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A Resilient Crop for the Philippine Drylands

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A Resilient Crop for the Philippine Drylands

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Foreword

The deepest pockets of poverty in the world are mainly in tropical dryland areas in developing countries, inhabited by the highest percentage of people living on less than one dollar a day. The first step in reducing poverty and hunger in these countries is to invest in agriculture and rural development.

The Intergovernmental Panel on Climate Change (IPCC) states that drylands are one of the areas at most risk of suffering from climate change. Agricultural activities in the drylands, to be secure and stable, have to keep pace with the changing dynamics of climate.

This emerging scenario presents a challenge for Philippine agricultural researchers to identify and promote food crops that are suited to the country's drylands, have multiple uses, and are suitable for cultivation by resource-poor farmers. Harnessing residual moisture in the soil by cultivating crops such as pigeonpea, can bring about a viable livelihood prospect for dryland farmers of the Philippines, most especially for paddy fields that are left fallow after rice cultivation and in other microniches such as swidden, home gardens and border plots.

The growing interest in pigeonpea by farming communities of the country necessitates learning materials such as this bulletin, that encapsulates the botanical attributes and socio-economic potential of the crop, including areas to exploit for its commercialization. ICRISAT's contribution in taking the initiative for synthesizing the initial R&D work on pigeonpea in the Philippines is a headstart for more comprehensive documentation. In the long run, it will serve as an invaluable resource to create awareness and facilitate adoption for greater impact.

Our research partners from the Philippines deserve appreciation for their contribution in making this material possible. We look forward to a more robust partnership, where pigeonpea is seen as a crop that can revolutionize the country's agricultural system by its ability to improve soil fertility and stability and fodder requirements, and most importantly by its use as an excellent source of protein.

William D Dar
Director General
ICRISAT

Pigeonpea: A Resilient Crop for the Philippine Drylands

Role of Pigeonpea In Philippine Drylands

Rationale

Drylands are characterized by lack of water, which limits their two major interlinked services - primary production and nutrient cycling (www.fao.org/ag/agl/agll/drylands/definitions 2005). Drylands have thus been defined as land areas where the mean annual precipitation is less than two thirds of potential evapo-transpiration, which include arid, semi-arid, and dry sub-humid areas. These lands are characterized by low and erratic precipitation, which is reflected in relatively low and notably unpredictable levels of crop and livestock production. The important factor in cultivating crops in the rainfed areas is the number of growing days that would constitute the length of the growing period of less than 120 days. Within this range, arid lands have less than 75 growing days while semi-arid lands and dry sub-humid areas have more than 75 days (www.greenfacts.org 2009), which includes much of the Philippines' rainfed farms affecting majority of the Filipino farmers. Many farms in the low-lying areas of the Philippines are actually rainfed and qualify as drylands. In both lowland irrigated and dryland areas, food production is affected by urban sprawl, inundations during the wet season, and drought in the summer months due to inadequate irrigation supply. The Philippines have vast drylands in higher elevations, as well as in coastal areas, that can be the next frontiers for food production. In all of the food production areas, aside from the shortage of labor resources and expensive inputs, farming is becoming difficult because of the problems associated with climate variability. There are evidences of changing weather patterns causing compromises in food production in the country. Floods and hurricanes devastated farms in 2008 and 2009. In the first quarter of 2010, drought (or the El Niño effect) has caused the reduction in area planted to rice and maize, and crop damages in affected areas amount to a staggering P 9.58 billion ($ 191.6 million) with 12 regions experiencing dry spell conditions that affect production of rice, maize, fruits, flowers, high-value-commercial crops and livestock. About 753,606 hectares of land was affected, with an equivalent total production loss of 685,485 metric tons (Aquino 2010). In the Cordillera region, reports on damaged vegetables due to the cold Siberian winds have been made. All these take their toll on the country's economy, which means increased food prices due to decreased food supply. This emerging scenario presents challenges for Philippine agricultural researchers. One of these challenges is to identify and promote food crops that are suited to the country's drylands and have multiple uses, and that are suitable for cultivation by resource-poor farmers.

The India-headquartered International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the National Agricultural Research System (NARS) of the Philippines have joined hands towards the introduction and promotion of science-based production systems for pigeonpea (*Cajanus cajan* L. Millsp.), grain sorghum (*Sorghum bicolor* L. Moench), sweet sorghum (*Sorghum vulgare* Pers.), groundnut (*Arachis hypogaea* L.), and chickpea (*Cicer arietinum* L.).

The Pigeonpea project in the Philippines is becoming a major initiative of the Philippine NARS including agricultural state universities and colleges (SUCs) because the country is ideal for the production of pigeonpea. It is a food legume suitable for cultivation by resource-poor farm households, and helps reduce soil erosion in hilly and rolling areas. Initial research done includes successful cultivation of improved varieties of pigeonpea that are promoted in the regions of Ilocos; Cagayan Valley; Central Luzon; CALABARZON (Calamba, Laguna, Batangas, Rizal, Quezon); Bicol; western and eastern Visayas; northern Mindanao; Zamboanga Peninsula; and Cordillera Administrative Region (CAR) (Figure 1). Pursuant to this, a memorandum of understanding has been signed by ICRISAT and the Philippine Government for supporting the conduct of research on adaptation and promotion of improved pulses, groundnuts, cereals and fuel crops in the country.

Facts and Figures of Pigeonpea

Pigeonpea or red gram [*Cajanus cajan* (L.) Millspaugh] is an important food legume of the semi-arid tropics of Asia, Africa and Americas. It occupies a prime niche in sustainable farming systems of smallholder rainfed farmers. It is a photoperiod sensitive plant with a typical short-day requirement for induction of flowering. The traditional landraces and varieties of pigeonpea are sown at the onset of the rainy season and harvested after 6-9 months. Due to its strong photosensitivity requirement, pigeonpea cultivation is

Figure 1. Map of the Philippines comprising 79 provinces in 17 regions.

restricted to the latitudes between of 30°N and S, with a temperature range of 20° to 40°C (Sinha 1977). Recently, ICRISAT pigeonpea breeders have developed high yielding early maturing varieties, which do not have such strong short photoperiod requirements and can be grown successfully up to 46° latitude (Saxena 2008).

