Probable Agricultural Biodiversity Heritage Sites in India: XI. The Upper Gangetic Plains Region

Anurudh K Singh
Department of Genetics, MD University, Rohtak 124001, Haryana, India
(email: anurudhksingh@gmail.com)

Abstract

The Upper Gangetic Plain, the western part of the larger Gangetic Plains, has been one of the epicenters of origin and evolution of agriculture in India from the Neolithic period. The favorable climate and the landscape of the region have attracted the local people towards domestication of plants and animals. It led to evolution of settled agriculture from a nomadic pastoral life. The archaeological and literary (Vedic) evidences suggest it to be one of the regions where rice was first brought into cultivation from the wild, and where wheat was introduced through interactions with the Harappan civilization, followed with the domestication and introduction of a number of cereals, grain legumes, oilseed and other crops from other parts of the world involving most people from the early days. These crops were better exploited with improved cultivation practices, including the introduction of the plow. For these reasons, this region made faster economic progress compared with other regions, and evolved valuable genetic diversity in a wide range of crops. With increasing population, it expanded to other parts with new settlements and/or by sharing the knowledge gained and the products with other parts of the region, making India principally an agriculture-based economy. The economic prosperity of the region led to urbanization and establishment of the initially Hindu doctrine and way of life. Thus, the region can be considered the mother of much of agriculture in India and is being proposed as another National Agricultural Biodiversity Heritage Site, based on established indices.

The Gangetic Plain, watered by perennial rivers such as Ganga (Ganges), Yamuna, Ghagra, Gomati, Gandak, Son, and several tributaries with a long stretch of sedimental land, including the Upper Gangetic Plain (UGP), laid the foundations of agriculture in India by the early farming communities and can be considered the mother of much of agriculture practiced in other parts of the country. Over the ages, the Gangetic landscape with fertile soil and hospitable climate of river valleys and plains attracted most human settlers to the region, as these factors are fundamental to agricultural productivity and essential for the growth and development of agriculture and civilization. There is much evidence to suggest that agriculture in the Gangetic plains began with Neolithic settlements, evolved over times, and that it has been the main occupation of human populations in the region since then. The beginning of
agriculture in the region can be traced with evidence from Mahagara and Koldihwa (District Allahabad) in the Belan Valley (Tripathi, 2008).

The prevalent ecosystems, the land forms and the differential development, conditioned by limits of human intellect over time, divided the Gangetic plain into three regions – the upper, the middle, and the lower Gangetic plains. The UGP is comparatively drier and more arid, with climate being little more prone to extremes. It has by and large homogenous soil, with evidences of very early beginning of agriculture traced to the Neolithic period, engaging most people. It can share the credit for the earliest domestication of rice at Koldihwa and Mahagara, with Chopani Mando (District Allahabad, Belan river) of the Middle Gangetic Plain (MGP) in the same area, except China from where new evidences have risen in recent years (Tripathi, 2008). The region also had significant archaeological and other evidences for early cultivation of cereals, pulses, oilseeds, fruits, and vegetables. Further, there are evidences to suggest interaction with other early civilizations, for example, wheat cultivation was introduced into the region by the Painted Gray Ware (PGW) culture. It is quite likely that it entered into the region through Harappan interactions, as proven by the sites such as Bhagwanpura in Haryana or because of the movement of people from Harappan civilization towards the more fertile Ganga-Yamuna river valley, due to climatic changes in the Indus Valley. It is also suggested that due to favorable ecology and generation of superior technology, the PGW folk favorably exploited the land for greater yield and for a richer variety of agricultural products. Consequently, the UGP attained a superior economic growth in course of three to four centuries of PGW culture. Therefore, the region can be credited for evolving agriculture from the early stages of human settlement, domestication of rice, introduction of wheat from Harappan civilization, further domestication of plant and animal species, improved cultivation involving initial plowing technology, making agriculture the main economic activity, and dispersal of technologies and varieties of crops to other parts of the Gangetic plains, and the country at large with or without new settlements. During these developments, it evolved a large amount of genetic diversity in major cereals, pulses, oilseeds, and vegetable crops and practices like double cropping, etc. Culturally, it can be credited with the evolution of urbanization with emergence/establishment of cities, and evolving and establishing the initial doctrines of the Hindu way of life. For these significant contributions to agriculture and culture, the region is being proposed to be another National Agricultural Biodiversity Heritage Site based on the indices illustrated by Singh and Varaprasad (2008).

**Location and extent**

The UGP region falls between the western Himalayas in the north and the hills and plateau in the south, and comprises the major portion of Haryana and Uttar Pradesh (UP). The Allahabad-Faizabad tract can be the dividing line between the Upper and Middle Gangetic plains (Tripathi, 2008). Ecologically, the northern plains
of Punjab, Haryana, and the western parts of eastern UP can be included into this region (Fig. 1). The region is bounded by the Himalayan subtropical pine forests, Terai-Duar savannas and grasslands and Himalayan subtropical broadleaf forests in the Himalayan foothills on the north, by the drier northwestern thorn scrub forests and Kathiawar-Gir dry deciduous forests in the west, by the Narmada Valley dry deciduous forests of the Malwa and Bundelkhand uplands on the south, and by the more humid MGP with grasslands and moist deciduous forests on the east (Fig. 1).

Administratively, it may include districts of northern Punjab, most of Haryana and western UP, and the districts such as Bareilly, Plibhit, Lakhimpur Kheri, Sitapur, Hardoi, Sitapur, Barabanki, Lucknow, Unnao, Rae Bareilly, Kanpur, Kannuj of Central UP, and Allahabad, Pratapgarh, Sultanpur, Faizabad, Gonda, and Balrampur of eastern UP (Fig. 1). The important sites of the region with remains of ancient agriculture, which might have been the epicenters of origin and evolution of agriculture, include Lal Qila, Atranjikhera, Springpur, Hulas, Noh, Hastinapur, Radhan, etc.

Landscape

The dominant landscape of the Gangetic Plains is a gentle slope. More than 95% of the ecoregion has been degraded or converted into agriculture with settlements of dense human population from thousands of years. Only the block running along the Himalayan foothills in UP remains protected. The landscape of the Gangetic Plains is sometimes classified into four divisions:

- **The Bhabar**: the areas adjacent to the foothills of the Himalayas, consisting of boulders and pebbles that have been carried down by the river streams. As the porosity of this belt is very high, the streams flow underground. The bhabar is generally narrow with its width varying between 7 and 15 km.

- **The Terai**: the area lying next to the bhabar region, composed of newer landscapes.

The Gangetic Plain, watered by perennial rivers such as Ganga (Ganges), Yamuna, Ghagra, Gomati, Gandak, Son, and several tributaries with a long stretch of sedimental land, including the Upper Gangetic Plain (UPG), laid the foundations of agriculture in India by the early farming communities and can be considered the mother of much of agriculture practiced in other parts of the country.
Agricultural biodiversity heritage sites

The underground streams reappear in this region. The region is excessively moist and thickly forested. It also receives heavy rainfall throughout the year and is populated with a variety of wildlife.

- **The Bhangar**: the area consisting of older alluvium and forming the alluvial terrace of the flood plains. In the Gangetic plains, it has a low upland covered by laterite deposits.

- **The Khadar**: the area covering the lowland areas after the bhangar. It is made up of fresh newer alluvium which is deposited by the rivers flowing down the plain.

