus latifolia* (Roxb.) Bedd., *Boswellia serrata* Roxb., *Buchanania lanzan* Spreng., *Diospyros melanoxylon* Roxb., *Madhuca longifolia* Macbride var. *latifolia*, *Embllica officinalis* Gaertn., *Terminalia alata* Herb. Madr. ex Wall., *Tectona grandis* L., etc., and small stunted trees, *shebrati* (*Acacia pennata* Willd.), *Butea monosperma* (Lam.) Taub., *Cassia fistula* L., *Eriolaena hookeriana* Wt. & Arn., *dhaula* (*Morinda pubescens* J.E. Smith), *Wrightia tinctoria* (Roxb.) R.Br., *Ziziphus mauritiana* Lam. (syn. *Z. jujuba* Mill.), and *Z. vulgaris* Lam. The main scrub forest elements are *Acacia catechu* Brandis var. *chundra* (syn. *A. chundra* Willd.), *A. horrida* (L.) Willd., *babool* [*A. nilotica* (L.) Delile var. *indica* (Benth.) A.F.Hill], *A. leucophloea* Willd., *Limonia acidissima* L., and *pachunda* (*Capparis divaricata* Lam.). The common grasses of fodder value are *Andropogon pumilus* Roxb., *Chloris dolichostachya* Lag., *Cynodon dactylon* Pers., *Eleusine indica* Steud., *Eragrostis tenella* (Linn.) P. Beauv., *Pennisetum pedicellatum* Trin., *Setaria*

pumila (Poiret) Roemer & Schultz., and *Urochloa panicoides* P. Beauv.

Agriculture and agrobiodiversity

Around 64 per cent of the people are employed in agriculture and allied activities. Field crops include wheat, rice, sorghum, pearl millet, minor millets, pulses, and oilseeds, while horticultural crops are dominated by tropical fruits such as mango, grape, banana, orange, pomegranate, etc., and diverse vegetables. Cash crops include cotton, sugarcane, turmeric, groundnut, and tobacco. The net irrigated area is 33,500 square kilometers.

The farmers of the region traditionally practice rainfed farming (Fig. 2). The major traditional crops are *jowar* (sorghum) (Fig. 3), *bajra* (pearl millet), cotton, *tur* (pigeonpea), and *anuvulu* or field beans (*Dolichos lablab* L.) in the Maharashtra and Andhra Pradesh areas of the region, and sorghum and pigeonpea in Karnataka. The major rainy season crops cultivated in the area are sorghum, pigeonpea, pearl millet, and cotton. The postrainy season crops,



Figure 2. A farmer toiling the soil for cultivation.



Figure 3. Harvest of sorghum, the staple food of the region (Source: www.cgiar.org).

grown on soils with residual moisture, are sorghum, safflower, and sunflower. The prolonged dry spells adversely affect the crop growth leading to frequent crop failures. The *kharif* sorghum is cultivated in the semi-arid districts, while cotton, pulses, groundnut, and small millets are sown as alternate crops. Sugarcane is an important crop in the Deccan Plateau areas of Maharashtra and northern Karnataka, where irrigation facilities are available through tube wells and irrigation canals. Sugarcane is planted during December–February, as a 12-month crop, which is referred as *eksali* (Fig. 4). In the extremely dry area of the Deccan in Andhra Pradesh, which is again a rainshadow region, *bajra* is cultivated. In the groundnut-based cultivated areas, the alternate crops are sorghum and small millets. In the dry districts of the Deccan plateau in northern Karnataka, the groundnut-based cropping system has sorghum as an alternate crop. Cotton, suited to dry climate and black soil is an important crop in the rainfed areas of the Deccan plateau, which includes the semi-arid districts in Maharashtra, northern

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Karnataka and eastern Andhra Pradesh (Fig. 5). In this area, the alternative crops are sorghum (*kharif* and *rabi*), groundnut, and small millets.



Figure 4. Sugarcane, the cash crop of the region (Source: www.civilsprep.in).



Figure 5. Cotton, the other cash crop of the region (Source: www.indianetzone.com).

The cropping patterns in different areas of the region are as follows: (i) Vertisols and related black soil zone, Solapur dryland region: green gram–sorghum, cowpea–sorghum; green gram–safflower, cotton–sorghum; and (ii) Akola dryland region: green gram/groundnut/sorghum–safflower (Rathore and Gupta, 1991). On the basis of annual rainfall (500 mm), the *rabi* crops are sorghum, safflower, and grain crops that are sown in September. Besides, the following other cropping patterns are followed: sorghum–safflower/sunflower/groundnut, soybean–safflower, soybean–chickpea, cotton–sunflower, cotton–groundnut, and pigeonpea–sesame. Sorghum, cotton, and pigeonpea are intercropped with soybean, sesame, and groundnut. The dominant intercropping systems in different areas are sorghum + pigeonpea in Akola, chickpea + safflower in Solapur, etc.

Rice, too, is grown in the Marathwada region, but it is a non-traditional area. Due to the erratic and low rainfall, the average productivity of rice crop is extremely low: 0.41 t ha⁻¹ (0.59 t ha⁻¹ for rough rice). The rice-based cropping systems are: (i) rice–finger millet (*ragi*); (ii) rice–pulses; (iii) rice–sorghum; (iv) rice–groundnut; (v) rice–sugarcane; and (vi) rice–oilseeds.

Traditional eco-farming or mixed cropping systems are still prevalent in the dryland soils of the Deccan Plateau, as the crop failures are quite common due to aberrant weather conditions, such as excessive rains, prolonged dry spells, rains at harvest, etc. To overcome these vagaries, small farmers practice a system of agriculture with 12 or more traditional crops, including cereals

such as sorghum, grain legumes such as pigeonpea, oilseeds, and other minor crops, following organic farming methods on their small landholdings, methods that constitute a blend of ethics, traditional experience, scientific knowledge, and pragmatism. In these combinations, the legume components enhance the soil fertility by symbiotic nitrogen fixation, while heavy leaf fall works as mulch and green manure, and tall, but short-duration cereals act as barriers to initial infestation of companion crops.

