Proceedings of the Fourth International Food Legumes Research Conference (IFLRC-IV), October 18–22, 2005, New Delhi, India
M. C. Kharkwal (ed.)

Historical perspectives of grain legumes in food security and sustainable agriculture with focus on South Asia

Y. L. NENE

Asian Agri-History Foundation, Secunderabad 500 009, Andhra Pradesh, India
E-mail: ynene@satyam.net.in

Abstract

Pulses, the food legmes, have been grown by farmers since millennia, and these have contributed in providing nutritionally balanced food to the people of India. While pigeonpea, blackgram, greengram, lablab bean, moth bean and horsegram have definitely originated and domesticated in the Indian sub-continent, there is a probability that chickpea and lentil (Indian type) were also domesticated in the Indian sub-continent. Pea, grass pea and cowpea were introduced in India millennia ago. Only faba bean was introduced in medieval times. This paper briefly describes how the pulses contributed an important item of food, how these were cultuvated, and how food preparations evolved. Though substantial progress has been made in evolving techniques to obtain high yields of pulses, their production per hectare has remained the same for the last two centuries. Lessons learned from this review have been listed.

Introduction

Pulses have been grown in South Asia since the past millennia and have been a vital ingredient of the human diet. Even the "balanced food", as defined over 1000 years ago, consisted of pulses, besides the cereals, vegetables and fruits, and milk products. Today, nutritionists tell us that pulses are important because they provide the essential protein. Mankind began as a carnivorous species and still is, but those who wanted to avoid killing animals for meat,

M. C. Kharkwal (ed.), Food Legumes for Nutritional Security and Sustainable Agriculture, Vol. 1: 143–153. © 2008 Indian Society of Genetics and Plant Breeding. Printed in India.

found out the utility of milk and its products and thus obtained nourishment with proteins of animal origin. Thus pulses and milk provide the full complement of proteins to people who avoid eating meat.

Including broad bean (*Vicia faba* L.), which never became popular except in some areas, India has been growing 11 different pulse crops. The others are: chickpea (*Cicer arietinum* L.), pigeonpea [*Cajanus cajan* (L.) Millsp.), lentil (*Lens culinaris* Medik.), black gram [*Vigna mungo* (L.) Hepper], green gram or mungbean [*Vigna radiata* (L.) Wilczek], lablab bean [*Lablab purpureus* (L.) Sweet], moth bean [*Vigna aconitifolia* (Jacq.) Marechal], horsegram (*Dolichos uniflorus* Lam.), pea [*Pisum sativum* (L.) var. *arvense* (L.) Poir], grasspea or *khesari* (*Lathyrus sativus* L.), and cowpea [*Vigna unguiculata* (L.) Walp.].

Any discussion on the history of crops usually begins with its geographical origin and domestication. Currently held views about the origin and domestication of different pulses are indicated in Table 1.

Conclusions regarding the origin and domestication have been drawn by plant explorers and botanists on the basis of three main criteria; namely, archeological findings, presence of wild relatives of a species in a region, and available documentation. All these three criteria suffer from severe limitations. For example, one could ask a simple question, "How extensive have been the archeological investigations?" Botanists have jumped to conclusion too often and one extreme example is that of finding a single carbonized seed, which looked like pigeonpea, in Egyptian tomb (2400–2200 BC) leading to the claim that pigeonpea originated in Eastern Africa (van der Maesen, 1990). Similar question can be asked about finding wild species because the exploratory expeditions have been too few and these covered some regions more thoroughly than others. Available documentation the world over of course is limited.