Figure 2 shows an increasing trend in pigeonpea cultivation globally with respect to area and production from 3.66 million hectares (M ha) and 2.23 million tons (MT) in 1961 to 4.63 M ha and 3.46 MT in 2006 (FAOSTAT 2008). However, the productivity level of pigeonpea has stagnated over time, estimated currently at 890 kg ha^{-1}. In India, the domestic consumption is approximately 3.4 MT annually while the annual production is around 2.0 - 2.5 MT (Price et al. 2003). To meet the shortage, India has to annually import about 1.5 - 2.8 MT of pigeonpea from Myanmar and East Africa (CRNindia.com 2008).

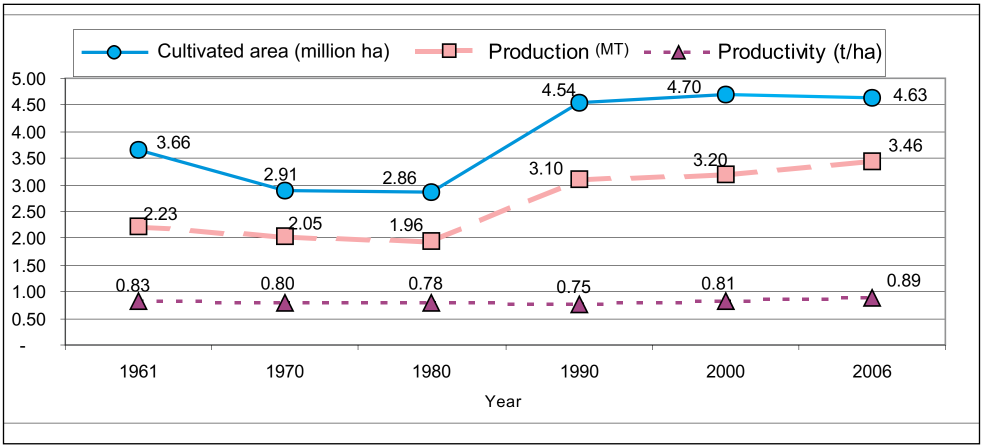

Figure 2. Trend of global pigeonpea area, production, and productivity from 1961-2006.

Pigeonpea is consumed in a wide variety of ways. In the Indian sub-continent, its dry dehulled split peas are cooked as a thick soup (*dal*) and eaten with *roti* (unleavened bread) or rice. In Africa and Central America, whole dry and immature seeds are cooked as vegetable. Its seed husk and pod wall are fed to domestic animals, while dry stems are used as fuel wood. In China, pigeonpea is grown in the hilly tracts for soil conservation because of its deep tap root system and canopy development.

The protein content in pigeonpea seed ranges between 18-22% and in quality, complements well with cereal protein. The protein of wheat, the staple diet of the poor population in many countries, is deficient in essential amino acids like lysine and threonine. The prolonged dependence on cereals could result in the prevalence of protein-calorie malnutrition, especially in the vulnerable groups of the population in developing and underdeveloped countries like the Philippines. Table 1 presents the chemical composition of *dal* (Figure 3), sun-dried seeds (Figure 4), and fresh seeds (Figure 5). The nutritional intervention program to reduce the malnutrition is of immediate interest. Pigeonpea is a high source of lysine and other essential amino acids, carbohydrates and minerals, proven to be an excellent crop to abate such nutritional deficiency. It is estimated that with an average yield of 650 kg/ha, the pigeonpea farmers can supply 170 - 200 kg of protein ha^{-1} to consumers (Saxena et al. 2002).

Figure 3. Pigeonpea dal. (Photo: ICRISAT).

Figure 4. Sun-dried pigeonpea seeds. (Photo: ICRISAT).

Figure 5. Fresh pigeonpea seeds. (Photo: ICRISAT).

Table 1. Chemical composition of pigeonpea *dal*, sun-dried seeds and fresh seeds.

Chemical composition	*Dal*	Sun-dried seeds	Immature seeds
Moisture (%)	15.2	9.9	69.5
Starch content (%)	57.6	53	48.4
Carbohydrates (%)	66.7	64.2	21.3
Protein (%)	24.6	20.5	21
Fat (%)	1.6	1.9	2.3
Fiber (%)	1.2	6.6	8.2
Ash (%)	4.2	4.2	1.4
Soluble sugar (%)	5.2	3.1	5.1
Phosphorous (%)	0.26	2.85	1.35
Lysine[1]	7.1	6.8	7.0
Theonine[1]	4.3	3.8	4.7
Methionine[1]	1.2	1.0	1.4
Cystine[1]	1.3	1.2	1.7
Calcium[2]	16.3	120.8	94.6
Magnesium[2]	78.9	122.0	113.7
Iron[2]	2.9	3.9	4.6
Copper[2]	1.3	1.3	1.4
Zinc[2]	3.0	2.3	2.5
Thiamine[2]	0.40	0.63	0.40
Riboflavin[2]	0.25	0.16	0.25
Niacin[2]	2.2	3.1	2.4
Potassium[2]			563
Sodium[2]			5
Ascorbic acid[2]			26
ß-carotene equivalent		55mg	145mg
Vitamin A	220 IU/100g	28 IU/100g	67 IU/100g
Calories		345	117

Source: Duke, 1981; Price, 1990; Faris and Singh (1990); Faris et al., (1987); USDA (2004)

1: g $100g^{-1}$ protein
2: mg $100g^{-1}$ dry matter

The Legume for Resource-Poor Farm Households

The traditional pigeonpea cultivars and landraces are of medium (160 –180 days) to long (>250 days) maturity durations. However through breeding efforts, some early maturing (≤ 120 days) types have been developed. At Patancheru (17° N) the earliest pigeonpea lines MN 8 and ICPL 88039 mature in 85-90 days. In the province of Ilocos Norte (MMSU, 18° 3' N and 120° 52' E), Philippines, ICPL 88039 flowers all year round. The variability in maturity duration present in pigeonpea plays an important role not only in the diversification of existing cropping systems but also in providing an opportunity for extending pigeonpea cultivation to new production niches. The plants of early maturing cultivars are relatively short in height and produce less biomass and, therefore, require high plant population per unit area for optimizing yield. Such types are generally cultivated as a sole crop. On the contrary, the longer and medium maturing cultivars on the basis of individual plants produce greater biomass and are traditionally grown either as an intercrop with cereals or as perennial hedges.