Horticulture is an important component of agriculture in the region, as the unique microclimatic conditions of the leeward side are suitable for raising tropical fruit crops during summer, *kharif*, and the sun-bathed cool climate of *rabi*. The latter climate supports quality production of grapes, pomegranate, *ber*, oranges, and guava in addition to mango, jackfruit, etc., fruiting from April to June.

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from their distribution area Osmanabad (Dharashiv) of Maharashtra. It covers the major part of southern Maharashtra (especially Osmanabad, Beed, Solapur, Latur, Parbhani, and Ahmednagar districts), western Andhra Pradesh, and northeastern Karnataka. Osmanabadi goats are mostly medium-sized animals usually black in color, but in some areas of Maharashtra and western Andhra Pradesh, brown or spotted ones can also be seen. Mostly the males are horned and the females may be horned or polled.

Representative species in various crop groups

Cereals, pseudocereals, and millets.

Amaranth (*Amaranthus hypochondriacus* L.), arika or argulu or proso millet (*Panicum miliaeceum* L.), bajra or sajjja or pearl millet [*Pennisetum glaucum* (L.) R. Br.], barley (*Hordeum vulgare* L.), barnyard millet [*Echinochloa crus-galli* (L.) P. Beauv.], dhane (*Eragrostis tenella*), kodi sama or little millet (*Panicum sumatrense* Roth; syn. *P. miliare*), kodo millet (*Paspalum scrobiculatum* L.), korra or foxtail millet (*Setaria italica*), maize (*Zea mays* L.), makra [*Dactyloctenium aegyptium* (L.) Beauv.] a famine food, ragi or finger millet (*Eleusine coracana* Gaertn.), rice (*Oryza sativa* L.), sawa millet (*Echinochloa frumentacea* Link), sorghum [*Sorghum*

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bicolor (L.) Moench], *thipa ragi* [*Eleusine indica* (Linn.) Gaertn.], and wheat (*Triticum aestivum* L. and *T. dicoccum* Schubl.).

Legumes and oilseeds. *Ambadi* or Deccan hemp (*Hibiscus cannabinus* L.), *amuvulu* or field beans [*Dolichos lablab*; syn. *Lablab purpureus* (L.) Sweet], black mustard [*Brassica nigra* (L.) Koch.], *bebbarlu* or cowpea (*Vigna unguiculata* L.), black gram [*Vigna mungo* (L.) Hepper; syn. *Phaseolus mungo* L.], castor (*Ricinus communis* L.), chickpea (*Cicer arietinum* L.) (light brown, black, and white seeded), *gaddi muvvulu* or niger [*Guizotia abyssinica* (L.f.) Cass.], grass pea (*Lathyrus sativus* L.), green gram [*Vigna radiata* (L.) R. Wilczek; syn. *Phaseolus aureus* Roxb.], groundnut (*Arachis hypogaea* L.), lentil (*Lens culinaris* Medik.), linseed (*Linum usitatissimum* L.), *manchi muvvulu* or sesame (*Sesamum indicum* L.; syn. *S. orientale* L.), mustard [*Brassica juncea* (L.) Hook.f. & Thomson], rice bean [*Vigna umbellata* (Thunb.) Ohwi & H. Ohashi], safflower (*Carthamus tinctorius* L.), *teega*

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pesari or creeper gram [*Vigna angularis* (Willd.) Ohwi & H. Ohashi], *togari* or red gram or pigeonpea [*Cajanus cajan* (L.) Millsp.], and white sweet clover (*Melilotus albus* Medik.).

Fodder and fiber crops. Fodder grasses: *Andropogon pumilus* Roxb., *Brachiaria ramosa* (L.) Stapf., Bermuda grass (*Cynodon dactylon*), *Chloris dolichostachya* Lag., *Dactyloctenium aegyptium*, *Dichanthium annulatum* (Forsk.) Stapf., *Eleusine indica*, *Eriochloa procera* (Retz.) C.E. Hubb., *Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult., *Ischaemum rugosum* Salisb., *Panicum psilopodium* Trin., *Pennisetum pedicellatum*, *Perotis indica* (L.) Kuntze. Rev., *pillipesara* [*Vigna trilobata* (L.) Verdc.; syn. *Phaseolus trilobus* (L.) Aiton] a dual-purpose crop yielding fodder and green manure, *Sehima nervosum* (Rottl.) Stapf., *Setaria pumila*, and *Urochloa panicoides*. Fiber: *ambadi* (*Hibiscus cannabinus*), American cotton (*Gossypium hirsutum* L.), levant cotton (*Gossypium herbaceum* L.), red *ambadi* or roselle (*Hibiscus sabdariffa* L.), and *tula* or tree cotton (*Gossypium arboreum* L.).

Vegetables. Bamboo [*Dendrocalamus strictus* (Roxb.) Nees] (young shoots are eaten), *bhindi* [*Abelmoschus esculentus* (L.) Moench], bitter gourd (*Momordica charantia* L.), brinjal (*Solanum melongena*), chili (*Capsicum annuum* L.), *kharbuj* or muskmelon (*C. melo* L.), *khira* or cucumber (*Cucumis sativus* L.), *kundri* (*Coccinia indica* Wight & Arn.; syn. *C. grandis* Voigt), pumpkin (*Cucurbita pepo* L.), ridged gourd [*Luffa acutangula* (L.) Roxb.], sponge gourd (*Luffa cylindrica* Roxb.; syn. *L. aegyptiaca* Mill.), and tomato (*Lycopersicon esculentum* Mill.).