The Terai zone is dominated by moderate to gentle slopes. In the ancient times, thick vegetal cover, especially with moist deciduous forests covered the land. The plains are man-made, developed through deforestation. The region is predominantly watered and irrigated by the Ganga river system (Fig. 2), which consists of the network of the Ganga and Yamuna, the two major rivers with tributaries such as the Gomati. A host of streams rising out of the Shiwalik Range irrigate the western part of the plains. On the eastern side, there are Kalindi, Sukanta, Hindon, etc. Most of the rivers are perennial, providing hospitable land for human settlement. Because of these reasons the region is the most cultivable part of India.

**Agroclimate**

The region is characterized as a hot subhumid ecoregion with alluvium-derived soil. The climate of the region is characterized by hot to warm summers and cool winters. It is relatively more prone to extremes. Winters could be frosty, especially in January, with hailstorms up to February, which often damages the crops. During these months, the temperatures at times drop down to 5–7°C. In summers, the temperatures go up to 45°C during May and June, when the rains start cooling the scorching heat of the

---

**Therefore, the region can be credited for evolving agriculture from the early stages of human settlement, domestication of rice, introduction of wheat from Harappan civilization, further domestication of plant and animal species, improved cultivation involving initial plowing technology, making agriculture the main economic activity, and dispersal of technologies and varieties of crops to other parts of the Gangetic plains, and the country at large with or without new settlements.**
summer. The region receives a mean annual rainfall of around 1,000 mm, of which 70% falls during the summer monsoon period extending from July to September. The monsoons are southwest originating in the Bay of Bengal. Therefore, the eastern reaches of the Middle and Lower Gangetic plains receive more moisture, with a gradual trend towards drier conditions in the west, the UGP. The rainfall during this period averages around 500 mm. The rainfall covers 70% of the evapotranspiration, extending the availability of moisture from 150 to 180 days (Sehgal et al., 1992), which is the growing period for crops. The dry period is from February to June.

The soils of the region are generally deep loamy and have developed on alluvium. The dominant soil-scapes that represent the region constitutes gentle to very gentle sloping Ustochrepts, Haplustalfs, and Ustifluvents as per the soil classification. The Terai zone is dominated by the soil-scapes with moderate to gentle sloping Hapludolls and Hapludalfs. The moisture availability in these soils ranges from medium to high. The Basiram (silt loam soils) and Haldi (sandy loam) series represents the soils of the plains and of the piedmont plains, respectively; the latter are rich in organic matter (Sehgal et al., 1992).

The soils of the region are by and large homogenous with usar and bhabar, being the two dominant types, depending on the drainage pattern of the particular area. Other soils are khadar and bhangar. Khadar soils, rich in nutrients are found in the flood plains of river, generally with pH ranging between 6 and 8. Bhangar soil is more extensive in inter pluvial zones. The soluble salts are present in a smaller percentage. It is neutral to slightly acidic in reaction. The soils closer to Ganga are loamy to sandy-loamy in texture, while the Yamuna region has more silt composition. The bhangar soil is poor in phosphoric acid, nitrogen and other organic matters (Tripathi, 2008).

**Floristic diversity**

The region is rich in floristic diversity. In the ancient times, the land was covered with a thick vegetal of moist deciduous forests. According to ancient literary sources, the area between Saraswati and Sadanira was covered with thick forests such as Basundha, Naimisaranya, and Utpalaranya. Sal, babool, khair, shisham, semal, etc. were the common trees growing. Most of these plants have been testified from the excavations at Lal Qila, Atranjikhera, Hastinapur, etc.

The major natural vegetation in the region is tropical dry deciduous forests. The dominant tree species in the region are khair (Acacia catechu Brandis), bael [Aegle marmelos (L.) Correa ex Roxb.], siris [Albizia lebbeck (L.) Benth.], bakli [Anogeissus latifolia (Roxb.) Bedd], palas [Butea monosperma
Agricultural biodiversity heritage sites

(Lam.) Taub.), amaltas (Cassia fistula L.), shisham (Dalbergia sissoo Roxb.), bargad (Ficus benghalensis L.), peepal (Ficus religiosa L.), haldu [Haldina cordifolia (Roxb.) Ridsdale; syn. Adina cordifolia (Roxb.) Bra], jamun [Syzygium cumini (L.) Skeels], sal (Shorea robusta C.F. Gaertn.), and bahaera [Terminalia bellirica (Gaertn.) Roxb.]. The important grass species are kilikanal (Arundo donax L.), senr [Chrysopogon fulvus (Spreng.) Chiov.], jarakush [Cymbopogon martinii (Roxb.) Wats.], kush (Deshmostachya bipinnata Stapf), bhalai [Imperata cylindrica (L.) P.Beauv.], narkul [Phragmites karka (Retz.) Steud.], kans (Saccharum spontaneum L.), and khuskhus (Vetiveria zizanioides L.). Based on the phytogeographical association, Rhind (2010) classified the forest vegetation into four categories.

I. Moist Deciduous Forests

These are the original forests dominated by sal (Shorea robusta), which form an upper canopy of trees reaching heights of up to 35 m. Other commonly associated trees include Adina cordifolia, Dillenia pentagyna Roxb., Lagerstroemia parviflora Roxb., Stereospermum suaveolens DC., Terminalia bellirica, and T. tomentosa Wight & Arn. However, today they remain only in the area extending along the Himalayan foothills of UP. In the Siwali Hills, canopy trees other than the ones mentioned above include Anogeissus latifolia, Diospyros tomentosa Roxb., Garuga pinnata Roxb., Lannea coromandelica (Houtt.) Merr., and Pinus roxburghii Sarg. Common second-story species are Buchanania lanzan Spreng., Dendrocalamus strictus Nees., Ehretia laevis Roxb., Ougeinia ooejinensis Hochr., and Semecarpus anacardium L.f., while typical third-story species include Berberis asiatica Griff., Clerodendron viscosus Vent., Colebrookea oppositifolia Lodd., Murraya koenigii (L.) Spreng., Pogostemon plectranthoides Desf., and Woodfordia fruticosa Kurz. Common shrub-layer species are Chrysopogon fulvus, Heteropogon contortus L., and Thysanolaena maxima (Roxb.) Kuntze, while herbs include Bauhinia vahlii Wight & Arn., and Milletia extensa (Benth.) Baker (syn. M. auriculata Baker ex Brandis).

However, the physiognomy of these forests depends on various factors particularly relating to variations in local climate, topography, geology, and soil.

II. Tropical Moist Deciduous Riverine Forests

These forests occur on recent alluvium plains throughout the moist part of the Plains, particularly the sub-Himalayan zones of UP. These riverine areas are usually well drained but liable to erosion and flooding. So much of the well-established forest occurs on the higher and more stable alluvial terraces. The upper story typically includes Adina cordifolia, Bombax ceiba L. (syn. B. malabaricum DC), Garuga pinnata, Gmelina arborea Roxb., Hymenodictyon excelsum Wall., Lagerstroemia parviflora, Lannea coromandelica, and Terminalia bellirica. A few climbers and bamboos are also found. Common second-story species are Cassia fistula, Dendrocalamus strictus, Ehretia acuminata R.Br., Emblica officinalis Gaertn., Holarrhena antidysenterica Wall. ex A.DC., Mallotus philippensis (Lam.)
Müll.Arg., Randia longispina DC., and Ziziphus mauritiana Lam. (syn. Z. jujuba Mill.; Z. vulgaris Lam.). However, the trees in these forests rarely form extensive stands, and usually a shrub layer is well-developed. Typical shrubs include Adhatoda vasica Nees, Callicarpa macrophylla Vahl, Glycosmis cochinchinensis Pierre ex Engl., Helicteres isora L., Murraya koenigii, and Podostemon plectranthoides. In places, the shrub layer is so dense that few ground-layer species can exist and even grasses are often sparse or absent. Ground-layer species include Cryptolepis buchanani Roem. & Schult. and Vallaris heynei Sprengel.