Pigeonpea is a short-lived (3-5 years) perennial shrub and this unique trait of the crop favorably suits moisture-stressed environments (Figure 6). Its strong deep tap root system and large food reserves help the plants to survive under unfavorable conditions such as drought. Pigeonpea is also known to have built-in compensation mechanisms for survival and podding. These factors encourage regeneration of vital plant parts (Saxena 2008). For example, if there is a sudden loss of flowers due to severe insect damage, short spells of drought, or low temperature, the plants will produce a second flush of leaves, flowers and pods as soon as the environmental conditions become conducive for their growth and development. Similarly, when pigeonpea plants are harvested by cutting the main stem and branches at about 2-3 feet from the ground level, a second flush of vegetative and reproductive growth will occur, provided there is available soil moisture. This ability of regeneration (or ratooned growth) can be exploited in seed production (Saxena 2006). In addition, this system will require less inputs and labor costs. ICRISAT has used this system and found that under good cultural management, a total of 5,200 kg ha^{-1} seed of a short-duration cultivar ICPL 87 was harvested in three harvests at Patancheru (Chauhan et al. 1987). This production technology can be used in multiplying valuable nucleus and foundation seed of pigeonpea.

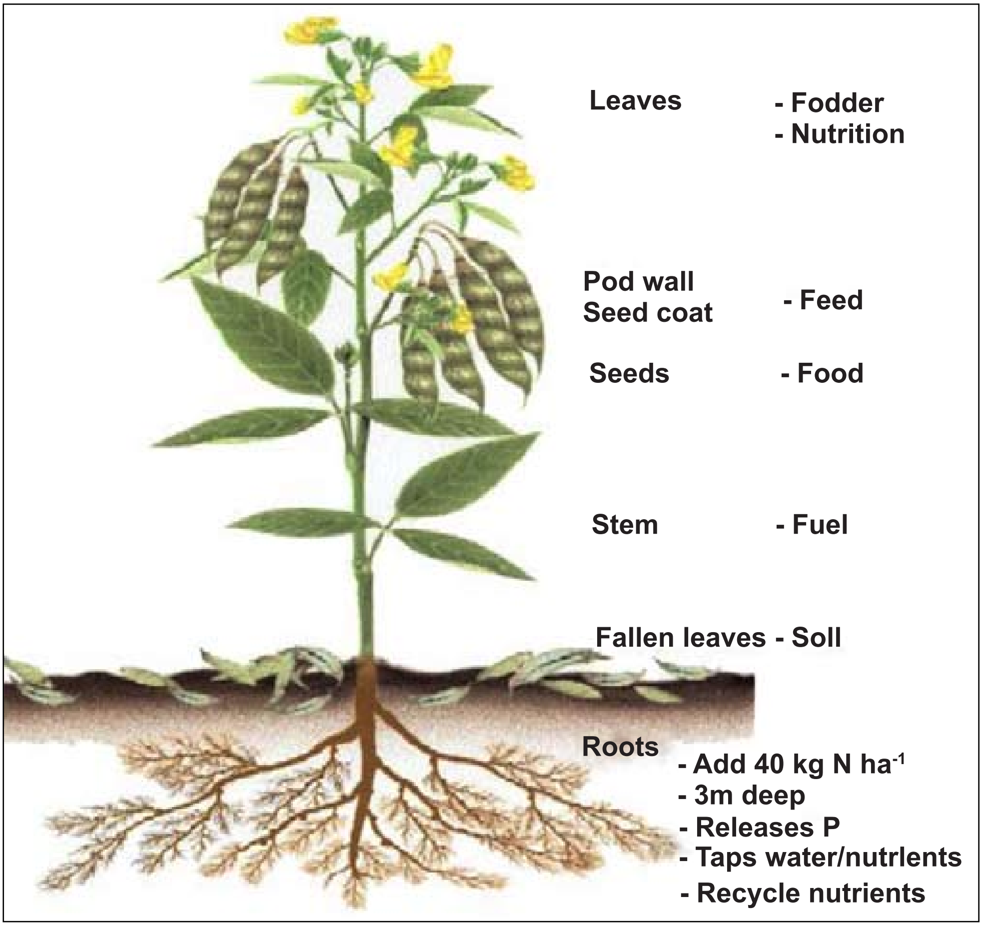

Figure 6. The pigeonpea plant.

Pigeonpea in the Philippines

Agriculture in drylands has become relatively risky as it mainly depends upon the intensity and frequency of rainfall during the cropping season. The Philippines has more than 3 million hectares of drylands covering Northern Luzon, Central Visayas, and Southern Mindanao provinces. Specifically, the dryland areas include regions of CAR, Ilocos, Cagayan Valley, Central Luzon, Western Visayas, Central Visayas, and the SOCCSKSARGEN (South Cotabato, Cotabato, Sultan Kudarat, Sarangani, General Santos) Region (Figure 1). Over 5 M households, most of whom are poor and dependent on dryland farming, inhabit these islands. Dryland farming contributes to about 40% of total domestic food production. The 20 million poor people who live in the drylands are at high risk because of farming conditions that are vulnerable to drought, pest infestation, poor and degraded soils, and lacking in physical infrastructure and social services. Taking into account the extreme drought experienced in 2005, 2007 and throughout the 1st quarter of 2010 covering Central Luzon, Ilocos Region and the Cagayan Valley Region, the occurrence of recurrent droughts and environment degradation owing to climate alterations aggravated the living conditions of the poor communities. Various sectors, specifically the Department of Agriculture (DA) in coordination with the Local Government Units (LGUs) are encouraging farmers to plant drought tolerant crops like pigeonpea to beat the effects of El Niño, which damaged croplands.