Table 1. Geographical origin and domestication of various pulses grown in South Asia

Crop	Scientific name	Geographical origin and domestication
Chickpea	*Cicer arietinum* L.	Turkey-Syria
Pigeonpea	*Cajanus cajan* (L.) Millsp.	India
Lentil	*Lens culinaris* Medik.	Southwest Asia (Turkey-Cyprus)
Blackgram	*Vigna mungo* (L.) Hepper	Indian subcontinent
Greengram	*Vigna radiata* (L.) Wilczek	Indian subcontinent
Lablab bean	*Lablab purpureus* (L.) Sweet	Indian subcontinent
Moth bean	*Vigna aconitifolia* (Jacq.) Marechal	Indian subcontinent
Horsegram	*Macrotyloma uniflorum* (Lam.) Verdc.	Indian subcontinent
Pea	*Pisum sativum* L. var. *arvense* (L.) Poir	South Europe
Grasspea	*Lathyrus sativus* L.	South Europe
Cowpea	*Vigna unguiculata* (L.) Walp.	West Africa
Faba bean	*Vicia faba* L.	West Asia

In this paper, I have selected three crops; namely, chickpea, pigeonpea, and lentil, which are the major legumes not only in South Asia but also in other parts of the world.

Chickpea (*Cicer arietinum* L.)

Origin

As mentioned earlier, it is claimed that chickpea originated in Turkey-Syria region and then spread eastwards towards South Asia. According to van der Maesen (1987), there are more than 30 wild species (the number now stands around 40), of which 13 perennial species are found in the Afghanistan-Pakistan-India (API) region. An annual species, *Cicer reticulatum*, which is considered to be the progenitor of the cultivated chickpea has not yet been found in the API region; however, discovering the presence of *C. reticulatum* or another annual species "close" to the "*desi*" chickpea in future cannot be ruled out.

Domestication

It is usually a matter of speculation that presence of wild species of a domesticated species in a geographical area indicates origin of the latter, as also its domestication. Accordingly, West Asia is claimed to be the region where chickpea was domesticated. Let us look at the documented history of chickpea in South Asia. The Vedas (Rigveda, Yajurveda, Samaveda, Atharvaveda) were compiled between c. > 8000 and 1000 BC. A commentary on Rigveda, called Brahadaranyaka, mentions a grain called *khalva.* Yajurveda that followed the Rigveda specifies *khalva* as a pulse (Sudarsan Sarma, 1989). There is a big gap in documentation since the time Brahmanas, Aranyakas, and Upanishads (c. 6000 –1000 BC) were compiled. However, we find that Kautilya (321– 296 BC) mentions *kalaya* as a postrainy season crop that is consumed in various ways including the roasted form. We should realize that even today chickpea in roasted form is consumed much more commonly than any other pulse. The word *kalaya* has a striking resemblance to *khalva* and very similar words are used today in Karnataka (*kadale*) and Kerala (*kadala*) states of India for chickpea. In the Buddhist literature (c. 400 BC), the word *chanaka* for chickpea gained popularity and today most Indian languages, except Marathi, have words for chickpea derived from *chanaka.* Another old Sanskrit word for chickpea existed. It was *harimanth* (*hari* = horse; *manth* = agitating/ chewing); chickpea grain was fed to horses since ancient times. Today the word in Marathi for chickpea is *harbhara,* which closely resembles *harimanth*, and has a similar meaning.

According to van der Maesen (1987), the Greek word *erebinthos* was mentioned in Homer (c. 1000–800 BC), but Theophrastus (370–285 BC) specified it for chickpea. Alexander III of Macedon (336–323 BC), who invaded northern India in 326 BC, was a contemporary of Theophrastus. It is easily possible that the word *harimanth* of Sanskrit was corrupted, during the Greek-Indian interaction, to the word *erebinthos*. The common Greek word for chickpea is *krios*, meaning ram's head, indicating resemblance of chickpea to ram's head.

By the time Theophrastus specified the word *erebinthos* for chickpea, the *desi* chickpeas had become a very common crop in India. I would therefore like to question the claim made in literature that domestication of chickpea occurred in West Asia.