Leafy vegetables. *Adavi gogu* (*Hibiscus aculeatus*) (leaves used as pot herb), amaranth (*Amaranthus caudatus* L., *A. polygamus* L., *A. viridis* L.), *chamkas* [*Corchorus depressus* (L.) Stocks] (leaves used as pot herb), Deccan hemp (*Hibiscus cannabinus*), *panivel* (*Cissus repanda* Vahl.), purslane (*Portulaca oleracea* L.), and greens such as *atakamamidi* (*Boerhavia diffusa* L.), *doggali kura* (*Amaranthus viridis*), *gunugu/kodijuttu kura* (*Celosia*

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argentina L.), *mulludoggali* (*Amaranthus spinosus* L.), etc. are eaten in the Andhra Pradesh area.

Root, tuber, and bulbous crops. *Dkaval kodi* (*Dioscorea pentaphylla* L.), elephant yam [*Amorphophallus campanulatus* (Roxb.) Bl.], garlic (*Allium sativum* L.), *mahakizhangu* (*Decalepis hamiltonii* Wight. & Arn.) (roots are edible and pickled), onion (*Allium cepa* L.), yams [*Dioscorea bulbifera* L. (syn. *D. sativa* L.), *D. intermedia* Thw., *D. wallichii* Hook. f., *D. wattii* Prain & Burkill], etc.

Spices. Black mustard [*Brassica nigra* (L.) Koch.], chili (*Capsicum annuum*), *chironji* (*Buchanania lanzan* Spreng.), coriander (*Coriandrum sativum* L.) (small-seeded variety), ginger (*Zingiber officinale* Rosc.), curry-leaf tree [*Murraya koenigii* (L.) Spreng.], niger (*Guizotia abyssinica*), and turmeric (*Curcuma domestica* Valet.; syn. *C. longa* L.).

Fruits. Acid lime [*Citrus aurantifolia* (Christm.) Sw.; syn. *C. medica* L.], *ber* (*Ziziphus mauritiana*; syn. *Z. jujuba*), banana [*Musa acuminata* Colla (Cavendish Group)], grape (*Vitis vinifera* L.),

Indian cherry (*Cordia myxa* Roxb.; syn. *C. dichotoma* Forst.), jackfruit (*Artocarpus heterophyllus* Lam.), *jamun* [*Syzygium cuminii* (L.) Skeels], *kondai* [*Flacourtia indica* (Burm.f.) Merr.], *lovi-lovi* (*Flacourtia inermis* Roxb.), mandarin orange (*Citrus reticulata* Blanco), mango (*Mangifera indica* L.), pomegranate (*Punica granatum* L.), sweet orange (*Citrus sinensis* L. Osbeck), wild date [*Phoenix sylvestris* (L.) Roxb.], wood apple (*Limonia acidissima* L.), and watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai].

Other economic crops. Bamboo [*Dendrocalamus strictus* (Roxb.) Nees.], indigo (*Indigofera tinctoria* L.), sugarcane (*Saccharum officinarum* L.), and tobacco (*Nicotiana tabacum* L.).

Gums, resins, and tannins. These are being obtained from *babool* [*Acacia leucophloea* Willd., *A. arabica* (Lam.) Willd.; syn. *A. nilotica* (L.) Delile subsp. *indica*], *Acacia farnesiana* (L.) Willd., *shebrati* (*Acacia pennata*), *Albizia lebbek* (L.) Benth., *Anogeissus latifolia* (Roxb.) Bedd., *Boswellia serrata* Roxb. (syn. *B. glabra* Roxb.), *karanj* [*Pongamia pinnata* (L.) Pierre] (oilseed), *Terminalia arjuna*, and *T. bellirica*, as non-timber products collected from forest or even cultivated. The tribal communities of Gadchiroli and around are specifically associated with the five species, *dhavda* (*Anogeissus latifolia*), *satawari* (*Asparagus racemosus* Willd.), *chironji* (*Buchanania lanzan*), *mahua* (*Madhuca indica* J.F. Gmel.; syn. *M. longifolia* Macbride), and toddy palm (*Borassus flabellifer* L.), and are economically dependent on, as they are part of the existing forests and accessed by tribal communities.

Medicinal and aromatic plants. The local communities have developed significant knowledge about the medicinal properties of plants as reflected by some of the recent publications. Mali and Bhadane (2008) reported medicinal properties of 226 plant species collected from Jalgaon district alone. Survase and Raut (2011) reported 50 tree species belonging to 30 families used for medicinal treatment in the Marathwada area. Some other commonly used or researched plants for medicinal purposes are: *Agave vera-cruz* Mill., *aghada* or *uttareni* (*Achyranthes aspera* Linn.), *ambadi* (*Hibiscus cannabinus*), *Blumea eriantha* DC, *Blumea lacera* L., *Boerhaavia diffusa*, *Chlorophytum tuberosum* (Roxb.) Baker, *Cissus quadrangularis* Linn., *Corchorus depressus*, *Eriolaena hookeriana*, *garika* (*Cynodon dactylon*), *guntakalagara* [*Eclipta alba* (L.) Hassk.], *nattu* [*Imperata cylindrica* (L.) Beauv.], red *ambadi* or roselle (*Hibiscus sabdariffa*), *tagarancha* (*Cassia tora* L.), *tummi* (*Leucas aspersa*), and *Wrightia tinctoria*. In addition, *ait* (*Phaseolus trilobus*), *Cymbopogon martinii* (Roxb.) Wats, and *Santalum album* L. are commonly used medicinally, while *Hemidesmus indicus*, *Canthium parviflorum*, and *Canavalia gladiata* are being investigated for compounds responsible for various biological activities (Pasumarthi *et al.*, 2011).

