

# **FUTURE CROPS**

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*Editor*

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## Chapter 15

# VEGETABLE PIGEONPEA

## [*Cajanus cajan* (L) Millspaugh]

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Majority of food proteins of plant origin derived from legumes in developing countries are generally grown under low input conditions in marginal environments. Currently, the protein availability among the rural poor in the developing world is less than one-third of its normal requirement; and with a growing population and stagnation of production, the availability of protein is projected to reduce further. Since the food production programmes in most countries are always in favour of staple cereals, the issue of protein availability assumes a greater significance for human nutrition. Among the legumes, pigeonpea or red gram [*Cajanus cajan* (L.) Millspaugh] occupies an important place in rainfed agriculture. Globally, it is cultivated on 4.92 million ha, with 3.56 million ha in India alone. Although, pigeonpea is reported to be grown in 22 countries, the remaining major producers are Myanmar, China, and Nepal in Asia. Kenya, Malawi, Uganda, Mozambique, and Tanzania also produce considerable amounts of pigeonpea. A few countries in Caribbean islands and South America also cultivate pigeonpea.

In India, de-hulled split cotyledons of dry pigeonpea seed are cooked to make *dal* or sambar for eating with chapati or rice; while in southern and eastern Africa, and South America, whole dry seeds are used for porridge, and its green seeds are used as fresh, frozen, or canned vegetable. Broken seeds, husks, and pod shells are fed to cattle; while the dry stems are used as household fuel wood. Pigeonpea is credited to be the most suitable crop for subsistence agriculture that needs minimum external inputs. Pigeonpea is known to produce reasonable grain yield even under unfavorable production conditions, mainly due to its abilities such as drought tolerance, nitrogen fixation, and deep root system. Its seeds contain 20–22 per cent protein and contain important amino acids such as glutamic acid (19.2 per cent), aspartic acid (9.8 per cent), phenylalanine (8.7 per cent), and leucine (7.6 per cent) (Duke, 1981).

**Table 15.1:** Global area, production and yield of pigeonpea in different countries in 2007.

Country	Area ('000 ha)	Production ('000 tonnes)	Productivity (kg ha <sup>-1</sup> )
India	3560	2310	649
Myanmar	570	540	947
Kenya	161.5	95.6	987
Malawi	154.5	159.3	619
Uganda	87.0	89.0	1023
Tanzania	67.5	48.5	719
Nepal	21.0	19.2	917
Dominican Republic*	20.4	19.4	952
Congo	9.9	5.8	582
Haiti*	6.2	2.5	403
Panama*	4.8	2.0	406
Venezuela*	2.5	2.0	797
Burundi	2.0	1.8	900
Bangladesh	1.5	1.4	961
Philippines	0.8	1.4	1636
Jamaica*	0.7	0.9	1197
Grenada	0.6	0.5	964
Trinidad and Tobago*	0.5	1.1	2444
Comoros	0.4	0.3	727
Puerto Rico*	0.3	0.2	807
Bahamas	0.2	0.1	675
Total/mean	4672.3	3300.8	706

Source: FAO 2008, and other resources.

\*Vegetable pigeonpea.

### Origin and Taxonomy

The presence of pigeonpea seeds in Egyptian tombs suggested that it was cultivated there during the 2000 BC. A perusal of early literature indicates that pigeonpea originated either in Africa (Zanzibar or Guinea) or India. The presence of high diversity among landraces made Vavilov (1939) to conclude that India is a primary center of origin of cultivated pigeonpea. De (1974) and van der Maesen (1980) also supported its Indian origin and is believed that pigeonpea was taken to Africa about 4000 years ago from India.

Linnaeus (1753) gave pigeonpea its first binomial nomenclature—*Cytisus cajan*. van der Maesen (1986) studied the taxonomy of genus *Cajanus* in detail and reported it to be closely related to genus *Atylosia*. Based on further taxonomic studies, he merged genus *Atylosia* *Cajanus* and hence, the genus *Cajanus* now contains a total of 32 species and among these the only cultivated species is *Cajanus cajan*.

According to De (1974) *Tuvari* and *Tuvar* are the oldest vernacular names of pigeonpea as these are mentioned in “Gathasaptasati” that was published during 300–400 AD. There are several local

names of pigeonpea in different parts of the world (Saxena, 2008) but today's most popular name 'pigeonpea' was coined by Plukenet (1692) in Barbados, where the crop was grown in barren lands for feeding its grains to pigeons.