The Agronomy

Kautilya (321–296 BC) mentions seed treatment of pulses prior to sowing (Shamasastry, 1961), which consisted of exposing seed to dew in the night and drying it under sun during the day for 3 to 5 nights. It is well known that such a treatment should loosen the seed coat and possibly kill the propagules of potential pathogens on or in the seed. Kashyapa (800 AD) stated that pulses are grown without irrigation (Ayachit, 2002). Kashyapa also mentioned two kinds of varieties, large seeded and small seeded, and that the large-seeded varieties were to be sown in lines. Prior to sowing (small), seed was moistened and broadcast. During the Sultanic period (1206–1555 AD) in India's history, seeds were soaked for 24 hours in warm water before sowing (Naqvi, 1984). This procedure was also recorded by a Mogul Prince Dara Shikoh (c. 1650) to produce 'bigger' seed at harvest (Razia Akbar, 2000). Watt (1889) recorded large seeds (reddish or black), small (light brown), and white ("*cabuli*") in northern India and Pakistan; the "*cabuli*" were rare. We find the earliest mention of '*kabuli*' chickpea in Ain-i-Akbari, in c. 1590 AD (Blochman, 1927). Traders coined the word "*desi*" to describe non-white seed varieties apparently only in the 20th century.

Kashyapa (800 AD) has clearly mentioned interculture operations in the pulses of postrainy season (Ayachit, 2002). Weeding was to be done about one month after sowing and interestingly, manure (obviously cow dung manure) was to be mixed with soil near plant roots. Three months after sowing, leaf senescence begins and pods appear. Maturity of seeds depended on varieties and the method of interculture. Kashyapa has clearly indicated varietal adaptation; that is what we describe today as genotype environment interaction.

During Alauddin Khilji's time (1296–1316 AD), there was an interesting crop rotation followed in northern India (Lal, 1980). This was black gram and moth bean in the rainy season, followed by wheat or barley in the postrainy season. Then the land was left follow in rainy season, but followed by chickpea in the postrainy season. This is a good example of cereal-legume crop rotation.

Buchanan (1807) recorded (i) considerable chickpea crop mixed, with safflower in the Andhra Pradesh-Karnataka border areas and (ii) chickpea crop followed rice or finger millet harvest. Buchanan also mentioned, what we state today, that chickpea grows well on soils endowed with residual moisture.

Watt (1889) recorded sole as well as mixed (with wheat or barley) chickpea, or chickpea on fallow lands in Uttar Pradesh. Some farmers from Maharashtra and from Pakistan perceived that chickpea enriches soil and also "kills" weeds. To reduce possibility of excessive vegetative growth, cattle were allowed to graze on plants in Pakistan, while mechanical 'detopping' was done in Uttar Pradesh for the same purpose. Watt also recorded a perception of Pakistani farmers, which holds true even today, that lightning and thundershowers injure chickpea, a reference to Ascochyta blight epidemic that is favored by these weather conditions.

Yields and Markets

Unfortunately ancient documents give very little information on yields per unit area. There are many reasons such as (i) measurement of land varied in different periods and in different regions, (ii) weight measurements were rarely done, (iii) volumetric measurements, such as number of bags per unit area was common, but lacked uniformity, and (iv) commercial farming was never the goal; the produce was used by family and domestic animals and only surplus was marketed. In addition to these reasons a millennium of political turmoil, after 900 AD, in the subcontinent discouraged farmers to increase productivity of land. It is only after the British gained political control of Indian sub-continent and aimed at exploiting the resources of India to strengthen the empire that we begin to see definite data on yields. Watt (1889) recorded the following information.

1. Uttar Pradesh: Non-irrigated, 460–750 kg ha^{-1} (sole), 550–830 kg ha^{-1} (mixed). Irrigated; 1100 kg ha^{-1} (sole), 1300 kg ha^{-1} (mixed)
2. Central India: 1000 kg ha^{-1}
3. Gujarat: 1120 kg ha^{-1}
4. Maharashtra: 740 kg ha^{-1}.