The diversity in morphological traits of pigeonpea makes it a crop with great potential for the rainfed areas in the Philippines. The existence of various maturity types of pigeonpea makes it ideal for different cropping systems in the country. The introduction of pigeonpea will not only help in soil amelioration but also generate income per unit of land. Pigeonpea is likewise ideal for home gardening because of its nutritive value. This can be one good crop to combat malnutrition especially among pre-school children, the elderly and even women. Apart from its use as food and fodder, pigeonpea can be used for preparation of processed food that is known for long shelf life, which can generate employment through the creation of small-scale industries. Since pigeonpea also produces quality fodder, it can also be integrated in the crop-livestock farming system (Rao et al. 2003) or as feed supplement in aquaculture.

Geography of the country in relation to pigeonpea cultivation

Most parts of the Philippines are suitable for pigeonpea cultivation. It is an archipelago comprising 7,107 islands with a total area of 300,000 km^2, stretching 1,839 km North-to-South off the southeast coast of Asia. It lies in the western rim of the Pacific Ocean and fronts the southernmost extension of the Eurasian Continent and is located between latitudes 4° and 21° North and longitudes 116° and 127° East (Figure 1). Philippine's total land area of 298,170 km^2 comprises arable land (19%); permanent crops (12%); permanent pastures (4%); forest and woodland (46%), and other type (19%) of land uses. There are three composite islands, Luzon (141,000 km2), Visayas (57,000 km^2), and Mindanao (102,000 km^2), and these are characterized by high mountains with alluvial plains and narrow fertile valleys. The country's mean annual temperature is about 80°F (27°C) with the interior valleys tending to be a little warmer and the mountain peaks a little cooler than the mean. The relative humidity averages about 77%. Rainy season is from May to November, while the dry season occurs during December to April. The country experiences more rain from June to October and the annual rainfall in the mountainous East coast section of the country measures as much as 5,000 mm; while the average rainfall in the lowlands is about 2,030 mm a year, but less than 1,000 mm in some of the rain-shadow valleys. Typically, the weather is cool from November to February, while it is hot and dry from March to May (en.wikipedia.org/wiki/Geography_of_the_Philippines).

Soil suitable for pigeonpea production

The majority of the Philippine soils are Inceptisols, which are suited for high value crops, while some other soil types such as Entisols, Vertisols, and Mollisols are economically important for rice and other forms of cultivation, including maize and sugarcane (Table 2). Some are considered problematic soils (Ultisols) because of their high erodibility and low nutrient content, but which still has potential for agricultural production (Gonzales and Gatchalian 1994). Moreover, these identified types of soils are well suited for pigeonpea cultivation.

Table 2. Uses and distinct features of Philippine soils by taxonomic order.

Soil order	Estimated area (ha)	Uses	Distinct feature affecting productivity
Inceptisols	14,652,684	Cultivated crops; steep areas suited to woodland, recreation, and wildlife	Embryonic soils with few diagnostic features; leaching
Ultisols	8,113,453	Shifting cultivation, timber	Low base status forest soils
Alfisols	3,973,611	Cultivated crops, pasture and forest	High base status forest soils (fertile) but prone to erosion
Entisols	1,540,737	Rice paddies and other forms of cultivation	Fertile soil material subject to flooding
Vertisols	733,117	Rice production, pasture	Shrinking and swelling dark clay soils
Mollisols	762,767	Food production, grasslands	Melanization, slightly leach, high base status, lack sufficient moisture in drier areas and flooding in lowlands

Contd...

Contd.

Soil order	Estimated area (ha)	Uses	Distinct feature affecting productivity
Oxisols	39,922	Forest, shifting cultivation, limited grazing, plantation	Rich, highly weathered soil (low nutrient reserve)
Andisols	39,854	Upland crops cultivation	Productive soils of volcanic origin
Histosols	342	Vegetable production	Organic soils, drainage problem

Converting wastelands for pigeonpea production

Even though 46% of Philippines' total land area is devoted to forest and woodlands, small farm holders slowly reduce this area due to deforestation and with their 'slash and burn or 'swidden' farming practice. Farmers of this type tend to cultivate the area for 2-3 years and then leave the area, which eventually becomes a wasteland. By definition, wastelands are lands that are neglected, barren, uncultivated or without vegetation; improperly managed or with unproductive activity. According to a study conducted by Cuerdo and Santos (1989), the country's forest cover has been reduced to half; from 12 million to 6 million in less than 100 years, leaving the present generation of Filipinos just a million hectares of primary forest. Forestlands are being leveled at the rate of 105,000 hectares a year causing massive soil erosion with 60% of the country's arable land already eroded. The unabated soil degradation is taking a heavy toll on the country's capacity to produce food. Agriculture is less able to reap an abundant harvest from increasingly unproductive and barren soil resources. Declining productivity is aggravated by the widespread practice of intensive farming and monoculture. While only half a billion hectares are suitable to agriculture, the national capability to meet the demand of a rapid growing population is diminished. The country's population was estimated at 97 million in July 2009, which will surely strain the declining productivity of agriculture.

Pigeonpea landraces

Pigeonpea is grown primarily as fresh vegetable by small farm holders in the Philippines for home consumption. Pigeonpea landraces, mainly vegetable type (locally known as kadios, kadyos, kardis or kidis) are grown on a limited scale in the Ilocos Region (Figure 7), Cagayan Valley Region (Figure 8); Batangas (Figure 9); Cordillera Administrative Region; Bicol Region; and Visayas Region. The late-maturing Philippine landraces are grown from April to February (9-11 months). They generally have erect branches, hairy

Figure 7. Pigeonpea landrace cultivated in the uplands of Narvacan, Ilocos Sur, Philippines. (Photo: MG Mula).

Figure 8. Pigeonpea landrace grown in Tumauini, Isabela, Philippines. (Photo: M Palaje).