### ***Important Attributes of Vegetable Pigeonpea***

#### ***Growth and Development***

The traditional pigeonpea cultivars and most landraces are of medium (160–180 days) to long (>250 days) maturity durations. However, some early maturing types have also been bred and the earliest maturing pigeonpea variety MN-5 flowers in 54–58 days (Saxena, 2008) and matures in 80–85 days at Patancheru, India (17° N). Between these extremes, there exists an almost a continuous variation for maturity which plays an important role in different cropping systems. Pigeonpea is a photo-period sensitive plant and its photo-period reaction is positively linked to maturity duration and biomass production (Wallis *et al.*, 1981), and so far no germplasm has been identified that is truly photo-insensitive. Besides photo-period, the flowering initiation and development is also strongly influenced by temperature and its interaction with photoperiod. Turnbull *et al.* (1981) showed that the time from floral initiation to flower opening (floral primordial development rate) varied from 40 days under an 8 hour photo-period at 24/16°C to 22 days under extended photoperiod at 32/34°C.

#### ***Growth Habit***

There are two major plant growth habit groups in pigeonpea, and these are designated as determinate and non-determinate. The determinate (Figure 15.1a) type plants have pods in clusters at the top of their canopy and a somewhat corymbs-shaped inflorescence terminates the plant growth. Hence, the plant growth almost ceases after flowering and maturity of such plant is relatively uniform.



**Figure 15.1(a):** Determinate type of plant.



**Figure 15.1(b):** Non-determinate type of plant.

The determinate types are more susceptible to pod borer attack and both *Helicoverpa armigera* and *Maruca vitrata* can cause serious yield losses. On the contrary, in the non-determinate (Figure 15.1b) types, the floral racemes form a long terminal panicle and pods are borne in axillary clusters and the terminal buds are vegetative and continue to grow under conducive environment. The determinate types are shorter in height than the non-determinate types. In comparison to determinate types, the non-determinate genotypes tolerate major biotic and abiotic stresses much better due to their inherent capacity to regenerate under conducive environments. These types show good adaptation to a wide range of moisture regimes, soil types, and hence in subsistence agriculture.

### **Pod Colour**

There is a large variation for fresh pod colour in pigeonpea. Saxena *et al.* (1983) studied the effect of pod colour on important organoleptic properties of vegetable pigeonpea, and found that fresh seeds from purple pods had poor texture, flavour and taste as compared to green seeded types; but such differences disappeared after cooking, suggesting that the pod colour may not play any important role in determining the organoleptic qualities of vegetable pigeonpea. In a survey conducted in Gujarat state of India, where green pigeonpea is consumed as a vegetable on a large scale, it was revealed that the rural consumers preferred pods which had green base with purple streaks on its surface. In contrast, the urban consumers preferred green coloured fresh pods. In a consumer survey conducted by Yadavendra and Patel (1983) in Gujarat State found that cultivar ICP 7979 was the best because of its green coloured pods, easy shelling, and good taste of seeds.

### **Pod and Seed Size**

In pigeonpea, seed size and pod size are invariably correlated. The large podded types have large immature and dry seeds. In some vegetable type lines the immature seed is large but their size reduces gradually with maturity. On average, the number of seeds in a pod varies from 2 to 9 Saxena (2008) observed that all the ovules in the long podded genotypes did not develop to their full size due to ovule abortion (Figure 15.2). The exact reason for the abortion of ovules is not fully understood, but there appears to be blockage in the supply of carbohydrates and other vital nutrients to the growing ovules, causing their pre-mature cessation.

## **Quality Parameters**

### **Quality Traits**

In general, green pigeonpea seeds are considered superior to *dal* in nutrition. The observations recorded at ICRISAT, and some other laboratories show that pigeonpea *dal* is better than vegetable with respect to starch and protein. On the contrary, the green pigeonpea grains have higher crude fibre, fat, and protein digestibility. As far as mineral elements are concerned, the green peas are superior in phosphorus by 28.2 per cent, potassium by 17.1 per cent, zinc by 48.3 per cent, copper by 20.9 per cent, and iron by 14.7 per cent. The *dal* however, has 19.2 per cent more calcium and 10.8 per cent more manganese. Singh (1988) reported that the vegetable type pigeonpea had higher amount of polysaccharides and low crude fibre content than *dal*, irrespective of their seed sizes. They also reported that crude fibre content in vegetable pigeonpea was similar to that of garden pea (*Pisum sativum*). Trypsin inhibitor activity, however, was higher in pigeonpea than that of garden pea.

Like other legumes, pigeonpea seeds also contain some anti-nutritional factors. Pigeonpea seeds contain polyphenolic compounds which inhibit the normal activity of digestive enzymes like trypsin, chymotrypsin, and amylase. According to Kamath and Belavady (1980) dry pigeonpea seeds have unavailable carbohydrates which adversely affect bio-availability of certain vital nutrients. Some of



**Figure 15.2:** Ovule abortion (left) in a developing pod.

the anti-nutritional factors such as phytolectins are heat sensitive and are destroyed during cooking. Some of the flatulence causing oligosaccharides such as staychyose, raffinose, and verbascose are also present in dry pigeonpea seeds.