It is interesting to note that in Uttar Pradesh, yields of chickpea from a mixed crop were more than the sole crop. One reason may be that chickpea was mixed usually with a cereal crop such as wheat that received manure, which in turn could have benefited chickpea. On the other hand, yields of sole crop were low because these were rarely manured.

Ain-i-Akbari, which was written around 1590 AD, gives interesting and useful information on market prices of chickpea (Blochman, 1927). The *kabuli* gram cost twice that of the *desi*, and *kabuli* gram was 33% more costly that wheat. The *kabuli* chickpea and the green gram dhal were sold at the same price, thereby showing a high demand for the green gram dhal. Chickpea flour, because of value addition, was sold at par with wheat. I have not given actual prices, since both the units of weight and money were very different.

Storage

We find same descriptions for all pulses. These were kept in big pots, borders and inner wall were smeared with oil, and ash was spread all around these pots (Risala Dar Falahat c. 1400 AD; Majumdar, 1984). Apparently ash and oil were commonly used by the Romans (Orlob, 1973) and the technique must have spread to India through West Asia, because I have so far not come across the use of oil and ash to protect stored grains in any of the ancient Indian texts. During the Sultanic period (1206–1555 AD), grains were mixed with pounded bones of elephants and also by placing leaves of pomegranate, *Lactuca* sp. with grain, the ratio being 1 part of leaves to 100 parts of grain (Naqvi, 1984). Again, I must point out that that I have not read the practice of placing leaves such as that of neem so far in any of the ancient Indian texts.

Food

Chickpea serves as food in many ways. The cooked dhal, called *soup* in Sanskrit, constituted a common food item. We find it mentioned by Charaka (c. 700 BC); he stated that the

chickpea soup has good food value and it helps in recovery from spleen and liver disorders (Vidyalankar, 1994). Chickpea leaves have been cooked as a vegetable (Susruta, 400 BC), green seeds, dry whole seed, and flour (Krishnamurthy, 1991). A common food since the time of Rigveda (c. > 8000 BC) was preparing flour from roasted chickpea and barley or wheat, mixing it in milk or water with some cane jaggery; this was the instant food item. Roasted chickpea enabled hungry people to survive under adverse conditions, such as wars (Khan, 1982). Collection of acids from leaves for medicinal use (digestion; cooling effect) was mentioned by Vagbhatta II around 700 AD (Gode, 1961). The practice of collecting acids from leaves is unique to South Asia.

Feed

As pointed out before, horses have been fed with chickpea grain since the ancient times. Likewise seed hulls were fed to cattle and are still fed. Elephants were also given chickpea grain (Gode, 1961). Manasollasa (1130 AD) mentions chickpea flour as fish feed and the grains as feed for buffalos and boars, used for fights (Gode, 1961; Sadhale and Nene, 2005).

Pigeonpea [*Cajanus cajan* (L.) Millsp.]

Origin

After some debate, whether pigeonpea originated in Africa or India, it is now generally agreed that the most likely region where pigeonpea originated is the Eastern Ghats in the Indian subcontinent. Most probable progenitor of pigeonpea, *Cajanus cajanifolia*, is found in India in addition to about 17 *Cajanus* spp. Some 13 wild species are found in Australia and one in Africa (van der Maesen, 1990).

The Latin name *Cajanus cajan* came from the Malay word, *cachang*, which in turn was a corrupt form of the Telugu word *kandi*. The Telugu word has its origin in the Sanskrit word *kaand* (a stem), a reference to the long stem of pigeonpea plant.