III. Sporobolus-Chloris Saline Scrub
In these areas, there is restricted drainage combined with high summer temperatures and low monsoonal rainfall, and soils have high concentration of salts. The vegetation has an irregular, semi-savannah appearance, with Acacia arabica Willd. [syn. A. nilotica (L.) Delile] dominating the loamy soils, and Butea frondosa Roxb. ex Willd., the clayed waterlogged areas. Azadirachta indica A. Juss. is frequent and the palm Phoenix sylvestris (L.) Roxb. has a scattered distribution. At the ground level, the gregarious, perennial grass Sporobolus pallidus Benth. often dominates together with the annual grass Chloris montana Roxb., and the annual forb (non-grass herb) Cyanothis axillaris (L.) D.Don. However, many of the characteristic species have sporadic distributions, which include Aeschynomene indica L., Alysicarpus bupleurifolius (L.) A.DC., Aneilema nudiflorum Miq. ex C.B.Clarke, Corchorus acutagulus Lam., Cyperus aristatus Hook.f. & Thoms. Partim ex C.B.Clarke, Oldenlandia diffusa Roxb., Portulaca oleracea L., P. tuberosa Roxb., and the grasses such as Aristida hystrix Linn.f., Desmostachya bipinannata (L.) Stapf., and Paspalidium flavidum (Retz.) A. Camus. In hollows and shallow depressions where rainwater can accumulate “wild paddies” often develop, characterized by species such as Echinochloa colonum L., Ischaemum rugosum Salisb., and Paspalum scrobiculatum L.

IV. Phragmites-Saccharum-Imperata Grassland
These grasslands are found throughout the Gangetic Plain, from Punjab to the Brahmaputra Valley. They are characteristic of low-lying, poorly drained land with higher water tables. The typical perennial grasses are Imperata cylindrica (L.) P.Beauv., P. karka (Retz.) Steud., and Saccharum L. species, such as S. arundinaceum Retz. (syn. S. procerum Roxb.), S. bengalense Retz., and S. spontaneum. Other perennial grasses represented throughout this formation include Bothriochloa intermedia (R.Br.) A.Camus, B. odorata (Lisboa) A.Camus, Chrysopogon aciculatus (Retz.) Trin., Cynodon dactylon Pers., Desmostachya bipinannata, Hymenachne pseudointerrupta Müll.Hal., Ischaemum timorensen Kunth, Narenga porphrocoma Bor., Neyraudia reynaudiana (Kunth) Keng ex Hitche., Panicum notatum Retz., Sclerostachya fusca A.Camus, Sporobolus indicus (L.) R.Br., and Vetiveria zizanioides. Typical annual species are Apluda mutica L., Chionachne koenigii (Spreng.) Twaites & Hook.f., Dactyloctenium aegyptium
(L.) K.Richt., *Echinochloa colonum*, *Eragrostis viscoss* Scribn., *Ischaemum rugosum* Salisb., *Microstegium ciliatum* A.Camus, *Paspalum scrobiculatum*, and *Schizachyrium brevifolium* (Sw.) Nees ex Büse. In addition to grasses, over 50 species of herbaceous forbs have also been recorded. These include *Alysicarpus monilifer* (L.) DC., *Blumea membranacea* DC., *Euphorbia hirta* L., *Hypitis brevipes* Benth., *Kyllinga brevifolia* Rottb., *Leucas aspera* Link, *Lindernia crustacea* (L.) F.Muell., *Lochnera rosea* Rchb., and *Mikania scandens* Willd. However, in very swampy areas, the reed *Phragmites karka* can become mono-dominant covering 90% of the areas.

**Agriculture and agrobiodiversity**

The agriculture in the region is very old, dating back to the Vedic Age \[1,500–600 BCE; 8000–1000 BCE (editors)\] and before, which saw the development of agricultural activities on a large scale. The people of the early phase were semi-nomadic and subsisted on large herds of domesticated cattle and farm animals. They moved their settlements from one pastoral area to another and lived on agrarian and dairy products obtained from cattle. As their requirements grew, they brought large tracts of fertile land under the plow, driven by oxen. Therefore, agriculture or farming has been the mainstay of the people of this region from time immemorial; in fact, the region has been the epicenter of origin and evolution of agriculture due to the availability of water for the most part of the year from rains, and the network of tributaries of major rivers (that later evolved into the canal system). For this reason, traditional farming practices relate to both rainfed and irrigated agriculture. The region is often referred as a granary or the breadbasket of India.

Rice was domesticated in the region, and wheat domesticated early suited well to the dry winter climate. Therefore, most of the farming and cropping systems that evolved revolve around these two crops. During the rainy (*kharif*) season, the common crops grown in the area are rice, maize, and pigeonpea, and during the postrainy cold (*rabi*) season, wheat, chickpea, rapeseed mustard, and vegetables are grown. Sugarcane is cultivated as a post-*rabi* crop during November–December and February–March. The post-*rabi*, summer crops include short-duration pulses such as *Vigna* spp. and vegetables such as cucurbits, which are also cultivated in river beds.

Rice is the main *kharif* crop, traditionally cultivated in the eastern districts of the UGP (Fig. 3). The alternate crops are

---

*The region is rich in floristic diversity. In the ancient times, the land was covered with a thick vegetal of moist deciduous forests. According to ancient literary sources, the area between Saraswati and Sadanira was covered with thick forests such as Basundha, Naimisaranya, and Utpalaranya. Sal, babool, khair, shisham, semal, etc. were the common trees growing.*
maize, sorghum, pulses, sugarcane, and groundnut. Traditionally, wheat–chickpea based cropping patterns were main *rabi* crops in the areas of northwestern districts of UP and Haryana. The network of canals in Punjab, Haryana, and northwestern districts of UP support irrigated wheat crops (Fig. 4). The alternative important *rabi* crops are maize, sugarcane, and groundnut. The *kharif* maize has the largest area in UP, with alternate crops as rice in *kharif* and wheat in *rabi*. However, in some areas, groundnut, sugarcane, finger millet, and pulses are the alternate crops. Hence, the major crops of the region are rice, maize, pearl millet, wheat, barley, sorghum, chickpea, pigeonpea, lentil, black gram, green gram, pea, rapeseed mustard, sunflower, groundnut, linseed, cotton, sugarcane, potato, vegetables, etc.

The major cropping systems are rice–wheat, which brought about the Green Revolution in the region. Other cropping systems are sorghum–wheat, sugarcane–wheat, cotton–wheat, pearl millet–rapeseed mustard, maize–wheat, maize–wheat–green gram, pigeonpea–wheat, groundnut–wheat, rice–chickpea, rice–lentil, rice–mustard, rice–fallow–fallow, rice–fallow–rice, potato–black gram/green gram, etc. Presently, of the 77 cropping systems practiced, 38 are rice-based. About 7% of the area is covered by 5 single-crop systems; 72% of the area by 56 double-crop systems; and the remainder 21% by 16 triple-crop systems.

In addition, to ensure the availability of diverse food, mixed cropping is also a part of traditional agricultural cropping systems, which include vegetable crops. For example, the planting of *Cucumis melo* var. *momordica* or *C. sativus* mixed with maize and pearl millet is a common constituent of subsistence agriculture.