Figure 9. Pigeonpea green pods and peeled seeds sold in Batangas market, Philipines. (Photo: F Sugui).

plant, and are 1-2 meters tall. Leaves are oblong-lanceolate to oblanceolate with three leaflets. Flowers are yellow, borne in sparse peduncled racemes, about 1.5 cm long. The pod is hairy, 4-7 cm long, 1 cm wide, containing 2-7 seeds (Philippine Alternative Medicines 2008). The crop is also planted as live fences, on rice bunds in low-lying areas, on roadsides, rainfed uplands after rice, and in the highlands where farmers practice the slash and burn system of farming. Because of the crop's perennial growth habit, small farm holders feed its fresh fodder to livestock.

Pigeonpea research for development in the Philippines

Its beginning

Initial research activities on pigeonpea in the Philippines started in 1975 with the objective of adapting improved pigeonpea germplasm from ICRISAT. This was conducted in collaboration with the NARS, specifically the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) and the Cereals and Legumes Asia Network (CLAN). Research was conducted in different SUCs namely, Mariano Marcos State University (MMSU), Batac, Ilocos Norte; University of the Philippines (UP), Los Baños, Laguna; and Quirino Province from 1975 to 1997. However, these research activities were discontinued in 1997.

Recognizing the importance and potential of the crop by the scientists from NARS and ICRISAT, the project was revived in 2005. Through PCARRD, Bureau of Agricultural Research of the Department of Agriculture (DA-BAR), and the Commission of Higher Education (CHED), commitment with ICRISAT was revived (Figure 10) with MMSU as the national lead institute. From 2008 to date (June 2010), pigeonpea lines from ICRISAT were tested in Ilocos Region (Ilocos Norte, Ilocos Sur, La Union, Pangasinan); Cordillera Administrative Region (Apayao, Kalinga, Benguet, Ifugao, Abra, Mt. Province); Cagayan Valley Region (Isabela, Ilagan, Nueva Vizcaya); Central Luzon (Bulacan, Nueva Ecija, Tarlac); Bicol Region (Camarines Norte), CALABARZON (Laguna, Batangas); Western Visayas (Iloilo);

Figure 10. Collaborative pigeonpea research by DA-BAR, ICRISAT, MMSU, PCARRD, CHED, DAR and LGUs. (Photo: RV Kumar).

Central Visayas (Bohol); Eastern Visayas (Leyte); and Zamboanga (Zamboanga CIty); Northern Mindanao (Misamis Oriental). To strengthen research activities, the concept of seed production was integrated into the system, and training was provided to Filipino scientists (seen in Figure 11) at ICRISAT.

Figure 11. DG Dr William Dar (center) presides in a meeting in October 2008 with ICRISAT principal scientists and Filipino scientists led by Dr Jocelyn Eusebio of PCARRD (right side of DG). The main objective of the meeting was to strengthen pigeonpea programs in the Philippines. (Photo: ICRISAT).

Adapted cultivars and their agronomy

The initial research results of the 1975-1987 field experiments conducted in Laguna and Ilocos Norte during the dry season (October to February planting) after rice crop revealed that medium and short duration ICRISAT bred pigeonpea lines produced yields of 1,000 to 3,900 kg ha^{-1}. In the mid-80s, ICRISAT-bred pigeonpea lines were evaluated in the northern areas of the Philippines, which were promising (Table 3). ICPL 83024 was found to be the best variety with green seed yield of 3,585 kg ha^{-1}. This line matured in 127 days. The 100-green seed mass was also high (28.7 g) with more than 50% shelling. ICPL 151 matured early (107 d) and stood second in green seed yield (3,095 kg ha^{-1}). This genotype showed highest (68%) shelling. The 100-green seed mass varied from 22.2 g (ICPL 151) to 28.7 g (ICPL 83024).

Table 3. Performance of short-duration vegetable pigeonpea lines grown in Ilocos Norte, Philippines during dry season of 1989.

Entry Name	Days to		Plant height (cm)	100-green seed weight (g)	Greenpod yield (kg ha^{-1})	Green seed yield (kg ha^{-1})	Shelling(%)
	flower	mature					
ICPL 83024	77	127	119	28.7	6848	3585	52
ICPL 151	74	107	99	22.2	4605	3095	68
ICPL 86010	73	129	106	22.8	4433	2455	54
ICPL 86005	77	131	123	24.4	3573	2188	62
ICPL 87	78	131	96	22.8	3345	1858	55
ICPL 85031	74	131	109	22.9	2528	1348	55
SEm	±0.2	±1.2	±2.4	±0.09	±403.1	±219.8	±3.4
Mean	75.5	126.0	108.7	23.96	4222.0	2421.5	57.7
CV (%)	0.7	1.9	4.5	7.84	19.0	18.2	11.5

Cudapas et al. (1989) tested 16 high yielding cultivars from ICRISAT in 1986 to 1989 during the dry season at the Mariano Marcos State University (MMSU), Batac, Ilocos Norte. The promising varieties, as revealed by the testing, were ICPL 85016, ICPL 151, ICPL 85015, ICPL 85014, ICPL 84032, and UPAS 120, which yielded 2,200 kg ha^{-1} to 2,800 kg ha^{-1}. ICPL 85016 was consistent in its yield performance giving the highest mean of 2,800 kg ha^{-1}. Aside from ICRISAT cultivars, five promising Queensland pigeonpea varieties were also evaluated. QPL 67 produced the highest seed yield of 2,100 kg ha^{-1}.

From 1991 to 1994, a few short duration lines were tested employing different dates of sowing (November, December, and May). ICPL 84032 registered the highest yield of 2,127 kg ha^{-1} (Table 4).

Table 4. Mean performance of determinate pigeonpea varieties grown in Ilocos Norte, Philippines during dry season of 1991-1994.