Wild relatives of crop species. Arora and Nayar (1984) recorded *Abelmoschus ficulneus* Wight & Arn., *Boehmeria platyphylla* D. Don., *Canavalia stocksii* Dalz. a variant of *C. ensiformis* (L.) DC (endemic and rare), *Capparis decidua* (Forsk.) Edgew., *Chionachne koenigii* (Spreng.) Thw.,

Cichorium intybus Linn., *Coffea bengalensis* Heyne & Willd. [syn. *Psilanthus bengalensis* (Roxb. ex Schult.) J.-F. Leroy], *Corchorus antichorus* Raeuch. [syn. *C. depressus* (L.) C. Chr.], *Grewia tenax* (Forsk.) Aschers & Schwl., *G. villosa* Willd., *Linum mysorensense* Heyne ex Wall., *Malva rotundifolia* Linn., *M. subangulata* Blume, *M. sylvestris* Linn., *Momordica cymbalaria* Fenzl. ex Hook. f., *Panicum hippothrix* K. Schum. (grains are cooked like rice), *P. trypheron* Schult., *Phoenix robusta* Hook. f., *Sesamum laciniatum* Klein., *Setaria glauca* (Linn.) P. Beauv., and *S. pallidifusca* (Sch.) Stapf. et C.E. Hubb. (variability in inflorescence type), as the wild relatives of cultivated species from the region. Later, *Abelmoschus manihot* (L.) Medik. ssp. *tetraphyllum* (Roxb. ex Hornem.) Borss. Waalk. var. *megaspermum* Hemadri, *Eleusine indica*, *borpudi* (*Indigofera glandulosa* Wendl. var. *sykesii*), *I. deccanensis*, *Corchorus urticaefolius* Wight et Arnott, *Phoenix sylvestris*, *pillipesara* (*Vigna trilobata*; *V. trilobata* var. *pusilla*), *Setaria pumila*, *Solanum nigrum* Linn., *Sorghum deccanense* Stapf. ex Raizada, *S. stapfii* C.E.C. Fischer, and *Vigna hainiana* Babu, Gopinathan & Sharma have also been recorded from the region.

Endemic species. As the region is not very rich in species diversity, the endemism of species is limited. Nevertheless, a few species or varieties (ecotypes) of economic significance have been reported endemic to the region, such as: *Abutilon ranadei* Wooder. ex Stapf., *lal aghada* (*Achyranthes coynei* Santapau), *Alysicarpus luteovexillatus* Naik & Pokle, *girmul* [*Cissus woodrowii* (Stapf. ex Cooke) Santapau], *Crotalaria decasperma*

Naik (syn. *C. mysorensis* Roth), *Panicum paianum* Naik & Patunkar, *P. phoinicladus* Naik & Patunkar, *Phyllanthus scabrifolius* Hook.f., *Tripogon polyanthus* Naik & Patunkar, *Urochloa panicoides* P.Beavu var. *marathensis* (Henr.) Bor (grasses), etc. (indiabiodiversity.org/content/checklist-endemic-plants-maharashtra; Nayar *et al.*, 2009). Table 1 lists some of the agriculturally important endemic species from the region.

Threatened species. The Red Data Book (Nayar and Sastry, 1987, 1988, 1990) has listed *Achyranthes coynei*, *Asparagus jacquemonti* Baker (syn. *A. racemosus* Willd.), *Ceropegia maccannii* Ansari, *Euphorbia katrajensis* Gage, *son ghanta* (*Abutilon ranadei*), etc. to be under various levels of threats. Nayar *et al.* (2009) have further listed *Acacia campbellii* Arn. (in Andhra Pradesh), *Aegle marmelos* var. *mahurensis* Zate, *Asparagus rottleri* Baker (in Andhra Pradesh and Karnataka), *Brachystelma volubile* Hook.f. (in Andhra Pradesh and Karnataka), *Ceropegia intermedia* Wight., *Ceropegia odorata* Hook. f., *Erythrina variegata* L. forma *mysorensis* Maheshwari, *Jasminum wightii* C.B. Clarke, and *Madhuca diplostemon* (C.B. Clarke) P. Royen to be under threat. Representative agriculturally important plant species under threat are presented in Table 2.

Associated culture and tribes

As evidenced by the archeological remains, agriculture appears to have been practiced in the region from ancient time, starting from Neolithic culture. The Deccan Plateau region with granite hills attracted human settlements because of

the availability of suitable caves or rock shelters. The evidences found suggest that this region, like Kathiawar, is a further southern expansion/extension of Harappan culture. It appeared to be the part of the peripheral zone, but with an independent regional style of local hunters and food gathering tribes/communities. The Chalcolithic cultural remains characterized by the use of copper in the region, as is evidenced by the excavations at Savalda, on the banks of the river Tapti in West Khandesh of Maharashtra (characterized by different ceramics). From the deposits of Savalda culture at Daimabad in Ahmednagar, grains of dwarf wheat (*Triticum sphaerococcum*) and barley (*Hordeum vulgare*) were found (Kajale, 1977a; Vishnu Mittre *et al.*, 1986). Also were found *Acacia* wood charcoals (Sharma, 1984). Later, presumably under the influence of Malwa culture, the cereals might have been followed by grain legumes, and Malwa culture was followed by Jorwe culture (ca. 1,400–900 BCE), known to be initiated from the bank of the Pravara river in district Ahmednagar and represented by more than 200 sites spread over the semi-arid zone of the Deccan Plateau, including Inamgaon, Theur, Sonegaon, and Chandoli in the district of Pune, Bhal in Jalgoan, Prakashe in Dhulia district and Jorwe and Nevasa in Ahmednagar district. Importantly, the presence of elements of substances like ivory in some of these remains, suggests introduction and integration of materials from southern culture of India, a development strengthened in the subsequent period.