**Table 15.2:** Comparison of green pigeonpea seeds and *dal* for important quality parameters.

<i>Constituent</i>	<i>Green Seeds</i>	<i>Dal</i>
Starch content (per cent)	48.4	57.6
Protein (per cent)	21.0	24.6
Protein digestibility (per cent)	66.8	60.5
Soluble sugars (per cent)	5.1	5.2
Crude fibre (per cent)	8.2	1.2
Fat (per cent)	2.3	1.6

### ***Morphological and Chemical Changes in Developing Seeds***

Under normal growing conditions, pigeonpea plants produce profuse flowers and pods. In small seeded varieties pod load on an individual plant is much higher than those of large seeded varieties. Pod development takes about 45–50 days from pollination to seed maturity under sub-tropical growing conditions. During this period both pods and seeds pass through a number of physiological, morphological, and chemical changes. It has been observed that the floral petals wither completely and the ovary starts emerging three days after fertilization. A young pod of about one centimeter long is generally visible after one week. Such pods grow rapidly and reach their full size in about 25 days. During this period of pod growth, the young seeds (ovules) inside pods remain alive and intact but do



not gain noticeable size and weight. Soon after achieving the potential pod size, a greater proportion of food reserves of the plant get diverted into the ovules, and soon rapid increases in seed size and weight are observed for the next 10–12 days. From nutritional and marketing view points, it is essential that the green pods are picked at a proper stage to harvest maximum grains with high nutritional quality.

**Table 15.3:** Trace and mineral elements (mg 100<sup>-1</sup>g) identified in green seeds of vegetable variety ICP 7035 and *dal* of variety C11.

<i>Element</i>	<i>Green seeds (ICP 7035)</i>	<i>Dal (C 11)</i>	<i>SEm</i>	<i>Superiority of Vegetable Grains (per cent)</i>
Phosphorus	264.00*	206.0	± 3.95	28.2
Potassium	1498.00*	1279.0	± 12.74	17.1
Calcium	92.30	114.3*	± 1.98	(-) 19.2
Zinc	3.07*	2.07	± 0.01	48.3
Copper	1.39*	1.15	± 0.08	20.9
Iron	5.16*	4.50	± 0.06	14.7
Manganese	0.99	1.11*	± 0.02	(-) 10.8
Magnesium	108.30	108.5	± 10.86	–

\*Source: Singh *et al.* (1984)

**Table 15.4:** Major anti-nutritional factors and toxic substances identified in dry pigeonpea seed.

<i>Constituent</i>	<i>Range</i>	<i>Mean</i>
Protease inhibitors (units mg <sup>-1</sup> )		
Trypsin	8.1–12.10	09.9
Chymotrypsins	2.1–3.60	03.0
Amylase inhibitors (units g <sup>-1</sup> )	22.5–34.20	26.9
Oligosaccharides (100 g <sup>-1</sup> )		
Raffinose	0.24–1.05	0.47
Stachyose	0.35–0.86	0.49
Polyphenols (mg g <sup>-1</sup> )		
Total phenols	3.0–18.30	10.70
Tannins	0.0–0.20	0.03
Phytolectins (units g <sup>-1</sup> )	400	400

\*Source: Singh (1988)

## ***Genetic Enhancement of Vegetable Pigeonpea***

### ***Breeding Objectives***

Popular vegetable type pigeonpea varieties are characterized by their large pods and seeds. It has been generally observed that in most germplasm accessions these two traits are linked and such lines are invariably photo-sensitive, late maturing (>180 days at 17°N) and perennial in nature. These

cultivars flower at the onset of short photoperiods and produce fresh vegetable pods for about 40–50 days, permitting 2–3 pod pickings. To ensure profitable processing and marketing, a regular supply of quality green pods for extended periods is essential. Besides this, the vegetable pigeonpea should have good appearance, taste, and other organoleptic properties. The breeding objectives in a vegetable pigeonpea breeding programme revolve around such traits. Therefore, the major objectives in an ideal vegetable pigeonpea breeding programme are:

- ☆ early podding,
- ☆ round-the-year flowering and pod production,
- ☆ dual purpose varieties,
- ☆ high multiple-harvest pod yield,
- ☆ long green pods with fully grown ovules,
- ☆ non-sticky pod surface with easy shelling,
- ☆ large attractive seeds with good taste, and
- ☆ long shelf-life of pods and seeds.

### **Vegetable Pigeonpea Germplasm**

ICRISAT has a global responsibility for collection, characterization, maintenance, and distribution of pigeonpea germplasm. Currently the ICRISAT Genebank has 13,548 accessions from 76 countries that are available for use in breeding programmes globally. Since long pod size is the most important characteristic of vegetable pigeonpea, the accessions with more than 6 seeds pod<sup>-1</sup> are considered in this group. A study of 231 long-podded germplasm accessions available in the gene bank showed that a considerable variation exists for important agronomic traits. In this material 50 per cent flowering varied from 80 to 229 days, and maturity duration varied from 133 to 270 days. The plant height ranged from 85 to 285 cm, while pod length varied from 3 to 12 cm. It was also observed that the majority of long-podded accessions originated from the African continent where traditionally large, white seeded cultivars and landraces are grown.