Traits	Varieties						
	ICPL 87	ICPL 85012	ICPL 85015	ICPL 85014	ICPL 84032	ICPL 84037	ICPL 312
Days to flowering	62	62	62	62	62	62	71
Days to maturity	113	113	113	113	113	113	122
Plant height (cm)	90	72	91	80	91	58	61
Pod damage (%)	23.74	19.84	30.79	28.29	32.56	26.89	28.50
Yellow mosaic virus incidence*	1	1	1	1	1	1	1
Bacterial wilt incidence*	1	1	1	1	1	1	1
Pods per plant	32	40	46	42	46	40	34
Seeds per pod	4.5	4.7	4.9	4.1	4.7	5.3	4.8
Pod length (cm)	7.38	6.96	8.61	6.76	7.51	8.58	7.17
100-seed mass - fresh (g)	29.0	25.7	24.0	25.0	29.0	25.3	29.9
100-seed mass - dry (g)	11.22	11.28	10.65	10.69	11.85	11.22	12.28
Shelling ratio (%)	62	61	60	59	59	60	61
Dry seed yield (kg ha-^{1})	2174	1674	2082	1852	2127	1601	1711

Note: *1 (highly resistance), 5 (highly susceptible)

In the 1996 to 1997 dry season cropping, Sugui et al. (1997) reported that ICPL 93015 produced the highest mean yield of 8,214 kg ha^{-1} when harvested as green pods and 2,085 kg ha^{-1} as grain among the eight vegetable lines tested (Table 5).

Table 5. Mean performance of determinate pigeonpea lines grown in Ilocos Norte, Philippines during dry season of 1996-1997.

Characters	Lines							
	ICPL 93015	ICPL 93020	ICPL 93058	ICPL 93064	ICPL 93066	ICPL 93070	ICPL 87091	ICPL 87
Days to flowering	62	62	62	62	62	62	62	58
Days to mature	130	130	130	130	130	130	130	124
Plant height (cm)	145	134	131	153	130	142	126	120
Seeds per pod	5.6	6.3	6.3	5.3	6.6	5.6	5.3	5.0
Pod length (cm)	8.7	9.5	9.4	8.7	8.9	8.8	9.7	6.3
100-seed mass - fresh (g)	32.0	30.9	31.6	36.6	31.9	32.8	32.2	24.0
100-seed mass - dry (g)	13.6	13.7	13.8	15.0	13.9	14.1	13.9	11.3
Shelling (%)	59	59.5	60	60	61	59.3	60.2	61.7
Green pod yield (kg ha^{-1})	8214	5659	4144	6885	5802	5524	5326	7631
Dry seed yield (kg ha^{-1})	2085	1211	1000	1489	1249	1170	1116	1958

In 2005, 16 new cultivars of different types (short, medium and long duration cultivars) from ICRISAT were tested in MMSU, Batac, Ilocos Norte, Philippines. Of these, ICPL 88039 (early maturing grain type) and ICP 7035 (medium duration vegetable type) were found adapted to the region (Figure 12). ICPL 88039 was discovered as the best alternative crop after rice in the rice-fallow cropping system of the rainfed areas of Ilocos region (Figure 13); while ICP 7035 is a potential intercrop to maize. In 2008-2009 cropping season, ICPL 88039, which is the main crop, produced 875 kg ha^{-1} and after ratooning, it generated a yield of 625 kg ha^{-1}. In the 2007-2008 cropping season, the Isabela State University revealed that ICP 7035 productivity was

Figure 12. Pigeonpea cultivar ICP 7035 in Luna, Apayao, Philippines. (Photo: RV Kumar).

Figure 13. Pigeonpea cultivar ICPL 88039 sown after rice in Brgy Bungon, Batac, Ilocos Norte, Philippines. (Photo: RV Kumar).

remarkable at 2.2 to 3.1 t ha^{-1} while ICPL 88039, planted in the alluvial plain, produced 3.2 t ha^{-1}. These cultivars are now being tested in the different regions of the Philippines (Region 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10) under multi-location trials study (Figure 14).

Aside from the aforementioned varieties, other ICRISAT bred lines that showed good potential were ICPL 87119, ICPL 87091 and ICPL 20092 (long duration dwarf forage type). With these numerous research undertakings, results suggest that commercial pigeonpea cultivation can happen in the Philippines.

Figure 14. Pigeonpea cultivars tested in a multi-location trials in Region 8, Philippines. (Photo: E.Torres).

Promising cultivars for the Philippine drylands

ICPL 88039 (Figure 15) is an extra short-duration line. This is a non-determinate (NDT) line, which matures in less than 100 days and is semi-spreading. The seeds are light brown and have 100-seed mass of 9.5 g and yields between 1.7 to 1.8 t ha^{-1}. This line is drought tolerant, with relatively low susceptibility to *Helicoverpa*, and is very well adapted to cultivation in the rice-fallow cropping system in the rainfed areas of the Philippines.

Figure 15. ICPL 88039 sown after rice at MMSU, Batac, Ilocos Norte, Philippines. (Photo: RV Kumar).

ICPL 87091 (Figure 16) is an excellent short-duration, determinate, vegetable pigeonpea line. It flowers in about 65-75 days and matures in about 130-135 days. It has long pods with 7-8 seeds pod^{-1} with large white seeds yielding 1.8 t ha^{-1} of dry seeds. Vegetable pigeonpea seeds are rich in minerals and vitamins. This line has become popular in dry areas of Kenya, Uganda and Malawi. It allows two to three green pod harvesting. The dry seed yield of this is about 1.8 t ha^{-1}. ICPL 87091 is suitable for homegardens and mixed or relay cropping with vegetables in the dryland areas of the Philippines.

ICPL 87119 (Figure 17) is an excellent wilt and sterility mosaic resistant high yielding line. It flowers in 120-125 days and matures in 170-180 days. Its seed weight is about 10.5 g per 100 seed mass and it yields around 2.0 t ha^{-1}.

ICP 7035 (Figure 18) is a wilt and sterility mosaic resistant variety. This is a medium-duration, high-yielding variety and it flowers in 140-150 days and matures in 200-210 days. Its sweet immature seeds are preferred as

Figure 16. ICPL 87091 tested in Leyte, eastern Visayas, Philippines. (Photo: E. Torres).

Figure 17. ICPL 87119 (released variety in India) tested in Leyte, eastern Visayas, Philippines. (Photo: E Torres).

Figure 18. ICP 7035 (Vegetable type). (Photo: MG Mula).

vegetable. The bold dark brown seed with speckles has 100-seed mass of 22 g and yields 1.5 t ha^{-1}. This variety was released in Fiji, China, and India for general cultivation for both green and dry seed production. ICP 7035 is perfect for backyard gardening, as live fences for farm-lots and houses, and appropriate as intercrop for maize.