Crop–livestock interaction has been a unique feature of the region, and there has been a tradition of using crop residue as the main fodder for livestock. For example, wheat straw is the most preferred feed for animals, which may be supplemented with pulse peels and oilcake. Livestock has a major input in crop production by providing all the energy required to perform most operations/activities.
Representative species in various crop groups

Cereals, pseudocereals, and millets. Amaranth (Amaranthus hypocondriacus L.), barley (Hordeum vulgare L.), buckwheat (Fagopyrum emarginatum Moench), foxtail millet [Setaria italica (L.) Beauv.], kodo millet (Paspalum scrobiculatum L.), maize (Zea mays L.), oat (Avena sativa L.), pearl millet [Pennisetum glaucum (L.) R.Br.], proso millet (Panicum miliaeceum L.), ragi or finger millet (Eleusine coracana Gaertn.), rice (Oryza sativa L.), sorghum [Sorghum bicolor (L.) Moench], and wheat (Triticum aestivum L.).

Grain legumes and oilseeds. Black gram [Vigna mungo (L.) Hepper], chickpea (Cicer arietinum L.), cluster bean (Cyamopsis tetragonolobus (L.) Taub.], garden pea (Pisum sativum L.), green gram [Vigna radiata (L.) Wilczek var. radiata], lablab bean [Lablab purpureus (L.) Sweet ssp. benghalensis (Jacq.) Cufod.], lentil (Lens culinaris Medic), moth bean [Vigna aconitifolia (Jacq.) Marechal], pigeonpea [Cajanus cajan (L.) Millsp], rapeseed mustard [Brassica juncea (L.) Hook.f. & Thomson; B. napus L.; B. rapa L. var. brown sarson; B. rapa L. var. yellow sarson; B. campestris L.; B. tournefortii Gouan], safflower (Carthamus tinctorius L.), sweet pea (Lathyrus odoratus L.), and taramira (Eruca sativa Mill.).

Fodder and fiber crops. Cluster bean (Cyamopsis tetragonolobus), cowpea [Vigna unguiculata (L.) Walp.], deenanath grass (Pennisetum pedicellatum Trin.), Ficus auriculata Lour., F. semicordata Buch.-Ham. ex Sm., Grewia optiva J.R. Drumm. ex Burret., guinea grass (Pennisetum maximum Jacq.), gular (Ficus racemosa L.; syn. F. glomerata Roxb.), Lathyrtus aphaca L., Leucaena leucocephala Lamk., levant cotton (Gossypium herbaceum L.), napier grass (Pennisetum purpureum Schumach.), oat (Avena sativa), rhodes grass (Chloris dolichostachya Lag.), Sesbania sesban (L.) Merr., Trifolium resupinatum L., tula cotton (Gossypium arboreum L.), and velvet bean [Mucuna deeringiana (Bort.) Merr.]. In addition, crop residues of major and minor cereals and their forage types are used as fodder.

Vegetables. Ash gourd [Benincasa hispida (Thunb.) Cong.], bhindi or okra [Abelmoschus esculentus (L.) Moench], bitter gourd (Momordica charantia L.; M. balsamina L.), bottle gourd [Lagenaria siceraria (Molina) Standley], brinjal (Solanum melongena L.), brussel sprouts (Brassica oleracea var. gennifera Zenker), cabbage [Brassica oleracea var. capitata (L.) DC.], cauliflower (Brassica oleracea
Asian Agri-History Vol. 16, No. 1, 2012   31

var. botrytis L.), cucumber (Cucumis sativus L.), kachari (Cucumis melo var. agrestis Naud.), kakri (Cucumis melo var. utilissimus Duthie and Fuller), kohlrabi (Brassica oleracea L. var. gongylodes L.), mitha kumra (Cucurbita maxima Lam.), muskmelon (Cucumis melo L.), phut or snap melon (Cucumis melo var. momordica Duthie and Fuller), pumpkin [Cucurbita pepo L.; Cucurbita maxima Duchesne], rape (Brassica napus L.), ras dhana (Amaranthus caudatus L.), ridge gourd [Luffia acutangula (L.) (Roxb.) syn. Citrullus fistulosus (L.); syn. L. aegyptiaca Mill.], satawar (Asparagus racemosus L.), sponge gourd (Luffa cylindrica Roxb.; syn. L. aegyptiaca Mill.), and tomato (Solanum lycopersicum L.; syn. Lycopersicum esculentum Mill.).

Leafy vegetables. Bathua (Chenopodium album L.), chaulai (Amaranthus paniculatus L.), garden lettuce (Lactuca sativa L.), green vegetable [Beta vulgaris L. var. orientalis (Roth) Moq.], lal sag (Amaranthus gangeticus L.), faridbutti used as pot herb (Farsetia hamiltonii Royle, F. jacquemontii Royle), latmhuria or leafy pot herb [Digera muricata (L.) Mart.], methi or fenugreek (Trigonella foenum-graecum L.), mustard green [Brassica juncea (L.) Czern. var. integrifolia (H. West) Sinskaya], spinach (Spinacia oleracea L.), and water spinach (Ipomoea aquatica Forsk.).

Rhizome, tubers, and bulbs. Arbi or arvi [Colocasia esculenta (L.) Schott], carrot (Daucus carota L.), lahsan or garlic (Allium sativum L.), jimikand or Indian yam (Dioscorea trifida L.f.; D. bulbifera L.), kand (D. kalkapershadii Prain & Burkill.), kanda or shallot (Allium ascalonicum L.; syn. A. cepa L. var. aggregatum), onion (Allium cepa L.), potato (Solanum tuberosum L.), radish (Raphanus sativus L.), and shakarkand or sweet potato [Ipomoea batatas (L.) Lam.].

Fruits. Anjir (Ficus carica L.; F. palmata Forsk.), aonla (Emblica officinalis Gaertn.), bael (Agle marmelos), ber (Ziziphus oenoplia Mill.), ber or European nettle tree (Celtis australis L.), guava (Psidium guajava L. Links), jackfruit (Artocarpus heterophyllus Lam.), jamun [Syzygium cumini (L.) Skeels], kaiphal (Myrica esculenta Buchanan-Hamilton ex D. Don), karaunda (Carissa carandas Lour.), karna orange (Citrus karna Raf.), khejri (Prosopis cineraria Druce.), kinnow (Citrus deliciosa Ten.; syn. C. reticulata Blanco.), kondai or parker [Flacourtia indica (Burm.f.) Merr.; syn. F. septiastra Roxb.], kondai or parker [Flacourtia indica (Burm.f.) Merr.; syn. F. septiastra Roxb.], krape (Citrus paradisi Macfad.), litchi (Litchi chinensis Sonn. Mill.), mango (Mangifera indica L.), shahtoot or mulberry (Morus alba L.; M. nigra L.), orange (Citrus sinensis L. Osbeck), papeeta or papaya (Carica papaya L.), Perilla ocymoides L., phalwara [Aesandra butyracea (Roxb.) Baehni], pomegranate (Punica granatum L.), pureni [Ampelocissus latifolia (Roxb.)

Crop–livestock interaction has been a unique feature of the region, and there has been a tradition of using crop residue as the main fodder for livestock.
Agricultural biodiversity heritage sites

Planch.; syn. Vitis latifolia Roxb., galphuli or salpan (Flemingia chappar Benth.), sansaru [Debregeasia hypoleuca (Hochst.) Wedd.], tamarind (Tamarindus indica L.), watermelon [Citrullus lanatus (Thunb.) Matsum. & Nakai], and wood apple (Feronia elephantum Correa; syn. Limonia acidissima L.).

Spices. Benarasi rai or black mustard [Brassica nigra (L.) Koch.], coriander (Coriandrum sativum L.), curry patta (Murraya koenigii Spreng.), fennel (Foeniculum vulgare Mill.), lal mirchi (Capsicum annuum L.), pudina (Mentha arvensis L.), and turmeric (Curcuma domestica Valet.; syn. C. longa L.).