Domestication

The oldest Sanskrit word for pigeonpea seems to be *adhaki*; both Charaka (c. 700 BC) and Susruta (c. 400 BC) used *adhaki* (Krishnamurthy, 1991; Vidyalankar, 1994). We find the same name *adhaki* in the Buddhist and the Jainism literature (400 BC–300 AD), and in the subsequent writings until the 16th century. Kautilya (Shamasastry, 1961) does not mention *adhaki*; however, there is a word *udaara*, which means a sort of grain with long stalks and *daara* means to split. I would like to suggest that Kautilya used the word *udaaraka* for pigeonpea. Amarsimha (c. 200 BC) in his lexicon mentions *adhaki, kakshi*, and *tuvarika* as names of pigeonpea (Jha, 1999). Bhavamishra (16th century) adds yet another word *shanapushika* probably because the yellow flowers of pigeonpea resemble those of the sunnhemp, *Crotalaria juncea*) (Chunekar and Pandey, 1986).

The word *adhaki* originated most likely from the word *ardha,* meaning one-half or split into two parts. Dry whole pigeonpea seed is rarely consumed; only the dhal is commonly eaten. One of the two common names used for pigeonpea in Indian subcontinent is *arhar*. It

is logical to assume that *arhar* is a corrupt form of *adhaki.* The second common name for pigeonpea is *tuvara.* In Sanskrit, *tuvara* or *tubara* means astringent. The green seed, which has been consumed in Gujarat for centuries, has an astringent taste. This, therefore, might have led to the word *tuvara* and its variants, *tuvarika*, *turri*, *tur,* etc. It is interesting to note that the word *arhar* is common in northern India and *tuvara* (with variants) in southern India. The Sangam literature of the Tamil people (100 BC–300 AD) does not mention pigeonpea, indicating that it found a place in the Tamil kitchens in the later centuries (Achaya, 1998). The *Ain-i-Akbari* (1590) does not mention pigeonpea (Blochman, 1927). Akbar was essentially a "Punjabi" and pigeonpea even today is not a common food item for the peoples, both in Indian and Pakistani Punjab.

The Agronomy

Kautilya (321–296 BC) mentions sowing of *udaaraka* with the onset of rain (Shamasastry, 1961). Kashyapa (800 AD) stated "science recognizes big and small varieties'; large seeded lines were sown in lines, both in irrigated and rain-fed lands (Ayachit, 2002). He also mentioned that excess rains after sowing damages the sown seed. We find a reference to a black-seeded pigeonpea (*krishnadhaki*) mentioned in Sivatatvaratnakara by Raja Keladi Basavaraja (17th century) of Shimoga in the Indian state of Karnataka (Achaya, 1998). Buchanan (1807), who traveled extensively in southern India, mentioned line sowing as well as broadcast sowing. For line sowing, a seed drill called *curigay* was used. In Karnataka, pigeonpea was intercropped with *Panicum miliare* (*kutki; samai*). Watt (1889) mentioned two varieties in Raipur (now in Chhatisgarh state); normal and early by two months, and also mentioned large and small seeded varieties in the Mysore region (Karnataka). Kashyapa (800 AD) gave information similar to that for chickpea; i.e., 3-month crop (Ayachit, 2002). This indicates availability of short duration landraces at least when pigeonpea was grown at the latitudes 18–22°N in eastern India. Watt (1889) repeatedly stated that pigeonpea was cultivated as a subordinate crop with sorghum, pearl millet, cotton, etc, but also as a sole crop in some parts of Uttar Pradesh. In Central India (Maharashtra and Madhya Pradesh), one row of pigeonpea was grown with 5 rows of cotton; a practice that continues even today with some variations. Watt described frost to be the chief 'enemy' of the crop in northern India, but also mentioned that manured crop withstands frost. Watt further mentioned a 4-month crop in Thane (near Mumbai) and that pod borer was controlled manually. Early morning, when caterpillars are rather quiet, plants were shaken, worms collected in baskets, and then destroyed by burying.

Yields and Markets

Again limited information is available. Watt (1889) mentioned an average of 645 kg ha^{-1} in Uttar Pradesh, with a range from 100 kg to 1480 kg ha^{-1}. This clearly points to the crop management as the key factor that holds well even today. CSIR (1950) mentions an average yield of 767 kg ha^{-1} in Bihar in 1935–36. Methods of storage were similar to those described for chickpea; i.e., use of leaves, ash, and oil.