**Table 15.5:** Variation for some agronomic traits within vegetable type pigeonpea maintained at germplasm bank at ICRISAT, Patancheru, India.

Region of Origin	No. of Accessions Available	No. of days to		Plant Height (cm)	Seeds Pod <sup>-1</sup>	Pods Plant <sup>-1</sup>	Pod Length (cm)
		Flower	Mature				
Eastern Africa	106	117–229	166–270	130–270	5.4–6.7	26–406	5–12
Southern Africa	17	131–194	163–260	185–260	5.4–6.1	33–154	5–11
Central Africa	4	141–166	215–232	200–230	5.4–5.6	74–130	7–9
Western Africa	13	142–156	194–218	170–250	5.4–5.6	67–246	7–10
Central America	26	106–151	167–202	85–240	5.4–7.2	19–160	7–11
South America	16	132–158	182–230	100–285	5.4–6.1	27–420	5–11
South Asia	39	80–175	133–235	85–230	5.4–7.2	55–830	3–9
South-east Asia	8	134–201	190–264	140–210	5.4–5.9	24–119	5–9
Europe	2	156–174	222–237	210–260	5.4–5.8	137	9
Total	231	80–229	133–270	85–285	5.4–7.2	19–830	3–12

## ***Inheritance of Traits Related to Vegetable Pigeonpea***

A good understanding of the genetic systems controlling important qualitative and quantitative characters is essential for breeding of vegetable pigeonpea. Research on this aspect in pigeonpea is limited and fragmentary. For most qualitative characters, there are large differences in the genetic interpretations, and sometimes the observed phenotypic segregation ratios cannot be explained with clarity. Also in most cases, only a few crosses have been studied, which do not generate accurate information on allelic control of important traits. Also, the genetic interpretations are often restricted to the parental materials used in the study and, therefore, any generalization of genetic information is difficult. The presence of both additive and non-additive gene actions for yield and other characters have been reported in literature (Saxena and Sharma, 1990). Important traits for which inheritance should be revealed for vegetable pigeonpea are pod length, seeds pod<sup>-1</sup>, pod colour, seed colour, seed size, and quality of cooked seeds.

## ***Breeding Methods***

### ***Progeny Selection***

Vegetable pigeonpea breeding programmes in most countries are predominantly based on selection and purification of native germplasm. The local landraces are generally well adapted to the area but natural out-crossing and mechanical mixtures have resulted in genetically impure varieties. With 25–30 per cent natural out-crossing, the pure lines have been contaminated and become heterogeneous. Breeders generally select individual plants of interest within such materials with due consideration to plant type, pod colour, seed colour etc. One or two branches of such plants are bagged using muslin cloth bags after removing fully opened flowers and young and old pods. An insecticide spray on the selected branches before selfing is always useful to inactivate insect eggs and larvae. At maturity, these selfed branches are harvested separately and their seed is used for evaluation in progeny rows in the subsequent season. Selection should be made among lines and in each selected progeny five plants be bagged again for raising their single plant progenies. In the subsequent generation again 4–5 plants are selfed in each selected progeny. The open-pollinated seeds can be used for evaluation, while the selfed seeds are used as nucleus seed for further multiplication.

### ***Hybridization and Selection***

Globally, very little work is being undertaken to breed specifically for vegetable type pigeonpea. However some efforts were made in the West Indies, Dominican Republic, and ICRISAT, Patancheru (India) to breed new varieties that produce vegetable pods early in the season and produce several flushes of flowers and pods. To achieve this, selection of parents for hybridization is the first step towards breeding. Attempts should be made to use pure lines in crosses. Early maturing varieties should be used as female parents. This will help in identifying the selfed plants present in an F<sub>1</sub> population. Selection in F<sub>2</sub> generation should be exercised for pod colour, seed colour, and their size and maturity. These plants can be handled further using classic pedigree selection method.

## ***Choice of Varieties***

The most popular vegetable pigeonpea cultivars have long pods and large seeds (weighing about 15 g 100<sup>-1</sup> seeds when dry), with relatively easy shelling. In Gujarat state of India, the vegetable pigeonpea cultivars with dry seeds weight of about 10–12 g 100<sup>-1</sup> seeds are popular. These cultivars are grown as a normal field crop, but green pods are harvested at an appropriate stage for use as vegetable. This practice is more prevalent around cities where green pods can readily be marketed at

attractive prices. The crop is left for producing dry seeds after harvesting green pods. Such dual purpose varieties are very profitable for peri-urban farmers.

## Asia

In India consumers prefer vegetable pigeonpea pods with green colour. Such varieties usually command better prices than the pods with other colours. However, studies at ICRISAT have shown that the differences in pod colour are not related to cooking time, taste, or nutritive value.