Table 1. Representative economic plant species endemic to the Northwestern Deccan Plateau Region.¹

Species	Family	Habit	Distribution	Remark
<i>Abutilon ranadei</i>	Malvaceae	Undershrub	Maharashtra	Ornamental
<i>Achyranthes coynei</i>	Amaranthaceae	Herb	Pune to Karnataka	Fodder, medicinal
<i>Cissus woodrowii</i>	Vitaceae	Woody shrub	Andhra Pradesh	Genetic resource
<i>Crotalaria decasperma</i>	Fabaceae	Erect herb	South India	Genetic resource
<i>Panicum paianum</i>	Poaceae	Annual grass	Maharashtra	Feedstock
<i>Panicum phoiniclados</i>	Poaceae	Annual grass	Maharashtra	Feedstock
<i>Phyllanthus scabrifolius</i>	Euphorbiaceae	Shrub or tree	Madhya Pradesh, Maharashtra, Karnataka	Medicinal, used to treat inflammation of urinary passage

1. Source: www.indiabiodiversity.org/content/checklist-endemic-plants-maharashtra; Nayar *et al.* (2009).

Table 2. Representative economic plant species under threat in the Northwestern Deccan Plateau Region¹.

Species	Family	Habit	Threat level ²	Remark
<i>Abutilon ranadei</i> ³	Malvaceae	Undershrub	EN	Ornamental, genetic resource
<i>Acacia campbellii</i> ³	Mimosaceae	Tree	VU	Wood, Andhra Pradesh
<i>Achyranthes coynei</i> ³	Amaranthaceae	Herb	EN/R	Fodder
<i>Aegle marmelos</i> var. <i>mahurensis</i>	Rutaceae	Tree	R	Fruit, wild relative
<i>Asparagus jacquemonti</i> ³	Asparagaceae	Undershrub	I or DD	Young shoots edible
<i>Asparagus rottleri</i> ³	Asparagaceae	Undershrub	I or DD	Young shoots vegetable
<i>Brachystelma volubile</i>	Apocynaceae	Tree	I or DD	Attractive foliage
<i>Ceropegia intermedia</i>	Asclepiadaceae	Twiner	I or DD	Tuber edible
<i>Ceropegia maccannii</i> ³	Asclepiadaceae	Herb	R	Tuber edible
<i>Ceropegia odorata</i> ³	Asclepiadaceae	Twiner	EN	Medicinal, ceropagine
<i>Erythrina variegata</i> forma <i>mysorensis</i>	Fabaceae	Tree	I or DD	Wood
<i>Jasminum wightii</i> ³	Oleaceae	Climber	R	Ornamental
<i>Madhuca diplostemon</i> ³	Sapotaceae	Tree	EN	Wild relative

1. Source: Nayar and Sastry (1987, 1988, 1990); Nayar *et al.* (2009).

2. EN = Endangered; I or DD = Indeterminate or Data deficient; R = Rare; and VU = Vulnerable.

3. Listed by the Ministry of Environment and Forests, Government of India.

The evidences collected from various sites of the region give us a fair idea about the crops cultivated in the olden times, which included wheat (*Triticum aestivum*, *T. compactum*, *T. sphaerococcum*), barley (*Hordeum vulgare*), rice (*Oryza sativa*), jowar (*Sorghum bicolor*), kodo millet (*Paspalum scrobiculatum*), ragi (*Eleusine coracana*), foxtail millet (*Setaria italica*), green gram (*Vigna radiata*), black gram (*V. mungo*), lentil (*Lens culinaris*), grass pea (*Lathyrus sativus*), field pea (*Pisum arvense*), pigeonpea (*Cajanus cajan*), chickpea (*Cicer arietinum*), horse gram (*Dolichos biflorus*), kidney bean (*Phaseolus vulgaris*), hyacinth bean (*Lablab purpureus*), safflower (*Carthamus tinctorius*), linseed (*Linus ussitatissimum*) in field crops, and baheda/myrobalan (*Terminalia bellirica*), jambo or jamoon (*Syzygium cumini*), Indian cherry (*Cordia myxa*), chironji (*Buchanania lanzan*), ber (*Ziziphus jujube*), wild date (*Phoenix sylvestris*), karanj (*Pongamia pinnata*), sugandhabala (*Pavonia odorata* Willd.), and tarla (*Heteropanax fragrans*), in horticultural crops (Kajale, 1977a, 1977b, 1988; Vishnu Mittre *et al.*, 1986). The discovery of cotton beads strung upon silk threads from the Jorwe period remains at Nevasa and those of flax at Chandoli are unique findings, indicating production and spinning of cotton and flax in the region (Gulati, 1961), and might even be proof of domestication of diploid cotton (*Gossypium arboreum*) in the region. The finding of bones of cattle, sheep, goat, and buffalo reflects the domestication of animals during Jorwe culture. The Megalithic activities in Maharashtra were corroborated by the finds of agricultural tools at certain sites in Nagpur district. The

finds of these remains also suggest that probably this region was the meeting point of exchange of knowledge and materials between North Indian, Harappan Indus Valley, and Indo-Gangetic cultures, and the South Indian culture, which evolved distinctly with primary domestication of plants and animals respectively. Such presumption is further corroborated by the similarity of food remains discovered for Megalithic sites at Veerapuram in Andhra Pradesh and at Vidarbha in Maharashtra. The finds of medicinal plants also support such proposition and the interactions between North and South Indian cultures, including the northwestern Indian region. It appears that sandalwood was brought from South India, *chironji* from Central India, and grapes and dates from Northwest India into the region. For these reasons, in ancient literature, it has been suggested that the innovations from the north arrived into the south through this southern corridor, referred as the 'Dakshinapatha', i.e., the Northwestern Deccan Plateau, in conjunction with the south-central Eastern Ghats. The evidences of plant remains belonging to the Iron Age collected from various parts of the Indian subcontinent indicate that by the first millennium BCE, products of North Indian and South Indian cultures dispersed all over the subcontinent (Saraswat, 1992).