Food and Feed

Since the ancient times, pigeonpea seed was split and decorticated for preparing soup or dhal; dilute *dhal* was cooked to go with rice and the thick dhal to go with the flat bread (chapati) made from cereal flour. Pigeonpea has been used in preparing very few dishes in contrast to chickpea. The dehulled material left over after obtaining dhal has all along been fed to cattle. It is a valued feed. Ayurvedic treatises since the time of Charaka (c. 700 BC) mention that pigeonpea dhal has properties of purifying blood and improvement of complexion (Vidyalankar, 1994). Its flatulence-causing property has also been documented.

Lentil (*Lens culinaris* Medik.)

Origin

It is generally stated that the lentil originated in the Turkey-Cyprus region (Southwest Asia) and that South Asia is a center of diversity (Cubero, 1981). It is claimed that the archaeobotanical remains of lentil were found in the excavations covering the period of the so-called Harappan civilization (3300–1300 BC) (It was a period in the Saraswati-Indus civilization). The truth is that these claims are based on very few studies.

The Latin name of lentil is *Lens culinaris*; the genus name *Lens* meaning lens in English, suggestive of lens-like shape of the lentil seed. *Lens orientalis* is considered to be the progenitor (Zohary, 1973). Most of the West Asian lentils have a flattened lens-like appearance. On the other hand, both sides of most South Asian lentils have convex shape. Thus the Sanskrit word *masura* for lentil seems most appropriate. The word *masura* means a pillow in Sanskrit. It is interesting to note that the Turkic word for lentil is *mercimek* and an Old Persian word was *marjunak*, both phonetically similar to *masura.* Today *adas* is the word for lentil in both Arabic and Persian. Another interesting fact is that all languages of India have derivatives of the name *masura* for lentil. Another Sanskrit word for lentil was *mangalya*, which connotes resemblance to the planet Mars or *Mangal* in Sanskrit.

Domestication

Archeological investigations have revealed presence of lentil as far back as 8500–6000 BC in Turkey-Syria-Iraq region. It is speculated that lentil spread from Turkey-Iraq region to the Nile, Greece, central Europe and eastwards to South Asia. A speculation made by De Candolle in 1882 makes an interesting reading. He stated, "it may be supposed that lentil was not known in this country (India) before the invasion of the Sanskrit-speaking race" (Cubero, 1981). Recent studies have convincingly proved that the so-called Aryan invasion of India never occurred. We need to have a fresh look at the subject of "domestication of crops', at least those crops that have been grown in the subcontinent for many millennia. *Masura* has been mentioned in Brahadaranyaka, a commentary on Rigveda (c. > 8000 BC) and also in the Yajurveda (c. 7000 BC). We find the same word *masura* for lentil written by Charaka (c. 700 BC), Susruta (c. 400 BC), Kautilya (c. 321–296 BC), and by later authors.

The Agronomy

Documents written during the Sultanic period (1206–1555) describe seed dressing with

cow dung to ensure faster plant growth and high yields. Another seed treatment mentioned was soaking seeds, prior to sowing, in bird droppings (Naqvi, 1984). The time for sowing has been indicated as the postrainy season in most documents, starting with that of Kautilya (c. 321–296 BC). Lentil crop was sown mixed most often with wheat, barley, horse gram, or chickpea. Rest of the agronomic practices mentioned are similar to those prescribed for chickpeas.

Yields and Markets

Watt (1889) mentioned an average yield of 740 kg ha^{-1}, when grown on residual moisture and 1110 kg ha^{-1}, when grown with irrigation. The lentil crop was grown all over India, but much more in Central India and Bengal (India and Bangladesh). The Ain-i-Akbari (1590) mention that lentil was as costly as wheat and the lentil dhal was priced 33% higher that wheat (Blochman, 1927).