Sweetness of fully grown green seed is also a preferred trait. Normal sugar content in green pigeonpea seeds are around 5.0 per cent; but researchers at ICRISAT have identified a line (ICP 7035) with a sugar content as high as 8.8 per cent. ICP 7035 is highly resistant to *Fusarium* wilt and sterility mosaic virus disease. Its flowers are dark red that produce purple coloured pods. The seeds of ICP 7035 are large, purple with a mottle pattern; while its pods are 7–8 cm long and, on average, contain six seeds (Figure 15.3). Another cultivar T 15–15, is widely grown in Gujarat state, India for both green and dry seed harvests. In southern India, the large-seeded lines such as HY–3C and TTB–6 are popular as vegetable. In hilly tribal areas of India many large-seeded landraces are traditionally grown for vegetable purpose. Scientists at ICRISAT have also bred an early maturing, determinate variety ICPL 87 which is also used for dual purpose. It produces pods for relatively longer time and allows 2–4 pickings within a crop season.



**Figure 15.3:** Seeds and pods of vegetable pigeonpea line ICP 7035.

## Africa

Considering the importance of pigeonpea in African agriculture, priority is given to breed high yielding wilt disease resistant late maturing varieties for deep soils, and medium maturing types for drought prone areas. The first early maturing variety ICPL 87091 was released in Kenya, Malawi, Uganda, and Tanzania for vegetable as well as dry seed production. In Eastern and Southern Africa, about 20 per cent of the farmers have adopted new medium maturing pigeonpea varieties such as ICEAP 00554 and 00557 both for grain as well as green vegetable purposes. In Tanzania, about 50 per cent of the farmers in Babati district have adopted new varieties and pigeonpea production area has now extended to the neighbouring districts of Karatu and Mbulu (SN Silim, personal communication). The adoption of a late maturing, *Fusarium* wilt resistant and consumer/market preferred variety ICEAP 00040 in Northern and Central Tanzania, Kenya, and Malawi has resulted in increased grain yields.

## Southern and Central America and the Caribbean Regions

The Caribbean region constitutes a chain of island countries extending from Trinidad in the south to Jamaica in the north. In this region Dominican Republic is the longest pigeonpea growing country (17000 ha) with an average yield of 945 kg ha<sup>-1</sup> (FAO, 2008). The other pigeonpea growing

countries are Panama, Venezuela, Jamaica, Trinidad & Tobago, Puerto Rico, and Grenada. Pigeonpea in these countries is essentially a small farmers' enterprise but it is an important crop at national level. Pigeonpea is generally grown as intercrop for consumption as fresh peas.

The first vegetable type variety released in the West Indies was 'Prensado'. It was early in maturity and determinate in growth habit. This variety did not become popular among farmers. Subsequently, three more varieties ('Tobago', 'St. Augustine', and 'Lasiba') were released, which were similar to traditional types in their phenology and are still under cultivation. In the mid 60s selections from breeding populations were also made which provided varieties with good quality grains and high yield under intercrop situations (Ariyanayagam and Spence, 1978). The important breeding objective for the Caribbean region was to develop varieties which could provide year-round fresh pods for marketing. In Dominican Republic, pigeonpea is mainly grown by small farmers and about 80 per cent of the annual harvest is exported in the form of canned or frozen green peas. According to Mansfield (1981) information on varieties in Dominican Republic is unclear and farmers generally use mixture of varieties such as 'Kaki' and 'Saragateado'. In general four pigeonpea varieties are recognized in Dominican Republic. These are 'Kaki', 'Pinto Villalba', 'UASD', and 'Year-round'. All these varieties have long pods with large and white seeds.

According to Rivas and Rivas (1975) a cultivar called 'Panameno' was released in Venezuela, 1972. In Puerto Rico, the main breeding objectives are to develop high yielding varieties of different maturities and to breed dwarf lines suitable for mechanical harvesting (Abrams *et al.*, 1978). 'Kaki' is the most popular pigeonpea variety in Puerto Rico (Aponte, 1963) and 2B Bushy is another early maturing semi-dwarf variety. The pigeonpea breeding programmes in Puerto Rico and Venezuela have released a few vegetable type varieties such as 'Panameno', 'Amarillo', 'Kaki', 'Saragateado', and 'Totiempo' (Rivas and Rivas, 1975). 'Guerrero' and 'Cortada' were released in Puerto Rico in 2000 and 'Navideño' was released in the Dominican Republic in 2005.

### ***Cultivation of Vegetable Pigeonpea***

Pigeonpea is known to be sensitive to photoperiod and temperature which influence the development of plant phenology. Early maturing vegetable type varieties are short in stature and require high plant density (about 300000 plants ha<sup>-1</sup>) in contrast to late maturing non-determinate types which require 40,000–50,000 plants ha<sup>-1</sup> for optimum yields. Hence specific agronomic practices are required for different agro-ecological conditions. However, some general guidelines for pigeonpea cultivation are given below:

#### ***Backyard and Bund Cultivation***

Many families grow pigeonpea plants in their backyards for domestic use (Figure 15.4). Such plants are maintained up to 4–5 years and they attain a height of over 3 m. The plants start flowering at the onset of short days and pods are picked for house-hold use as and when required. Under good soil moisture conditions, new flowers are produced for extended periods and one can see buds, flowers, young, mature, and harvestable pods on the same branch.