The first important reign to arise on the Deccan Plateau was the Satavahana dynasty (230 BCE). During the Satavahana period, extensive land and sea trade routes developed, further linking northern and southern India, making the region a cultural bridge, playing a great role in the exchange

of ideas and culture between the northern Indo-Gangetic Plain and South India. The rule of the Satavahana kingdom lasted from the second century BCE to the third century CE. It then split into smaller kingdoms that were ruled by families who had been feudal vassals of the Satavahanas.

Tribals in the region are mostly confined to the hilly areas. As per the 1991 census, the tribal population in Maharashtra was second only to that of Madhya Pradesh, containing 47 scheduled tribes. The major tribes of Maharashtra, including the Konkan region are *Gond-Madia*, *Bhil*, *Pavra*, *Mahadeo*, *Koli*, *Warli*, *Kokna*, *Thakur*, *Halba*, *Anah*, *Katkari*, *Oraon*, etc. Many tribes have ancestral land which they still cultivate. Some of these tribes had their own rules and administration. With the new land reforms and Acts, especially in Maharashtra, the tribals now have access to good education and political power. Some of them are doing progressive farming, while others have taken jobs in the cities. Many tribals have migrated to the plains and work as farm laborers. However, the most commendable job tribal farmers have done is preserving the important genetic diversity in millets, pulses, vegetables, etc., in the form of precious landraces, and medicinal plants. The greater part of the tribes still follows the primitive traditions. They live in groups and still lead a nomadic life moving from one place to another in caravans in search of livelihood. In the Andhra area, the major tribes associated with agriculture are *Adivasi*, *Girijan* and *Vanya Jati*, *Maria Gond*, *Katkari*, and *Kolam*. Culturally, during the festival days of Ugadi and Diwali, sweetmeats are prepared using

groundnut (*Arachis hypogaea*) and chickpea (*Cicer arietinum*). On the farmers' festival day "*Erokk Ponnami*", all the bullocks in the farming community of the village are decorated and taken out in a procession (Sateesh, 2002). During the "*Bhootalli*" festival for worshipping Mother Earth, songs mentioning and encouraging farmers to grow *sagam* (sorghum) are chanted, i.e., "*Olega sagam olega beliya jolave*" (Grow sorghum, grow prosperous). During the festive days farmers cook "*Bajikoora*" which includes all the vegetables, leafy and tender stems, pulses (pigeonpea, chickpea, green peas, amaranths, chilies), grown in the village as a ritual symbol, meant for the conservation of the life-supporting flora of the village (Sateesh, 2002).

Technology and products

Having to subsist in the parts of the semi-arid tropics that are characterized by general rainfall below potential evapotranspiration and of an unpredictable nature, which leads to moisture deficit in most years and flooding in some, the local people have developed some traditional water harvesting technologies in the region. These are *kohli tanks*, *bhanadaras*, and *phad*. The *kohli tank* system built in the Bhandara district by a small group of cultivators, consists of a number of water tanks of different sizes used for irrigation of sugarcane and rice, often with the provision of bringing water to the doorstep of their village farms. The *bhanadaras* are check dams built across rivers, raising the water level and forcing it to flow into the channels. They are also used to impound water from reservoirs. Usually villagers or individuals who built

such structures receive rent-free land in return. The *phad* is a community-managed irrigation system prevalent in northwestern Maharashtra in the Tapti River basin. The system starts with a *bhanadara* (check dam) built across the river. From here it is branched out into *kalvas* (canals) with a discharge capacity of about 450 liters per second. The lengths of these canals may vary from 2 to 12 km. From *kalvas*, *charis* (distributaries) are built for feeding water to different areas of the *phad*. *Phad sarangs* (field channels) channelize the water to individual fields. The *sandams* (escapes) are built along these structures to drain away the excess water. The *phad* system may extend from 10 to 200 ha, and is a community based effort, managed by the villagers, who decide on the area to be covered and the usage, ensuring healthy crop rotation, maintaining soil fertility, avoiding waterlogging and salinity of the soil.

The people of the region have great respect for forest and vegetation under the concept of “*Deva vanas*” (divine forests). Consequently, the region is also known for

sacred groves attaching significant sanctity to plants, which have been venerated from ancient times. The existence of sacred groves or “*Deva vanas*” has helped facilitate the conservation of local biodiversity including components of agrobiodiversity.

As the semi-arid regions are known for a relatively dry climate, the drought-resistant crops, such as sorghum and millets, are the dominant crops of the region. Over time they have become the staple food of the local population. The diverse landscape and ecological conditions have provided opportunities to the local tribes and communities to select traditional varieties suited to diverse ecological conditions, including the seasons, and with various desirable traits. In the case of sorghum, which is the dominant cereal crop (Fig. 3), variability with desirable features has evolved in the form of local landraces such as *Alluna jola*, *Dadar*, *Badi jowar*, *Dagadi jowar*, *Gulbendi*, *Harni jowar*, *Hulgi jola*, *Kavaali*, *Maldandi*, *Pandhari*, etc., from the Maharashtra area, and *Chiruthalavalu*, *Dhani jowar*, *Gingri jowar*, *Pandimutte jonna*, *Sadguru jonna*, *Tekdari jonna*, and *Vani jowar* from the Andhra Pradesh area. Most traditional varieties are associated with specific features: for example from Andhra Pradesh, the *Patcha Jonna* has yellow grain with excellent roti-making quality, keeps well and is grown in *kharif*; *Tella Malle Jonna* has white grain and is grown in *kharif*; *Yerra Jonna* has red grains and is grown in *kharif*; *Atta kodalla Jonna* has dull white grains often used for roti; *Maldandu* sorghum has white grain and is grown in *rabi*; *Pelala Jonna* has grains with good popping quality; *Kakimuttani Jonna*