Other crop species. Indigo (Indigofera tinctoria L.), rasna (Pluchea lanceolata Oliv. & Hiern), and sugarcane (Saccharum officinarum L.).

Medicinal plants. Adusa (Adhatoda zeylanica Medik.), aloe (Aloe barbadensis Mill.), arandi or castor (Ricinus communis L.), ashwagandha [Withania somnifera (L.) Dunal.], babchi [Psoralea corylifolia L.; syn. Cullen corylifolium (L.) Medik.], basil (Ocimum sanctum L.), behada (Terminalia bellirica), bael (Aegle marmelos), chitraka (Plumbago zeylanica L.), datura (Datura stramonium L.), false amaranth (Digera muricata Mart.), giloe [Tinospora cordifolia (Willd.) Hook.f. & Thomson], Indian madder [Rubia manjith Roxb. ex Flem.; syn. R. cordifolia L., Sesbania cannabina (Retz.) Pers.], kalmegh (Andrographis paniculata Nees), karihari (Gloriosa superba L.), lemongrass [Cymbopogon martini (Roxb.) Wats.], mentha (Mentha piperita L.), mustu (Lactuca remotiflora DC.), opium (Papaver somniferum L.), rasana (Pluchea lanceolata), rose (Rosa damascena L.) cultivated extensively in Aligarh, Sikanderabad, and Kannoj, satawar (Asparagus curillus Buch.-Ham. ex Roxb.; A. sarmentosus L.), shalaparni [Desmodium gangeticum (L.) DC], vach (Acorus calamus L.), and velvet bean [Mucuna pruriens (L.) DC.]

Timber. Babool [Acacia arabica Willd.; syn. A. nilotica (L.) Delile], dhau (Anogeissus latifolia), khair (Acacia catechu), red cedar (Toona ciliata M.Roem.), neem (Azadirachta indica), sal (Shorea robusta), semal (Bombax ceiba L.), and shisham (Dalbergia sissoo).

Multipurpose species. Buel (Grewia optiva), chironji (Buchanania lanzan), date palm [Phoenix robusta (Becc.) Hook.f.], Indopiptadenia oudhensis (Brandis) Brenan, khair (Acacia catechu), mahu (Madhuca indica J. F. Gmel.; syn. M. longifolia Macbrie), palas (Butea monosperma), pongam [Pongamia pinnata (L.) Pierre], siris (Albizia lebbeck), and Thysanolaena maxima (Roxb.) Kuntze (brooms).

Gum- and resin-yielding plants and forest products. Because of high crop productivity, there is less dependence on forest products. However, in areas around the forests, the local people do harvest food, folk medicines, fodder, fuel, and variety of other plant species, yielding products such as dyes, tannins, gum, fibers, resin, etc.

Wild relatives of crop species. Arora and Nayar (1984) recorded the following wild relatives of crop plants from the

**Endemic species.** Being open and spread over, the Gangetic plains are poor in endemism. Only a few species can be considered endemic, such as *Carex myosurus* Nees var. *oraestans* (C.B. Clarke) Kuek, *Derris scandens* Benth. var. *saharunpurensis*, *Indigofera gangetica*, *I. thothathri*, *Indopiptadenia oudhensis*, and *Praecitrullus fistulosus*. Table 1 summarizes the representative endemic species of the region.

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Family</th>
<th>Habit</th>
<th>Distribution</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Derris scandens</em> var. <em>saharunpurensis</em></td>
<td>Fabaceae</td>
<td>Woody vine</td>
<td>Terai region</td>
<td>Medicinal</td>
</tr>
<tr>
<td><em>Indigofera gangetica</em></td>
<td>Fabaceae</td>
<td>Herb</td>
<td>Upper Gangetic Plain</td>
<td>Genetic resource</td>
</tr>
<tr>
<td><em>Indigofera thothathri</em></td>
<td>Fabaceae</td>
<td>Shrubs</td>
<td>Uttar Pradesh</td>
<td>Genetic resource</td>
</tr>
<tr>
<td><em>Indopiptadenia oudhensis</em></td>
<td>Mimosaceae</td>
<td>Small tree</td>
<td>Eastern Uttar Pradesh</td>
<td>Fuel wood and fodder</td>
</tr>
<tr>
<td><em>Praecitrullus fistulosus</em></td>
<td>Cucurbitaceae</td>
<td>Trailing vine</td>
<td>Western Uttar Pradesh, Haryana</td>
<td>Vegetable</td>
</tr>
</tbody>
</table>
**Threatened species.** Nayar (1996) reported plant species such as Albizia thompsonii Brandis, Carex myosurus Nees var. oaraestans (C.B. Clarke) Kuek., Carum villosum Haines, Ligusticum albo-alatum Haines to be under various levels of threat. But now, because of various anthropological pressures, a number of species are under threat. As per a recent study in the Gangetic Khadar region, identified as one of the most vulnerable areas, a large number of species have been found missing. They included Bacopa monnieri (L.) Pennell, Hygrohiza aquatica, Coix lacryma-jobi, Sisymbrium irio L., Capparis zeylanica Roxb., Hypericum japonicum Thunb., Crotalaria orixensis Willd., Alternanthera philoxeroides Griseb., Polygonum plebejum var. indica, Rumex crispus L., and Mallotus philippensis (Lam.) Müll.Arg. (Khan et al., 2008). Recently, Prakash et al. (2010) reported Indopiptadenia oudhensis to be under threat, and the Ministry of Environment and Forests (Government of India), reported several more species, such as Arenaria curvifolia Majumdar, Brachystelma laevigatum Hook.f., B. pauciflorum Duthie, Ceropogia bulbosa Roxb., Cymbopogon flexuosus (Nees ex Steud.) Watson, Diospyros holeana Gupta & Kanjilal, Hemarthria hamiltoniana Steud., Indigofera thothathri Sanjappa, and Rauvolfia serpentina (L.) Benth. ex Kurz to be under threat, in their recent press release (PIB Press Release, 2010). Some representative species under threat are listed in Table 2.

In addition, to the above plant species, several animal species of economic and environmental value are under threat of extinction, such as the Ganges river dolphin (Platanista gangetica Lebeck; Roxb.), Ganges shark (Glyphis gangeticus Müller & Henle), swamp deer (Rucervus duvaucelii Cuvier), etc.

**Associated culture and tribes**

According to the German indologist Max Müller, Aryan tribes migrated to the Indian subcontinent and spread into the UGP. He believed that they soon mingled with the local people and adapted to an agrarian way of life after settling down in small, organized communities. However, archaeological evidence and scientifically authenticated Vedic literature suggest continuity from the Saraswati Valley and Harappan (Indus Valley) or Indus Sarasvata civilization to the Ganga Valley (Vedic or Indo-Gangetic) civilization. These sources also suggest that Aryans were local people, as no archaeological evidences related with Aryan culture are found anywhere else, except India (Swami, 2008). In the Vedic Age [(1,500–600 BCE; 8000–1000 BCE (editors)], Aryans established four scriptures of knowledge called the Vedas: the Rig Veda, the Sama Veda, the Yajur Veda, and the Atharva Veda. These collections of hymns, with their social, religious, and philosophical doctrines, laid the foundation of the Hindu way of thought, life, and the religion. Aryans settled down as full-time farmers and brought large tracts of fertile land of the region under the plow. Based on profession, they classified the society into four main castes: Brahmins, Kshatriyas, Vaishyas, and Shudras.

The tribal communities in the region are not large. There are other communities, comprising the backward classes, scheduled
Table 2. Representative species under threat in the Upper Gangetic Plain: parts of Punjab, Haryana, and Uttar Pradesh.