Relatively large populations are grown on field bunds, mainly around paddy fields for local market (Figure 15.5). In this system, generally 3–4 seeds are sown in a single hill and the plants produce a large number of branches on either side of the bunds. The green pods are picked manually and sold in market either as whole pods or shelled seeds.



**Figure 15.4:** A backyard crop of vegetable pigeonpea for domestic use.



**Figure 15.5:** Green pods are sold in retail market in India.

## Peri-urban Commercial Crop

### Field Preparation

The field should have a known history of good soil fertility. Since pigeonpea cannot withstand water-logging, low-lying fields should be avoided for vegetable pigeonpea production. Sowings on raised beds with appropriate slope is ideal for pigeonpea to avoid flooding. Application of 100 kg ha<sup>-1</sup> of di-ammonium phosphate (DAP) and other soil amendments for the known soil deficiencies is advisable.

### Sowing

Sowing should be undertaken at the onset of rains. This will ensure good plant growth and canopy development. For early maturing types, the row-to-row spacing of 50 cm at lower latitudes and 60 to 75 cm at higher latitudes, with plant-to-plant spacing of 25 to 30 cm is generally adopted. For medium and late maturing types, the seed should be sown to maintain row-to-row and plant-to-plant spacing of 100 and 50 cm, respectively.

### Weed Control

Slow seedling growth of pigeonpea makes it prone to weed competition during the first six weeks of growth. In general, three hand weedings at appropriate intervals are sufficient to control most weeds. Alternatively, one spraying of pre-emergence herbicide such as *Basalin* or *Prometryn*, each @1.5 L ha<sup>-1</sup>, followed by two hand weedings have been found very effective in managing weeds.

### Irrigation

Irrigation is generally not recommended if the crop is grown for domestic consumption on deep Vertisols. However, if the crop is grown for seed purposes, either on light Vertisols or Alfisols, irrigation at the early podding stage is considered beneficial for pod filling and production of new flush of flowers and pods.

### Chemical Control of Insects

Pod borers such as *Helicoverpa armigera* and *Maruca vitrata*, and pod fly (*Melanagromyza obtusa*) are major pigeonpea insects. These may cause severe pod damage and affect seed quality. To control the pod borers in pigeonpea, the following insecticides have been found effective at ICRISAT.

*Helicoverpa armigera* & *Maruca vitrata*

Indexacarb 70 SC @ 70 ml ai ha<sup>-1</sup>

Spinosad 45 SC @ 45 ml ai ha<sup>-1</sup>

Endosulfan 35 EC @ 350 ml ai ha<sup>-1</sup>

Monocrotophos 36 EC @ 360 ml ai ha<sup>-1</sup>

*Pod fly* (*Melanagromyza obtusa*)

Dimethoate 30 EC @ 300 ml ai ha<sup>-1</sup>

Imidacloprid 17.8 SC @ 20 ml ai ha<sup>-1</sup>

The first insecticide spray is generally recommended at flower initiation, and the second and third sprays should be done, if required, at 10–15 day intervals. If Knapsack sprayers are used, then 500 L of spray liquid is recommended to cover one hectare of a pigeonpea field. Since vegetable pigeonpea are consumed fresh, it is always advisable to consult a pest management expert before finalizing the spray schedule.

### **Disease Management**

*Fusarium* wilt and sterility mosaic are two major diseases of vegetable pigeonpea. Wilt is caused by a soil-borne fungus *Fusarium udum* Butler. This pathogen can survive in field for three years or more. Using wilt resistant cultivars reduces risk of damage by wilt.

Sterility mosaic virus is transmitted through eriophide mite (*Aceria cajani*). These virus-carrying mites survive on a number of alternative hosts and pigeonpea stubbles left in fields after harvesting the main crop. The disease management options include: (i) grow sterility mosaic resistant cultivars. (ii) uproot and destroy infected plants at an early stage of disease development, and (iii) spray *Metasystox* @ 0.1 per cent to control the mite vectors in the early stages of plant growth.

### **Harvesting of Pods**

Green pods are harvested for sale as fresh vegetable in nearby townships and cities. Since fully grown bright green seeds are preferred for vegetable purpose, the pods are harvested just before they start losing their green colour.

### **Production and Maintenance of Quality Seed**

Maintenance of genetic purity of elite genotypes is essential to ensure uniform crop. Considerable (20–30 per cent) natural out-crossing takes place (Saxena *et al.*, 1990) through insects in pigeonpea, making the seed maintenance more difficult than other pulses. A study conducted by Indian Council of Agricultural Research (1993) revealed that in most cases the farmer-saved seeds were found to be sub-standard with respect to genetic and physical purity. Pigeonpea, being a partially out-crossing crop, requires extra precautions to maintain variety purity.