ICPL 20092 (Figure 19) is a long-duration genetic dwarf line suitable as fodder for livestock. It flowers in about 135 - 140 days and the maturity ranges between 220 - 230 days. Its plant height is 130 - 140 cm and 100 seed mass is about 9.0 g with round shape white seeds. Generally, animals graze on the standing pigeonpea crop and eat its fresh young leaves and tender branches with gusto. The crop allows 2-3 cuttings for stall-feeding and it yields over 5 tons of fodder per hectare. In the Philippines, ICPL 20092 is suitable in upland areas where hillside agriculture is the dominant agricultural practice. The crop is ideal for contour farming where pigeonpea is planted as hedgerows to be soil and wind breakers aside from utilizing this

Figure 19. ICPL 20092 (Fodder type). (Photo: ICRISAT).

for grazing or as a cut and carry fodder for livestock. This is very popular as fodder variety in China and USA, as it provides nutritious and good quality fodder.

Potential production systems

Pigeonpea plants can adapt to a wide range of soil types from gravel-like soil (Figure 20) to heavy clays, provided there is no standing water on the soil surface. It can also tolerate moderate salinity and alkalinity, but not excessive acidity ie, pH <5.0. Pigeonpea is grown in a wide range of cropping systems. The short-duration types are used as monocrop under high-density production systems such as after rice in rainfed areas. This group generally escapes drought and major diseases; hence it will be best suited for the dry regions of the Philippines. At places where the postrainy season is warm, pigeonpea can be successfully grown after harvesting the paddy (rice) crop. The residual moisture in the rice fields is sufficient to produce economic yields in the short-duration varieties (Saxena 1999). Techno-demo farms were established after rice to demonstrate a condition of no irrigation, no fertilizer production system in the province of Ilocos Norte (Figure 21). The identified promising cultivars were sown for this purpose and showed a remarkable increase in yield. Cultivars ICPL 87091, 87119,

Figure 20. Pigeonpea cultivar ICPL 88039 grown on gravelly soil. (Photo: RV Kumar).

Figure 21. A farmer cooperator with his pigeonpea (ICPL 88039) sown after rice with no-irrigation and no-fertilizer production practice at Brgy. Bungon, Batac, Ilocos Norte, Philippines. (Photo: H Layaoen).

88039 and ICP 7035 yielded 2 t ha^{-1}, 3.1 t ha^{-1}, 3.2 t ha^{-1}, and 4 t ha^{-1}, respectively. Also, pigeonpea intercrop with maize will not only improve the soil but will provide additional income to farmers. This production niche will not only help in increasing the area of pigeonpea but also generate employment. The medium and long-duration pigeonpea is always grown as mixed crop or intercrop with cereals and other legumes resulting in better utilization of resources and gives high combined yields. It is likely to provide increased stability and food security to smallholder dry land farmers in the Philippines. For vegetable purpose, the usual practice is to grow pigeonpea as a sole crop. The new pigeonpea varieties developed at ICRISAT can be successfully grown as:

- a sole crop after rice (short-duration varieties) (Figure 22);
- an intercrop with sorghum (Figure 23), maize (Figure 24), banana (Figure 25), cassava (Figure 26), orchard (Figure 27), etc (medium-duration varieties);
- a cover crop in wastelands (medium or long-duration varieties) (Figure 28);

- a kitchen garden crop (medium or long-duration varieties) (Figure 29);
- a rice bund crop (medium or long-duration varieties); and
- a relay crop for vegetables (short or medium-duration varieties).

Figure 22. Pigeonpea after rice. (Photo: H Layaoen).

Figure 23. Pigeonpea intercrop with sorghum. (Photo: ICRISAT).

Figure 24. Maize intercrop with pigeonpea. (Photo: MG Mula).

Figure 25. Banana intercrop with pigeonpea. (Photo: KB Saxena).

Figure 26. Cassava intercrop with pigeonpea. (Photo: KB Saxena).

Figure 27. Orchard oranges intercrop with pigeonpea. (Photo: KB Saxena).

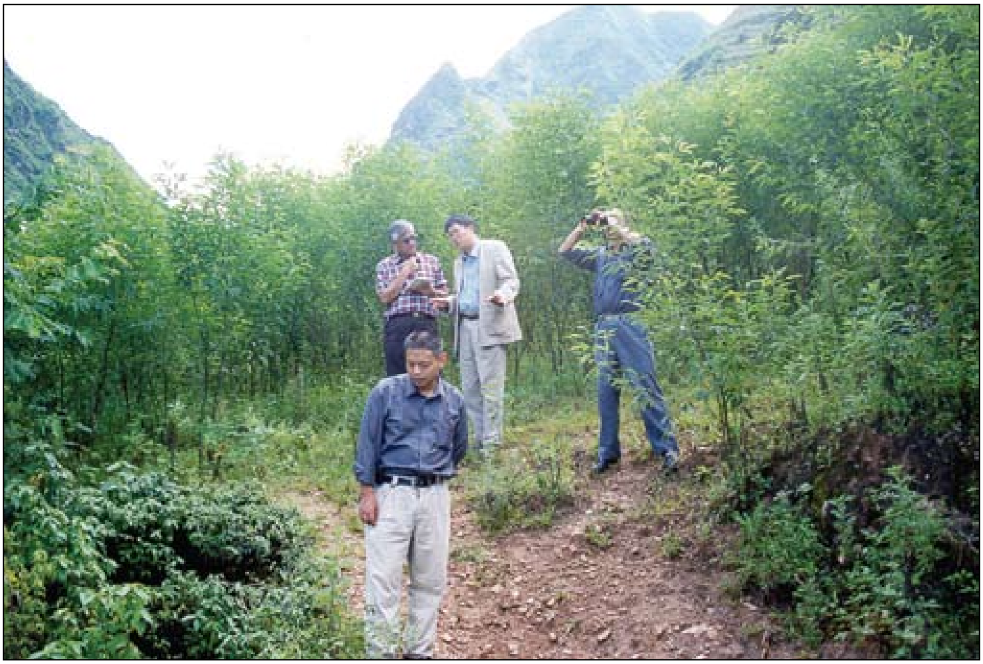
Figure 28. Pigeonpea grown on wastelands in China. (Photo: KB Saxena).