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has spotted grains and early maturity (3 months) and is often grown by small farmers because of early maturity, and is also called the poor people's food (*Gharib Jonna*); *Sai Jonna* has white grain and is a *rabi* variety, while *Thoka Jonna* has loose heads having good fodder yield and resistance to smuts. A rainy season variety from the Maharashtra area, *Ambemohor*, ripening in 4.5 months was reported to contain a special flavor like that of *Ambemohor* rice (*Arnbemohor* – mango inflorescence). This variety was specially cultivated by the farmers as a delicacy (Prasada Rao and Murty, 1983). The women farmers know the weakness and strength of each of these varieties. For example, *Gundo Jonna* is good yielder with round head (Fig. 3), but sensitive to even drizzle, *Thoka jonna* is a dual type with good fodder yield, insensitive to rain and storage pests, and can be grown on any soil. Several of these landraces are being used in breeding programs: for example, the seed parent of hybrid CHS 4 was a cross between CK60A and PJ8K, a local landrace from Maharashtra. SPV-462, a very popular variety has been developed through a cross between an American introduction and local cultivar IS1151 from Maharashtra and BP53

from Gujarat. CSV216R is a selection from a landrace collected from Maharashtra. Most landraces of the region have the ability to survive under stress conditions (Elangovan *et al.*, 2006). Additionally, several sources of resistance to important pests and diseases have also been identified from the region: for example, IS1044 from Parbhani, IS1054 and IS1055 from Pune, and IS1151 from Khandesh for stem borer resistance; IS14332 for anthracnose, and IS18758 for grain mold, sugary disease, rust, charcoal rot, zenate leaf spot, and anthracnose from Akola.

In minor millets, the variability of various species is reflected by the diverse landraces with different seed coat color. For example, foxtail millet (*Setaria italica*) has white, red, and black grain; finger millet (*Eleusine coracana*) has white and common red grain; little millet (*Panicum sumatrense*; syn. *P. miliare*) has black and common white grain, while proso millet (*Panicum miliaecum*) also express significant variability. In finger millet, sources of useful genes for physiological traits have been identified, such as GE325 with low stomata number, high photosynthetic efficiency and low leaf area and GE717 with higher biomass and high harvest index (>35%) from Akola.

South Maharashtra is known for *dicoccum* wheat. *Khapli dicoccum* of the region is well known for quality and stem rust resistance and is being widely used in the breeding programs (Singh *et al.*, 2006). From the Andhra Pradesh area, wheat varieties such as *Mullu godhumalu*, *Katte godhumalu*, and *Budda godhumalu* are known. In rice,

both aromatic and non-aromatic traditional varieties are known from the region, such as *Bhura rata*, *Chimansel*, *Kala rata*, *Kolam*, *Kolamba 184*, *Kolipi*, *Zinya 149* among non-aromatic, and *Ambemohar 102*, *157*, *159*, *Jirasel*, *Sathi*, *Kamod*, *Krishansal*, *Pankhari 203*, etc., among aromatic. Other traditional extant varieties and landraces known from the region are *Panvel*, *Jalgaon*, *Gangasagar*, *Bobbili gantalu*, *Chalka buchi vadlu*, *Cheruku luchchalu*, *Chinna sindhu bayalu*, *Chinna vodlu*, *Duppi tokalu*, *Erra vadlu*, *Goranka mukkulu*, *Kare budamalu*, *Kattakichidi*, *Nalla vadlu*, *Roti singaralu*, *Sudi vanja*, *Vulliguththulu*, etc. (Nayar *et al.*, 2009). Prabhavati, an aromatic, iron-chlorosis tolerant and semi-dwarf rice variety was developed from the tall landrace *Jalgaon 5* through mutation breeding (Nerkar and Misal, 1987).

The grain legumes of the region show significant variability in grain characteristics, for example, green gram (*Vigna radiata*) has variation in seed size, color, and surface texture; and black gram (*Vigna mungo*) has differences in pod length. There is also a bold-seeded type in the case of green gram, and a good plant type in the case of black gram. Pigeonpea (*Cajanus cajan*) has diverse seed coat colors, white, spotted, black, and red; horsegram (*Dolichos biflorus*) has white, black, and common red seed coat color; cowpea (*Vigna unguiculata*) has white, black, and red seed, and field bean (*Dolichos lablab* var. *lignosus*) has white, black, and red seeds. A significant amount of variability in pigeonpea is noticed in the Deccan region. Here, ICR1093, a local landrace from the Andhra Pradesh area, is a source of pod borer tolerance and has

been used in the development of the variety Abhaya (ICPL 332), while ICPL 161 is a short-duration landrace (Remanandan and Singh, 1997). In cowpea, variability exists in habit, flower color, coloration of plants, including pod and seed, and their size.

