GROWTH AND PRODUCTION OF PULSES

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Summary

Pulses are a source of supplementary protein to daily diets based on cereals and starchy food for a predominantly vegetarian population and for those who can not afford expensive animal protein. Pulses are therefore often regarded as poor man's meat. They also provide energy, essential minerals, vitamins and several compounds considered beneficial for good health. Their cultivation enriches soil by adding nitrogen, and improves the physical, chemical and biological soil properties.

Pulses are grown since ages in different parts of the world. They are well suited to diverse environments and fit in various cropping systems owing to their wide adaptability, low input requirements, fast growth, nitrogen fixing and weed smothering ability. Their short growing period and photoperiod sensitivity make them suitable for crop intensification and diversification.

Dry beans, which include green gram and black gram, are the most important pulse crops of the world, whereas chick-pea, pigeon pea and lentil occupy the third, fourth and sixth position, respectively. Notwithstanding their high production potential, their productivity is generally low as these are cultivated on poor lands, with no or little inputs, and are susceptible to several abiotic and biotic stresses.

The demand of pulses is fast increasing, both in developed and developing countries, where they meet the minimum protein requirements of an increasing population turning to a vegetarian diet. Their productivity can be doubled by improved cultivars and by modern production technologies.

1. Introduction

The family *Fabaceae* (earlier known as *Leguminosae*) comprises more than 600 genera and about 18,000 species of cultivated plants. It is the second largest family after *Poaceae* (earlier known as *Gramineae*), in terms of food and vegetable protein source, and of fodder. The sub-family *Papilionoideae* consists of 480 genera and about 12,000

species, of which only a few species are cultivated for human nutrition. Endowed with excellent food and fodder qualities, these crops also restore soil fertility by scavenging atmospheric nitrogen, adding organic matter, enhancing phosphorus availability, and improving physical, chemical and biological properties of the soil. Hence, they occupy an indispensable position in various cereal-based cropping systems in marginal and sub-marginal lands, where they sustain intensive agriculture and farming systems adopted by small and marginal farmers.

Food legumes refer to those plants of the *Fabaceae* family which are used directly or indirectly in the form of unripe pods, green grains and dry seeds as a source of food. The connotation 'legume' is derived from the Latin word '*legere'* meaning 'to gather', which points to the traditional practice of seed collection by hand instead of being threshed from the plants like cereals. The term 'grain legume' is often used to indicate that the product of primary concern for human consumption is the seed/grain rather than the pods, leaves or any other part of leguminous plants. Edible seeds of leguminous plants are also referred to as pulses.

The word 'pulse' is derived from the Latin word '*puls'* meaning pottage, i.e. seeds boiled to make porridge or thick soup. The Food and Agricultural Organization (FAO) of the United Nations has recognized 11 primary pulses, *viz.* dry beans, which include several species of *Phaseolus* and *Vigna*; common beans, *Phaseolus vulgaris* L.; lima beans, *Phaseolus lunatus* L.; tepary beans, *Phaseolus acutifolius* var. *latifolius;* scarlet runner beans, *Phaseolus coccineus;* black gram, *Vigna mungo* L. Hepper; green gram, *Vigna radiata* L. Wilczek; moth beans, *Vigna aconitifolia* Jacq Marechal; rice beans, *Vigna umbellata* Thunb Ohwi and Ohashi and adzuki beans, *Vigna angularis* Willd Ohwi and Ohashi), dry broad beans (*Vicia faba*), dry peas (*Pisum spp*.), dry cowpeas (*Vigna unguiculata* L. Walp), pigeon peas (*Cajanus cajan* L. Millspaugh), chick-peas (*Cicer arietinum* L.), lentils (*Lens culinaris* Medikus spp. *culinaris* or *Lens esculenta* Moench), bambara groundnuts (*Vigna subterranea*), lupines (*Lupinus* spp.), common vetch (*Vicia stiva)* and minor pulses (lablab, *Lablab* purpureus L. Sweet; jack beans, *Canavalia ensiformis,* sword beans, *Canavalia gladiata,* winged beans, *Psophocarpus teragonolobus;* velvet beans, *Mucuna pruriens* var. *utilis* and yam beans, *Pachyrrizus erosus).*

Pulses, or grain legumes in general, are an indispensable source of supplementary protein to daily vegetarian diets; these are regarded as poor man's meat. Pulse proteins are chiefly globulins and contain low concentrations of sulfur containing amino acids such as methionine and cystine, but higher concentrations of lysine than cereals. When supplemented with cereals, pulses provide a perfect mix of essential amino acids with high biological value. Pulses contain more calcium and iron than cereals. The demand of pulses is fast increasing to meet the minimum protein requirements of an increasing world population. Higher demands are also due to more people with increasing incomes turning to a vegetarian diet (especially in the industrialized world).