### **Commercial Processing of Vegetable Pigeonpea**

Commercial vegetable pigeonpea is commonly processed in to canned or frozen peas especially in the Caribbean countries and a few countries of South America. Dominican Republic stands first among countries exporting vegetable pigeonpea to the United States and other countries. The literature on various aspects of processing is scanty, but Mansfield (1981) gives details of vegetable pigeonpea processing technology. A brief review primarily taken from this publication are presented below:

The steps followed in canning and freezing procedures of vegetable pigeonpea are summarized in Figure 15.6.

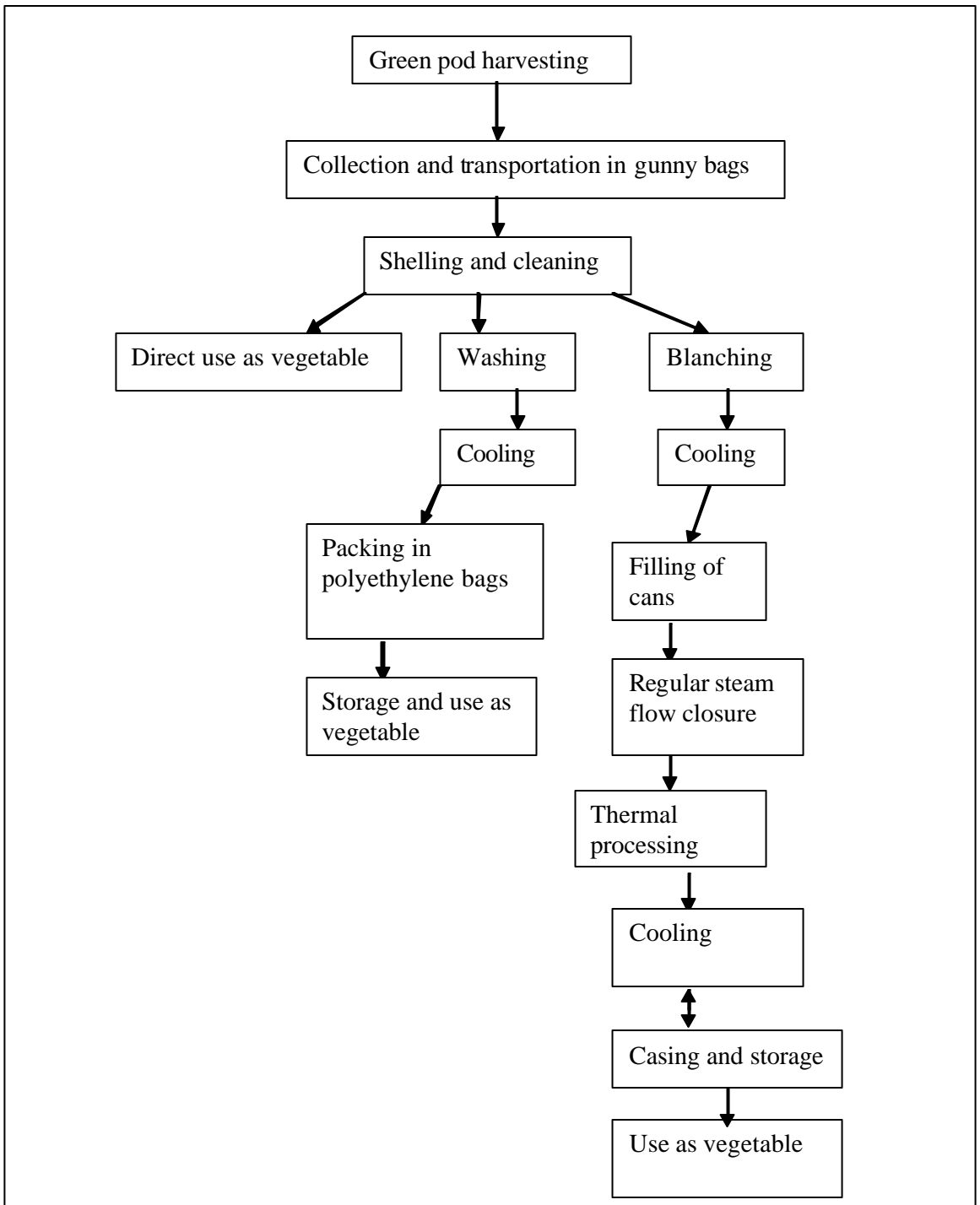
#### **Step 1. Vining**

To maintain freshness of harvested green pods, they should be shelled as quickly as possible. Vining (shelling) of small lots of pods is usually done manually and the shelled peas are generally consumed in local market either as fresh or frozen peas. The bigger lots are used for commercial canning, and for this purpose, vining is performed mechanically.