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Family</th>
<th>Habit</th>
<th>Threat level</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albizia thompsonii</td>
<td>Fabaceae</td>
<td>Tree</td>
<td>R</td>
<td>Wood</td>
</tr>
<tr>
<td>Bacopa monnieri</td>
<td>Scrophulariaceae</td>
<td>Herb</td>
<td>R</td>
<td>Ayurvedic medicine</td>
</tr>
<tr>
<td>Brachystelma laevigatum</td>
<td>Asclepiadaceae</td>
<td>Herb</td>
<td>VU</td>
<td>Attractive foliage</td>
</tr>
<tr>
<td>Brachystelma pauciflorum</td>
<td>Asclepiadaceae</td>
<td>Herb</td>
<td>EN</td>
<td>Food</td>
</tr>
<tr>
<td>Carex myosurus var.</td>
<td>Cyperaceae</td>
<td>Herb</td>
<td>EN</td>
<td>Fodder</td>
</tr>
<tr>
<td>Capparis zeylanica</td>
<td>Capparaceae</td>
<td>Shrub</td>
<td>R</td>
<td>Medicinal</td>
</tr>
<tr>
<td>Ceropogia bulbosá</td>
<td>Asclepiadaceae</td>
<td>Tuberos herb</td>
<td>VU</td>
<td>Food</td>
</tr>
<tr>
<td>Coix lacryma-jobi</td>
<td>Poaceae</td>
<td>Grass</td>
<td>R</td>
<td>Food grain</td>
</tr>
<tr>
<td>Crotalaria orixensis</td>
<td>Fabaceae</td>
<td>Perennial herb</td>
<td>R</td>
<td>Crotorixin, genetic resource</td>
</tr>
<tr>
<td>Cymbopogon flexuosus</td>
<td>Poaceae</td>
<td>Grass</td>
<td>EN</td>
<td>Lemongrass</td>
</tr>
<tr>
<td>Diospyros holeana</td>
<td>Ebenaceae</td>
<td>Tree</td>
<td>VU</td>
<td>Timber</td>
</tr>
<tr>
<td>Hemarthria hamiltoniana</td>
<td>Poaceae</td>
<td>Grass</td>
<td>EN</td>
<td>Grass</td>
</tr>
<tr>
<td>Indigofera thothathi</td>
<td>Leguminosae</td>
<td>Shrub</td>
<td>VU</td>
<td>Genetic resource</td>
</tr>
<tr>
<td>Indopiptadenia oudhensis</td>
<td>Mimosaceae</td>
<td>Tree</td>
<td>EN</td>
<td>Fodder, fuel wood</td>
</tr>
<tr>
<td>Mallotus philippensis</td>
<td>Euphorbiaceae</td>
<td>Tree</td>
<td>R</td>
<td>Dye, medicinal</td>
</tr>
<tr>
<td>Polygonum plebejum var.</td>
<td>Polygonaceae</td>
<td>Herb</td>
<td>R</td>
<td>Medicinal</td>
</tr>
<tr>
<td>Rauvolfia serpentina</td>
<td>Apocynaceae</td>
<td>Shrub</td>
<td>VU</td>
<td>Medicinal</td>
</tr>
<tr>
<td>Rumex crispus</td>
<td>Polygonaceae</td>
<td>Perennial herb</td>
<td>R</td>
<td>Medicinal</td>
</tr>
<tr>
<td>Sisymbrium irio</td>
<td>Brassicaceae</td>
<td>Herb</td>
<td>R</td>
<td>Mustard genetic resource</td>
</tr>
</tbody>
</table>

1. EN = Endangered; R = Rare; VU = Vulnerable.
2. Notified by the Ministry of Environment and Forests (MoEF), Government of India.

castes and scheduled tribes. The scheduled castes and tribes live in rural areas and are mostly dependent on agriculture, forming the landless labor class. The Government of India has recognized five of the tribal communities as disadvantaged scheduled castes: Tharus, Bhoksas, Bhotas, Jaunsaries, and Rajis. Being both Rajputs and Brahmans, the Jaunsari tribe occupies the major portion, and mostly work as laborers in fields, farms, and forests. Other tribes such as the Kolis, Koisor Koltas, Aujis, and Doms are known by the name Harijans. The Terai-Bhabar area is concentrated with the Bhoksas and
the Tharus, while the southern areas are populated by tribes such as the Agaria, Bhumiyar, Bhil, Chero, Gond, Kol, etc. Along with the Tharus and the Bhoksas, there are some other tribes who trace their origin from the Mongoloids and the Khasas of the Himalayan region belonging to the Indo-Aryan stock. The Bhils and the Saharujas belong to the Indo-Dravidian lineage, and the Gonds and Kols belong to Munda-Dravidian stock. Koltas till the land for the Khasa tribe. The Haryana region mostly belongs to the Indo-Aryan and Indo-Dravidian tribes and includes several allied agricultural communities, the major ones being the Jats, Rajputs, Ahirs, Rors, Gujjaras, etc.

**Technology and products**

Being one of the centers of origin and evolution of agriculture, the UPG region has made immense contributions to global agriculture both in terms of products and technology. The region can be credited with the earliest domestication of both plant and animal species and farming, beginning with Neolithic settlements around 2,000 BCE. The beginning of agriculture in the region can be traced with evidence from Mahagara and Koldihwa in Allahabad at the Belan Valley, where cultivated rice grains belonging to the Neolithic period were identified (Sharma, 1980). Subsequently, in the early Iron Age, the region was colonized by the Ochre-Colored Pottery culture. During this phase, it has been found to be associated with rice, barley, chickpea, and *khesari* dal, which were identified by Chowdhary (1983) in excavations at Atranjikhera (UP). Although, the people of that time were mainly food gatherers and growing of agricultural crops was an experiment, it reflected their ingenuity and desire to progress into settled agriculture (Chowdhary, 1983).

During the Iron Age, wheat cultivation was introduced into the region by the PGW culture. Wheat grains of *Triticum compactum* Host. without husk were collected from Atranjikhera. Wheat was also found at Hulas in UP and Mohrana in Punjab. This suggests that wheat entered in the region through interactions with Harappans. This is also well proven by the findings at sites such as Bhagwanpura in Haryana, which reveal the ingenuity and desire of the local people even in early times, for improving their agriculture with the introduction of potentially valuable food crops from other regions. It is worth mentioning that wheat discovered at these sites was *Triticum compactum*, and not the *T. aestivum* L. that is generally found in the MGP (Saraswat, 1994). In these excavations, it was further revealed that significant improvement was made in farming of the wheat crop to obtain high yields, a proof of the contributions of the local people in improving production technologies.

In subsequent periods, even legumes were cultivated. The literary evidences from the Vedic period that was contemporary with PGW, mention several cereals, such as *yava* (barley) and *dhanya* (paddy) with breeds like *plasuka* (fast growing), *sali*, *vrihi.swastika* (*sathi*), etc. *Upvaka* (barley), *godhum* (wheat), *syamaka* (millet), and other crops such as *masa* (lentil), *khalakula* (*kulthi*), *khalva*, *mudga* (*munrga*), *kulmasa*
(urad), sesame (til), and bajra (millet) also find mention. Incidentally, these crops are also identified in archaeological remains. Some other edible species mentioned in these texts are urvaru and urvauka (cucumbers), garmut (wild beans), karakandhu, kavala, and badara (jujube). In addition, there appear several other plant names, such as am, amla, gavindhuta, nimbi, priyangu, masusya, and saya (Sharma, 1983), reflecting the contributions of local people in discovering plants with food and nutritional value. Further, this also means that even in those early days the people were consuming a variety of grains and food items. Archaeological and literary evidences also indicate the circulation of many wild varieties of beans and millets, suggesting the contribution of local people in introduction of plant species. The variety of crops also suggests the practice of double-cropping right from 1,000 BCE.