Pulses have a wide range of adaptability to latitudes, longitudes and climatic variables. Though variable types of pulses are cultivated in almost every climate, adaptability of individual species of the domesticated pulses is confined in the areas of their origin. Pigeon pea, chick-pea, green gram, black gram and lentil are the five major pulse crops

which are grown on large areas, mainly in Asia and Africa under varied soil and management conditions.

Pigeon pea, green and black gram are mainly grown in lower altitude areas between 30^o N to 30^o S, in particular in the semi arid and lower humid tropics of South-East Asia, Africa and Central America. Chick-pea and lentil are cultivated extensively at low altitudes from 15^o N up to 40^o N. Cultivation of chick-pea extends even at higher altitudes near the equator in Ethiopia and Central America. Pigeon pea, green gram, black gram, chick-pea and lentil occupy significant positions in Asia (especially South-East Asia) and Africa. Green gram, black gram and pigeon pea are *kharif* (monsoon) season crops. Chick-pea and lentil are cool season legumes grown in the Indian sub-continent during winter.

2. Pigeon Pea

Pigeon pea (*Cajanus cajan* (L.) Millspaugh) is known by more than 350 vernacular names, the most popular being *arhar, tur, Congo pea, gandul, guandu, Angola pea, yellow dhal, catjang pea, red gram, ambrevade, pois d'angdie, quinochoncho*. The connotation pigeon pea probably originated in America where its seeds reportedly were favored by pigeons. The crop ranks fourth in importance as edible legume in the world.

Pigeon peas are extensively grown throughout the tropics, subtropics and warmer equatorial regions of Asia, East Africa and Central America between 30^o N and 35^o S latitude. The major production area is located in India, Myanmar, Kenya, Malawi, Uganda and Tanzania (Table 1). India alone occupies three-fourth of the global harvested area and contributes almost a similar share in production. Pigeon pea is the second most important pulse crop after chickpea in India.

Country	Area (million ha)	Production (million tons)	Productivity (kg/ha)
1. India	3.728 (76.7)*	3.076 (74.9)*	825
2. Myanmar	0.540 (11.1)	0.600 (14.6)	1111
3. Kenya	0.195 (4.0)	0.084 (2.1)	430
4. Malawi	0.168 (3.4)	0.150 (3.6)	893
5. Uganda	0.088 (1.8)	0.090 (2.2)	1023
6. Tanzania	0.067 (1.4)	0.048 (1.2)	718
World	4.861	4.105	844

* Values between parenthesis indicate per cent share of the world.

Table 1. Area, production and productivity of major pigeon pea growing countries of the world in 2008 (www.faostat, 2009)

2.6. History

Peninsular India and Eastern Africa are considered main centers of origin for pigeon pea. Remains of pigeon pea found in an Egyptian tomb at Dra Abu Negga (Thebe area) date back to 2400-2200 B.C. Thirteen wild species are also endemic to Australia.

2.7. Classification

Pigeon pea is a monotypic species of *Cajanus*. In the revised taxonomic classification, 17 species of *Cajanus* are endemic to the Indian subcontinent, 13 to Australia and one to Africa. India and Myanmar harbor eight endemic species. *Cajanus cajanifolius* (Haines) van der Maesen found in the Indian subcontinent is generally considered the progenitor of pigeon pea (*Cajanus cajan* L. Millspaugh) in the area.

The sub-tribe *Cajanae* is well distinguished from the other economic species (*Phaseolus*, *Vigna*, *Lablab*, *Macrotyloma*) belonging to tribe *Phaseoleae* by the presence of vesicular glands usually on the under surface of the leaves, calyx and pods.

2.8. Plant Description

Pigeon pea is a short day plant with C_3 pathway for carbon assimilation. It has extensive deep, strong, woody, tap roots with well developed laterals. Germination is hypogeal. The plant is determinate as it produces flower buds at different nodes, but flower opening starts from top to lower nodes. The plant is much branched, appears like a pubescent, woody, prostrate or erect annual shrub, a short lived perennial that can survive for 3-5 years under favorable conditions. Its growth cycle varies from 90 to 300 days.

Figure 1. Pigeon pea plant with flowers

The stem is ribbed, hairy with grooved and silky profuse branches. Leaves are trifoliate, compound, spiral and pubescent. The leaflets are elliptical or oblong lanceolate, with the lower leaflets shorter than top ones. Flowers are bright yellow, sometimes with red flags or red to purple veins on the dorsal side (Figure 1).

Stamens are diadelphous with longer filaments. In the same plant, the pods formed at different times usually differ in size. Pods appear on the late order branches and rarely on the main shoot (Figure 2).