Among oilseeds, significant variability has been recorded in the case of black mustard (*Brassica nigra*), and the variety Surya has been developed through selection from a local landrace. In groundnut, which is a 17th century introduction, the region has evolved significant genetic variability and local landraces such as Kadari-3 (naturalized Robut from Israel) in Andhra Pradesh and Jalgaon local in Maharashtra have been used in the development of varieties such as Robut 33-1 and JL 24, which are nationally the most stable high-yielding varieties till date in Virginia and Spanish cultivar groups respectively, and figure the maximum number of times in the parentage of nationally released varieties (Radhamani and Singh, 2008). Similarly in sesame, several varieties have been developed through selection from local landraces; for example, N58-2 from a landrace of Nashik, D-77-11-1 from a landrace of Dhule, Madhavi (SP1181) and TM6 from landraces of Andhra Pradesh, Gouri from a landrace of Kakkirapalli, and N-8 and N-128 from Nagpur local (Duhoon *et al.*, 2004). In niger, No.5, N-12-3, N-87, and Ootacamund have been developed from landraces of Nagpur since the inception of the All-India Coordinated Research Project in 1967. In safflower, some of the early varieties, N-630, Nagpur-7, and N-62-8 released for cultivation in the region were selected from local landraces. Cotton, which requires high temperature, light rainfall

or irrigation, and bright sunshine, is well suited to the region, and presents significant variability. The Central Institute for Cotton Research (CICR), Nagpur has collected a large number of distinct accessions from the region both in diploid and tetraploid cotton (Fig. 5). During collection in the Melghat area, although nine samples were collected, it was observed that tribal cultivation had created significant variability for leaf lobe shape, capsule size, etc., in diploid *Gossypium arboreum* (Singh *et al.*, 2013). The Melghat forest area is also considered to be the reservoir of variability for diploid *G. herbaceum* and for wild relatives of cotton, needing further exploration.

In vegetable crops, the region presents significant variability for *Solanum melongena* and chili for plant type and fruit characteristics. In several other crops the local cultivars/landraces have been used in the development of varietal products: for example, in the case of *Cucumis sativus*, Phule Shubangi has been developed through selection from a local landrace. In okra, the Red Wonder of Hyderabad has contributed to development of Co1. The wild relatives like *Abelmoschus manihot* ssp. *tetraphyllus* var. *megaspermum* and *A. ficulneus* provide additional genetic resource. The okra variety Parbhani Kranti was developed from the crossing of the extant variety Pusa Savani with the wild species *Abelmoschus manihot* ssp. *manihot* (Nerkar and Jambhale, 1985). While in onion, N53, Akra Pragati, Akra Kalyan, and Agrifound Dark Red were developed through mass selection in collections from Nashik; Akra Niketan from collections from Dubera; N-2-4-1 from a collection from Pune; Agrifound White Red from collections from Maharashtra; and

Baswant-780 from collection of Pimpalgaon, Maharashtra. In garlic, the variety Godavari has been developed through mass selection in a collection from Maharashtra (Pandey *et al.*, 2005).

Among spices, the region is known for variability in turmeric, where a variety such as Krishna has been developed through clonal selection from Tekurpeta collections with plump rhizome and resistance to pests and diseases. In the Chandrapur district, turmeric landraces are being grown as a rainfed crop.

The region is known for traditional varieties of mango, such as *Alphonso* (long shelf life, good for processing for pulp/juice/nectar), *Mankurad*, *Muloga*, *Pairi* (high pulp content), *Banganpalli* (large fruit size), and *Totapari* (regular bearing). In the foothills of the Satpura ranges, wide variability is observed in the local mangoes in the Dhule and Nandurbar districts. Among *Citrus*, the region is known for varieties such as *Nagpuri santra* in mandarin (*Citrus reticulata*); *Mosambi*, *Sathagudi*, *Malta*, *Blood Red* in sweet lime (*Citrus sinensis*); and *Kagzi lime*, *PKM-1*, *Vikram*, *Baramasi*, *Sai Sarbati*, seedless lime, etc., in acid lime (*Citrus aurantifolia*) (Karihaloo *et al.*, 2005). In fact, the color, sweetness, and flavor of the world-famous *Nagpuri santra* (mandarin) is geographically associated with the cool dry winter conditions of the Satpura hills (Vidarbha region), and is suitable for protection under Geographical Indication of Goods Act, 1999. Besides, the region has large variability in the case of custard apple (*Annona squamosa*) and *Tamarindus indica*.

South Maharashtra is known for dicoccum wheat. Khapli dicoccum of the region is well known for quality and stem rust resistance and is being widely used in the breeding programs.

The local tribes have also developed several practices for sustainability and increased productivity. For example, eco-farming or mixed cropping involving more than 12 crops is practiced in the Andhra Pradesh area. Mixed cropping is also used as a strategy for crop protection. Many farmers who grow ginger or turmeric as cash crops maintain castor plants along the borders of their fields in order to check the spread of diseases and provide shade. In the wheat–chickpea association, chickpea serves to divert rats from the wheat crop.

In most parts of the region, traditional farmers use the rhizosphere soil beneath the banyan tree for improving the soil fertility, and *Amritpani* (special bio-inoculant prepared from cow dung, cow ghee, cow urine, and honey) is being used for treating seeds and seedlings and for enrichment of soil for better germination and nutrition. These practices are now being popularized as part of organic agriculture programs.

Future perspective

Agroclimatically, the region has high productivity potential. However, the major constraint restricting agricultural productivity is the erratic rainfall and high evapotranspiration rate, which result in frequent water deficit for prolonged periods,

producing various types of droughts, adversely affecting the crop growth leading to lower yield and crop failures in some years. At other times, stormy cloud bursts causing heavy rainfall result in high runoff and soil erosion. Therefore, greater research is needed for effective water management using traditional watershed technological approach, and development of appropriate practices for efficient use of water and for supportive irrigation, which can be the key to further progress of agriculture in the region.

A large area of the region is adversely affected due to salinity, alkalinity, and waterlogging. Also, the soils of the region are deficient in major nutrients such as nitrogen and phosphorus and micronutrients such as zinc, iron, manganese, boron, and molybdenum, needing greater research for removal of nutritional imbalances.

The dry climate of the region is highly suitable for tropical horticultural fruit crops such as mango, grape, orange, lemon, banana, pomegranate, etc., and floriculture. Therefore, integration of technologies of drip irrigation, protective cultivation, cold storage, and transportation can help improve production and increase farmers' incomes.

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