As the region was more suitable, ecologically, for wheat cultivation, it developed technological skills needed for the cultivation of this crop. The relatively dry and sandy soil of the region could be plowed even with wooden plowshares; however, there are evidences to prove the use of the iron plowshare, suggesting the existence of plow cultivation in the region during 1,000–800 BCE. Thus, due to the favorable ecology and knowledge of superior technology, the PGW folk of the region were able to exploit the land for greater yield, and richer varietal products of wheat, and attained superior economic gains.

During the early urban culture, a new crop of pulses (Phaseolus mungo L.) appeared in the region. At Radhan in Kanpur (Lal, 1984), wheat, barley, pea and an unidentified cotyledon of legumes were found. During the Northern Black Polished Ware period, newer settlements came up in the entire Gangetic Plains, extending the culture and agriculture to other parts of the subcontinent, leading to its expansion into the Nepalese Terai region in the northeast, to Taxila and Udegram in the west, to Brahmagiri-Amaravati-Ter in the south, and across the peninsula from Gujarat, Saurashtra (Prabhas Patan) in the west to Chandraketugarh in Bengal in the east. The period of 600–300/200 BCE was the age of consolidation of power in the entire Gangetic Plains. This gradually brought a large number and rich variety of agricultural implements into practice.

Thus, the fertile Gangetic Plains with plenty of water resources became the center of cultivation of a number of plant species, and the recipient of introduced crop diversity from Central Asia and Africa, especially of cereals, legumes, vegetables, and oilseeds from the early times. These crop species, through adaptations and selections in time and space over the millennia, evolved into large genetic diversity as new varieties and cultivars adapted to different agroecological zones of the Gangetic Plains, converting the region into an important center of diversity. In rice, the region is known for variability for drought tolerance, deep-water floating types, scented rice, etc. For example, the winter variety Agahani and the group of varieties called Usar are well known for salt tolerance and have been used in breeding programs. In non-aromatic rice, cultivars such as Adamchini, Anjee, Bambasa,
Agricultural biodiversity heritage sites

Bansi, Dehula, Jaisuria, Jalamonga, N22, NP130, Tapachini, T100, T136, and Jhona (Haryana) are commonly known. In aromatic rice, Basmati, Duniapet, Hansraj, Kala Namak, Kalasukhdas, Lalmati, Sakkarchini, Tilakchandan, and Vishnuparag are commonly known. Some of the valuable traditional varieties with aroma, such as Kala Namak, evolved with resistance to soil salinity (Siddiq et al., 2006). Drought tolerance landraces are known from Nagina. Similarly, in wheat, traditional cultivars such as Muzaffarnagar white and Etawah white are known. Consequently, a number of landraces from the region, with resistance to Karnal bunt, leaf blight, heat tolerance, and several other desirable features, particularly resistance to biotic and abiotic stresses have been identified at the Directorate of Wheat Research, Karnal (Singh et al., 2006c). In barley, genetic variability for saline and alkaline conditions prevailing in UP has been collected (Verma et al., 2006), and varieties such as C84 (K84), a selection from Aligarh local, C50 (K50) from Sithapur local, and Type 4 from Rewari local have been developed. In maize, Teenpakhya is known from UP, and landraces such as Sathi (that matures in 65–70 days in summer) have been identified with high tolerance to heat (Saxena et al., 1994). In pearl millet, wide variation has been observed in plant height, flowering time, shape and size of spike and grain (Rao et al., 1983).

Among grain legumes, in pigeonpea, significant variability has been observed, and landraces such as ICP 7626 with resistance to wilt have been collected and used in the development of the variety Maruti (Remanandan and Singh, 1997). Another variety T7 was developed from a sample collected from Lucknow (Singh et al., 2006a). In lentil and pea, a wide range of diversity has been observed in seed size, shape, color, and time to maturity in material collected from Haryana and UP regions along the Yamuna river (Singh et al., 2006b), leading to the development of varieties such as Pant L234 from P230. In cluster bean, the region offers variability for early maturity, determinate habit, disease resistance, and fodder yield. In moth bean, Type 1 has been developed from a landrace collected from Meerut with spreading habit, medium bold seed, and late maturity (Dabas et al., 2006). There is variability in cowpea regarding its habit, flower color, coloration of plants including pod and seed, and their size.

Among oilseeds, the region has recorded significant variability in Brassica rapa, with early and dwarf types, particularly in cultivars of varieties Toria and Yellow sarson. Consequent of this, several varieties have been developed from local landraces, for example in B. rapa var. toria, T-9, a selection from 5509 of UP, T-36 from a local landrace of Etawah, TL-15 from Karnal local, and Bhilwani, a selection from a local landrace collected from the Terai region of UP. In B. rapa var. yellow sarson, T-10 a selection from Kanpur local, T-151 from Aliagar local, K-88 from Etawah local, Ragini (MYSL 203) from Allahabad local, and YST151 from Barabanki local have been produced (Kumar et al., 2004). In B. juncea, T-11 from a landrace of Kanpur, Shekhar (KR5610) from Etawah local, Narendra Rai from Atwa local, Kanti (RK9807) from Kanpur local, and Laha
101 (T101) from landraces of Etawah, Pusa Kisan (T6342) from a landrace of Agra have been developed. In *Eruca sativa*, T-17 has been developed from Gurgaon local (Kumar *et al.*, 2004). In safflower, the variability has been recorded in the form of a wild relative, *Carthamus oxyacantha*, growing as a weed in the region.

The Indo-Gangetic Plains appear to be the center of origin and diversity for *Gossypium arboreum*. All races of *G. arboreum* are derived from the northern perennial *arboreum* cotton (Singh *et al.*, 2004). The region is also known for the significant genetic variability in *Saccharum spontaneum*, a wild relative of sugarcane, distributed in the sub-Himalayan region from Dehradun to the Sunderbans, offering variability in desirable features such as resistance to diseases, insect pests, drought, salinity, and waterlogging.

The region is an important center of genetic diversity for vegetable crops, because it offers diverse agroecological niches for adaptation. In brinjal (*Solanum melongena*), landraces such as *Ramnagar Baingan* (long fruit type is suitable for the Ganga River belt), *Dudhiya Baingan* (cluster bearing fruit type), *Jethuwa Baingan* (suited for summer plantation), Haryana Brinjal 14, *Kuchabuchia Baingan* (small cluster bearing type), *Jafrabadi* (deep purple, round oval type with less seeds), and *Balfahwa Jathuwa Bhanta* (tall, perfuse branching, cluster bearing, better shelf life type, suited to summer cropping) offer desirable variability. Similarly, in chili, there is significant variability in fruit shape, size, and color (Kaloo *et al.*, 2005).

In cucurbits, the region is an important center of diversity for *Cucumis melo* and *Citrullus lanatus*. The round gourd *Praecitrullus fistulosus*, a monotypic genus that is nearly endemic to the region, was domesticated here and so did the ash gourd *Benincasa hispida*, adding important sources of food. The region has downy mildew and root rot wilt complex resistant types in *Praecitrullus fistulosus*. The andromonoecious type in *Lageneria siceraria* from Faizabad and Shahjahanpur are important from the breeding point of view. In several of these crops, varieties have been developed through selection from local landraces: for example, in muskmelon, Lucknow safeda from Lucknow local; in *Cucumis sativus*, Kalyanpur green from a local cultivar; in smooth gourd (*Luffa cylindrica*), Kalyanpur Hari Chikni; in ridge gourd (*L. acutangula*), Punjab sadabahar; in *Momordica charantia*, Kalyanpur Barahmasi and Pusa Videsh from Hapur local; and in *C. melo var. utilisimus*, Arka Sheetal from Lucknow local (Sirohi *et al.*, 2005). In addition, several wild species of these crops, such as *Luffa echinata*, *Cucumis satosus*, *Momoridica balsamina*, etc. offer further variability for use in the breeding programs.