#### **Step 2. Cleaning of Shelled Peas**

For local market the shelled peas are washed and cleaning operation is carried out to remove unwanted peas and inert materials. The mechanically vined peas are cleaned soon after shelling. The seed cleaning operation is performed by passing the shelled peas through an air blast which helps in removing small pieces of pods, dust, etc. The cleaned lot passes through a mesh screen that allows the peas to drop through it but retains large size peas and extraneous materials. Subsequently, the product passes through a fine mesh that retains shelled peas but removes fine dirt and splits. This dry cleaning operation is followed by washing for removing floating dirt, skins, split peas, etc. The washing is





**Figure 15.6:** Processing flow chart for vegetable pigeonpea.

carried out more than once in various types of flotation washers with cold running water. After washing the shelled peas are forced to pass through rotary rod washers where splits, undersize, and mashed peas are separated. The washed peas fall on a belt where off-coloured remaining worm-damaged and broken peas are removed manually for further processing.

### **Step 3. Blanching**

Heat treatment or blanching is an essential treatment for both freezing as well as canning. This helps in stabilizing colour and flavour besides improving the texture of seeds. According to Mansfield (1981) the blanching operation also helps in producing clear brine by discarding mucous substances, starch particles, and inter-cellular gases. The best blanching is done by heating the peas to 185°F for five minutes in hot water followed by cooling in cold (80°F) water (Sanchez Nieva *et al.*, 1961). Melmick *et al.* (1944) showed that steam is excellent in preserving nutrients of fresh peas but in most cases this process is not cost effective.

After the above mentioned series of treatments, the processed peas could be used either for canning or for freezing. These two follow-up treatments are summarized below:

### **Step 4(a). Freezing of Vegetable Pigeonpea**

According to Mansfield (1981), the following two methods of freezing peas are used in Dominican Republic.

#### **Automated System**

In this system the peas are cooled in water at ambient temperature soon after blanching and then taken to fluidized bed freezer. In this freezer, operating between -10°F to -20°F, the peas are quick-frozen individually while moving inside a vibrating conveyor screen which receives a rapid moving current of cold air from the lower side (Mansfield, 1981). The frozen peas are then hand picked and kept in wax treated cartons. These cartons are stored at 0°F.

#### **Batch Freezing System**

By this system a blast freezer is used for small quantities of shelled peas. The blanched peas are dropped in cold water tanks and then the peas are hand picked in polyethylene bags and placed for freezing in a batch freezer between -2°F to -10°F for 4 to 10 hours. These packets are stored at 0°F (Mansfield, 1981).

### **Step 4(b). Canning of Vegetable Pigeonpea**

For canning purpose the blanched peas are taken to volumetric filler through an elevator. Here the cans are filled with peas and 2 per cent brine at near-boiling (195–200°F) temperature. No additives are used for canning (Mansfield, 1981). For closing the cans, if near-boiling brine is maintained then the exhaust or steam closure is not adopted. This follows a thermal processing to check the growth of any thermophilic bacterium. After the thermal processing, the cans must be cooled immediately to reduce the thermal quality losses by putting the cans in cool water ponds to bring down their temperature to 90–105°F.

## **Marketing of Vegetable Pigeonpea**

According to Mansfield (1981) the growth for pigeonpea cultivation in the Dominican Republic has been due to the impulse given by canning plants from Puerto Rico. From the farm gate the green pigeonpea pods are collected by the representatives of canning plants. The processed cans are sold to wholesalers for export to the United States, Puerto Rico and other Latin American countries. In India

marketing of vegetable pigeonpea is not well established. Vegetable market local vendors (Fig. 5) buy the product from farmers for retail marketing.

### Conclusions

The importance of vegetables in human diet can not be under emphasized. Vegetable pigeonpea can be good source of valuable proteins, vitamins, carbohydrates, and dietary fibre for humans. Vegetable pigeonpea compliments the nutritional profile of cereals, and is a good source of protein, vitamins (A, C and B complex) and minerals (Ca, Fe, Zn, Cu). Vegetable pigeonpea scores manifold advantages over green peas (*Pisum sativum*). It has more than five times beta carotene content, three times more Thiamine (Vitamin B<sub>1</sub>), Riboflavin (Vitamin B<sub>2</sub>), and Niacin. The ascorbic acid content is more than two times over peas. Similarly, it scores over peas in terms of minerals such as calcium and copper (more than two times higher), and magnesium. Besides all this, the shelling percentage of vegetable pigeonpea is 72 per cent compared to 53 per cent of green peas. All these factors render vegetable pigeonpea a highly nutritive potential crop for all ages. It can become one of the most nutritionally rich vegetables of the daily cuisine, especially for the poor in India, Nepal and Myanmar. It is already a vegetable of choice for Kenya, Tanzania, Malawi, Uganda, and the Caribbean.

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