The ovary is monocarpellary. The fruit or pod is two-valved, straight, beaked, constricted, and flattened; it mostly consists of 3-6 seeds. Seeds are well filled in grain legume cultivars and loose in vegetable cultivars. Seeds are non-endospermic, laterally compressed, round to oval in shape and white, cream, purplish, yellowish brown or grey in color (Figure 3).

Figure 2. Pigeon pea plant with pods

Figure 3. Pigeon pea seeds

2.9. Breeding

With a chromosome number $2n = 22$, pigeon pea is self pollinated; cross pollination up to 20% usually occurs. Flowers are cleistogamous. Hand emasculation and pollination are used to make crosses. Increased productivity, stability, tolerance to various biotic and abiotic stresses, adaptation to diverse cropping systems and ecological niches, multiple uses and acceptable grain quality are different breeding objectives.

Since early times, most of the improvement in breeding cultivars has come from mass selection, pedigree evaluation and back crossing of landraces adapted to specific regions. Line x tester or diallel mating schemes are often used to assess the combining abilities of parents. Pedigree, bulk pedigree, back crossing, multiple crossing have been useful in recombining simple inherited characters. A number of cultivars have been developed by mutation breeding.

Identification of stable genetic male sterility and natural out-crossing by insects has produced pigeon pea hybrids. Two sources of genetic male sterility characterized by translucent anthers and dark brown arrow head-shaped anthers were identified. Population improvement using male sterility is also viewed to confer tolerance or resistance to pod borer. Future progress will depend on transferring genetic male sterility to different genetic backgrounds and in finding cytoplasmic male sterility.

Efforts are also needed to use cleistogamous flower morphology to achieve almost complete self pollination to maintain purity of lines.

2.10. Agronomy

2.10.1. Growing Conditions

Pigeon pea performs well in the temperature range of 25-35^{o} C and can survive even 45^{o} C if the soil contains adequate moisture. The crop is susceptible to low temperatures and frost. Day length of 12-14 hours is required for optimum growth and development. In India, it is cultivated in areas receiving annual rainfall of 600-1400 mm. However, early and short duration cultivars do not perform well in high rainfall areas. Cloudy weather or rains at flowering and fruiting result in poor pod setting and seed filling and may lead to increased damage by pod borers (*Helicoverpa armigera*).

The crop is photoperiod-sensitive, requiring a large dark period for blooming. In India, the post rainy (winter) season crop is successfully grown in areas where the temperature does not fall below 6-7^{o} C in January. All pigeon pea species grow at elevations between 0 and 1500 m, except *C. rugosus, C. mollis* and *C. grandiflorus* which are found at altitudes between 800 and 2000 m. Recently, *C. trinervius* was found above 1000 m in Sri Lanka and above 2000 m in India.

Pigeon pea is largely cultivated as dry land or rain fed crop, and is fairly drought tolerant. However, the crop, despite its deep root system, meets half of its total water requirement from top 50 cm of soil and thus responds quite well to irrigation. Water supply at branching, flower initiation and pod filling is most beneficial. The crop is sensitive to water logging, even for a very short period. Injudicious irrigations may make the crop prone to *Fusarium* wilt, caused by *Fusarium odum,* and to *Phytophthora* blight, caused by *Phytophthora drechsleri*.

Pigeon pea is a hardy crop that can be grown on a wide variety of soils ranging from sandy loam to heavy clay loam, and even on marginal soils. It thrives well on well drained black cotton and red laterite soils. Saline, alkaline and water logged soils are unfit for its cultivation. Two to three plowings followed by planking are enough to provide a suitable seed bed for sowing.

2.5.2. Cropping Season

Pigeon pea is grown throughout the year in coastal and peninsular India and during summer or *kharif* (rainy) season in the North India; *kharif* cultivation occupies the largest area. The crop is sown with the onset of rains in late June or early July. With irrigation facilities, its sowing can be advanced to early June to facilitate timely sowing of wheat in the following *rabi* (winter) season. It is also sown between the first fortnight of September in South India and mid-October in East India as a post rainy season (*rabi*) crop in areas where winters are mild.

Being photoperiod sensitive, late sowing results in lower yields due to less vegetative growth and early flowering. In areas where winter rains are scarce, late sown crops may

be exposed to terminal drought. As a summer crop in North India it is sown in mid April; long duration cultivars of pigeon pea are usually inter-cropped with early maturing cultivars of green gram or black gram. In Eastern Africa, it is sown in October-November. Day length changes in this region are small due to proximity to the equator and, therefore, the growing period of long and full season cultivars is not affected. The crop should be harvested when 80-90 % of the pods have turned brown, even though the leaves still appear green.

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