In potato, the Farakhabad region offers great variability; Agra-red has been derived from a local type (Shekhawat *et al.*, 2005). In okra, Mishra *et al.* (2000) have reported wild species of *Abelmoschus* from the Terai belt. Other species reported from the region are *Abelmoschus cancellatus* (Saharanpur), *A. manihot* (Behata and Mahoba), *A. manihot* ssp. *tetrathyllum* (Rampur, Nagina, and Dhampur), and *A. tuberculatus* (Sharanpur). In onion, Pusa Madhawi was developed
Agricultural biodiversity heritage sites

from Muzaffarnagar local and Kalyanpur red round from Kanpur local (Pandey et al., 2005). Variability has been recorded in some important spices, such as coriander and fennel, and varieties such as Pant Haritima and Azad Dhania, and Azad Saunf 1, have been developed through selection and mass selection from local landraces respectively.

The region represents rich genetic diversity in the case of tropical and arid fruits. The region has a number of traditional varieties in mango, such as Bombay green, Dashehari, Fazli, Langra, Safeda Lucknow, Smarbehishth, Chausa, etc. In guava, a wide range of variability occurs in Allahabad, Mirzapur, Kanpur, Unnao, and Fatehpur, and several traditional varieties, such as Lucknow 49, Allahabad Safed, Red flashed and Chitidar, Banarasi, Harijiha, etc., are commonly known for their distinct features (Mitra and Bose, 1999). In arid fruits such as Aegle marmelos, local cultivars Darogaji, Ojha, Rampuri, Azamal, Khamaria, Kagzi Gonda, and Kagzi Etawah offer a great deal of variability. In aonla or Indian gooseberry (Emblica officinalis), grown extensively in the region, wide variability for fruit characteristics has been recorded in local landraces such as Hathijhool, Basanti red, Deshi, Chakaiya, resulting in the selection and release of many varieties from the Acharya Narendra Dev University of Agriculture and Technology. In Zizyphus mauritiana, several forms are available in Western UP and Haryana, and varieties such as Gola Gurgaon, Sanaur 1, Safed Rohtak have been developed. In jamun or Java plum (Syzygium cumini), the region has a major concentration of variability for fruit size, shape, pulp color, acidity, and earliness, though no pure line has been established yet. Similarly, variability has been recorded in Grewia subinaequalis (phalsa) (Vashishtha et al., 2005). In lemon (Citrus lemon), variability has resulted in the selection of varieties such as Baramasia, Pant lemon, and Gandhraj (Karihaloo et al., 2005).

A number of traditional mixed cropping, intercropping, and crop rotation systems have evolved to suit different agroclimate requirements. The region is also known for several cultural practices for pests and disease control using natural products such as neem cake/leaves/powder and spread of cow-dung ash to control powdery mildew disease, etc. Additionally, the people of the region can be credited with the development of a unique by-product from the local vegetable species: the city of Agra is geographically associated with the sweet called Petha made from the ash gourd.

**Future perspectives**

The region has deep loamy soil having optimum soil–air–water relationship. However, it is the most populous region in the world, putting a great pressure on the natural resources that have been on the decline. The biodiversity of the region is under threat, as reflected by the number of

---

**The Indo-Gangetic Plains appear to be the center of origin and diversity for Gossypium arboreum. All races of G. arboreum are derived from the northern perennial arboreum cotton.**
species under threat and needs efforts for conservation of species diversity. Similarly, the genetic diversity has been threatened in important crops with the popularization of high-yielding varieties (90% and 60% respectively, in wheat and rice) and with the replacement of traditional cropping systems (millets, pulses, such as chickpea). Can a strategy like the preservation of heritage sites and/or peasant farming systems be an answer to genetic erosion?

Rapid expansion in agriculture and scarcity of water has made access to water as the central issue for the livelihoods of the rural poor and the principal driver for the development of the region. Therefore, effective management of water resources in the region needs immediate attention with steps towards integrated water management and land use, in order to ensure the future sustainability of all production and ecosystems.

Soil fertility decline in the region (Punjab, Haryana) is well recorded and there is a need to study the soil-related problems in the region to a greater depth. It would require greater research on cropping systems and integration of traditional systems (which were more amenable to sustainable or conservation agriculture) with modern farming systems, to evolve new systems, facilitating both conservation and functions of crop growth and production. In this regard, diversification from the rice–wheat system towards high-value agriculture, involving pulses and oilseeds on one side, and horticulture crops such as fruits and vegetables on the other, offers immense opportunities. It may be extended to other lines of high-value agriculture, such as horticulture, livestock rearing, fisheries, etc. If the above steps are integrated with appropriate warehousing, communications, transportation, and cold storage facilities, and are further augmented with modern technological interventions such as adoption of greenhouse farming in horticultural crops, and extension to dairy (Punjab, Haryana), meat, eggs, and fish, the region would become one of the world’s highest producer not only in field crops, but also of quality vegetables, fruits, and flowers.

**References**


Dabas BS, Nayar ER, and Dwivedi NK. 2006. Arid legumes. In: Plant Genetic Resources: Food


Paleotropical Ecosystems/Upper Gangetic Ecosystems.html)


Potential of Some Methods Described in Vrikshayurvedas in Crop Yield Increase and Disease Management

YL Nene

Asian Agri-History Foundation, Secunderabad 500009, AP, India
(email: asianagrihistory94@gmail.com)

Abstract

Knowledge of plant protection generated by our ancient and medieval scholars has become available during the last two decades. A good deal of that knowledge, the author believes, is applicable to the crop production in modern India, especially at the small farmers level. It is necessary, however, to validate effectivity of several ancient practices. This paper attempts to suggest the potential of some of those old practices in managing plant diseases. It is hoped that plant pathology researchers will take interest and conduct experiments to check validity of the suggested practices.

In the recent past, whereas the Sanskrit term “Vrikshayurveda” (the science of plant life) was known to a few scholars, most agricultural graduates, including me, had never heard the name during our college education. This situation continued until the Asian Agri-History Foundation (AAHF), Secunderabad, India began its activities in 1994.

There is only one ancient copy on palm leaves of Surapala’s Vrikshayurveda (c. 1000 AD) in the world preserved at the Bodleian Library, Oxford University, UK. The author obtained a microfiche in 1994 from the Bodleian Library. A printout was then obtained using the microfiche. A Bulletin with Sanskrit text, its English translation, and commentaries by scientists was published in 1996 by AAHF. In the last 15 years, the term “Vrikshayurveda” has become widely known amongst agriculturists not only in India but also in other countries.

In fact the term “Vrikshayurveda” has been in use since ancient times. By the time Kautilya (296–321 BC) compiled his “Arthasastra”, the term “Vrikshayurveda” was well-established and well-known. The next document on Vrikshayurveda, a very brief one, was compiled as “Brhat Samhita” by Varahamihira (505–581 AD).

We then find two texts compiled in the 11th century AD; Surapala’s Vrikshayurveda (c. 1000) and Vrikshayurveda chapter in Lokopakara composed by Chavundaraya (1025). In the 12th century AD, Chalukya King, Someshvardeva compiled an encyclopedia “Abhilashitarthachitamani” or “Manasollasa” in which a full chapter on Vrikshayurveda was included. We then find a 13th-century AD text titled...