Food

Lentil seeds, with or without hulls, are cooked as dhal and this has been the main dish for millennia. Ayurvedic treatises consider lentil to be a highly nutritious pulse, second only to the green gram or mung bean. It is also claimed to be blood purifier. One of the common usages has been to get rid of old skin marks by applications of lentil paste. There are sects in India, which do not include lentils in their food, probably because of the red color resembling flesh. For example, Kashyapa (800 AD) does not mention lentil in his treatise (Ayachit, 2002).

Additional Points

The Ayurveda experts of the past had studied how a very large number of food plants influenced human health. In addition to the facts I have mentioned earlier, Ayurvedic treatises considered green gram to be the best pulse for humans, being least flatulent of all pulses. Green gram also helps in improving eyesight; we know today that sprouted green gram is rich in b-carotene (Duke, 1981). Like the lentil paste, the green gram paste, when applied to skin, improves complexion (Chunekar and Pandey, 1986).

The role of legumes in enriching soil with nutrients such as nitrogen is well known. The "oldest record' so far that I have come across is from Nuskha Dar Fanni-Falahat, compiled by Dara Shikoh (c. 1650) (Razia Akbar, 2000). The statement reads, "Because its (*Vicia faba*; *baqla*) roots, branches, and leaves have the qualities of manure, it is grown among plants." It seems the knowledge that pulses enhance soil fertility spread to India from West Asia, because no Indian text that I have read so far mentions any similar observation.

I should also point out that the adverse effect of *Lathyrus* (*khesari*) on human health has been known at least since the 16th century. Sri Bhavamishra (16th century AD) mentions that consumption of *khesari* can bring in lameness and paralysis (Chunekar and Pandey, 1986). The role of pulses in the balanced nutrition was encapsulated by Kashyapa (800 AD) in Section II, verses 12–15 (Ayachit, 2002).

"Varieties of rice are first in the priority list, the pulses for preparation of soup are second, vegetables (and fruits) come third, and ghee, milk, etc., the fourth. These four together are stated to make a complete meal. This food brings stability to human life by providing nourishment and health. It sharpens intellect and enhances the span of life."

One can read cereals in place of rice. Pulses were second to cereals in human nutrition.

Lessons for Future

I have listed below the messages that we get from the historical review of the three important pulses for planning future research and development programs.

1. Most of the plant explorers seem to be obsessed with the idea that the Fertile Crescent (semicircle of fertile land stretching from Southeast coast of Mediterranean around Syrian Desert north of Arabia to Persian Gulf) is the only place in the world where agriculture and many crops originated. This attitude needs a change.
2. Pulses have been and shall continue to be an important ingredient in daily food and nutrition of the people of South Asia.
3. In terms of the quantity needed, pulses have always been second to cereals.
4. Pulses have not been normally grown in rich soils or with irrigation.
5. Pulses were almost always grown as subordinate crops in cropping systems.
6. Yield levels reported since the 18th century have not been different from the yield levels being obtained today.
7. The type of revolution in cereals and some other crops, characterized by a quantum jump resulting from high levels of management with purchased inputs and irrigation, is not required for pulses. This is because pulses shall always remain a 'secondary' food item. Export opportunities being limited, an excess production could result in market glut and loss to farmers. It is much more sensible to talk about increasing average yields of pulses to 1275 kg ha^{-1} to meet the needs of population by 2050 (Nene, 2000).
8. Improvement in management with regionally adapted and preferred varieties is the key.
9. Major research focus on pulses should be to obtain better yields with limited or no purchased inputs and on rain-fed pulses.
10. Biotechnology tools could be the answer to long-standing problems such as Ascochyta blight, pod borers, and sensitivity to salinity.
11. Eleven different pulses are grown and eaten in South Asia. In addition, 10 grain legume species were consumed during the past famines (Nene, 2004). These 10 species should be researched as additional crops.

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