Figure 29. Pigeonpea as kitchen garden in the Philippines. (Photo: MG Mula).

Pigeonpea as a complement to the existing rainfed-cropping system

Initiatives for increased crop productivity in the major dryland rice-producing regions of the Philippines started in the mid 70s. Farming in these areas is highly intensive, diversified, and commercialized. The cropping system is predominantly rice-based in the wet season and high-value cash crops are grown during the dry season. Farmers were encouraged to diversify their cropping system after rice through intercropping, relay cropping and a three-crop-per-year pattern. However, for the past ten years, agricultural productivity has declined due to climate variability and other factors. The occurrence of extreme climatic events like droughts and floods with extreme changes in temperatures has impacted agricultural productivity.

Current research initiatives on pigeonpea have opened several opportunities in which dryland rice-based patterns can be improved. To some extent, cultivating improved pigeonpea varieties was promising as an effective means of increasing the rice-based pattern productivity. Soybean and sorghum were the outstanding alternative crops after rice. However, the introduction and promotion of pigeonpea in the Philippine cropping system is meant to improve not only farm households' income and nutrition but also other advantages favorable to farmers such as the crop's tolerance to prolonged drought without affecting productivity and the nutrients it provides to the succeeding crop grown in the same field because of the fixed atmospheric nitrogen. In Africa, pigeonpea is usually grown as mixed crop with other crops; the most frequent companion crops are maize, sorghum and cassava or rotated with maize-groundnut-tobacco-pigeonpea (IITA 1997). In India, pigeonpea is planted in marginal soils and intercropped with other crops with limited inputs and crop management (Sharma and Jodha 1982). The most common intercropping practices are pigeonpea-cotton and pigeonpea-sorghum.

Potential uses

Pigeonpea is a versatile crop grown primarily as a vegetable in the Caribbean and South America and as a multi-use grain crop (*dal*) in India and some regions of Africa.

Human food. The whole dry seed of pigeonpea may be cooked alone or together with meat (Figure 30). Over 90% of the crop is consumed mainly as de-hulled splits (*dal*). The immature seed of pigeonpea can be used as a vegetable, which is more nutritious than the dry seeds. The green vegetable pigeonpea has a good market in Europe and North America and frozen and canned peas could be exported. Occasionally, the young pods are harvested (before the seeds develop) and cooked like French beans in curries. The other food items that can be prepared from dry pigeonpea seeds are fresh sprouts, *Tempe*, ketchup, noodles, snacks (Figure 31), roasted pigeonpea seeds (Figure 32) and various extruded food products (Saxena 2009). Pigeonpea flour is an excellent component in the snack industry and has been recommended as an ingredient to increase the nutritional value of pasta without affecting its sensory properties (Torres et al. 2007).

Figure 30. Cooked pigeonpea with meat. (Photo: ICRISAT).

Figure 31. Processed pigeonpea pack sold as snacks in China. (Photo: ICRISAT).

Figure 32. Roasted pigeonpea as finger food. (Photo: ICRISAT).

Animal feed, fodder and forage. Fodder scarcity is widespread in many areas of the Philippines and feedstuffs are often too deficient in nitrogen to allow efficient feed digestion in the rumen, which requires a minimum of 1 to 1.2% of feed nitrogen (van Soest 1994) and pigeonpea could well contribute to improved feed resources when used for such purposes (Table 6). Pigeonpea produces forage quickly and can be used as a short-lived perennial forage crop. The leaf and young pods can be harvested and conserved, or fed fresh. Mean nitrogen content in the pigeonpea forage is around 3.4% to 3.6%, suggesting that pigeonpea forage can serve as an effective supplement to nitrogen deficient feedstuffs (Alexander et al. 2007). Indian farmers have used pigeonpea plant and grains as animal fodder or feed for centuries. Even today, plants are left in the field to be grazed by animals after the crop is harvested. Previous findings reveal that pigeonpea has a high feeding value for beef and dairy cattle, swine, sheep and goats. The healthy leaves and podded branches, cut at 0.8 meters, have 40 to 50% dry matter, and protein up to 16% of the dry matter (Takahashi and Ripperton 1949). In China, fresh and dry pigeonpea leaves are valued as fodder and the chaff from threshing the crop is used as feed for milk livestock (Figure 33). The by-products such as seed coats, broken bits and powder from the *dal* mill makes valuable feed for pigs (Figure 34), poultry, and cows (Saxena et al. 2002). The high biomass of the pigeonpea crop can be used as quality fodder for goat raising (Figure 35). Studies conducted in Australia, Colombia, China and India reported the production of 30-50 t ha^{-1} fodder yield of pigeonpea. This fodder contains about 24% crude protein, 36% crude fiber and significant amounts of minerals. Seed and pod meal contain 5-10% crude protein and 2-4% fat and ash. In a research conducted in the Philippines by Sugui et al. (2007), pigeonpea is found to be a cheap source of poultry feed. Poultry birds fed with 15% pigeonpea seeds and 85% broiler mass produced heavier and higher daily gain in weight, better efficiency in feed conversion, and good quality carcasses. In another study conducted by George and Elliott (1986), raw pigeonpea seeds can be included at rates up to 400 g/kg in a commercial layer diet without affecting egg production performance and health and feed intake of the birds.

Table 6. Nutritional constituent of fresh green forage, dried and ground whole plant forage, seeds, seed coat, silage from foliage, and silage of pigeonpea.

Nutritional constituent	Fresh green forage*	Dried/Ground Forage*	Seeds**	Seed coat***	Leaves**	Silage from foliage**	Silage**
Moisture (%)	70.4	11.2	10.3				66.7
Crude Protein (%)	7.1	14.8	18.36	4.9	11.46	15.09	
Crude Fiber (%)	10.7	28.9	5.43	31.9	22.6	26.05	66.7
N-free extract (%)	7.9	39.9				32.8	32.8
Fat (%)	1.6	1.7		0.3			
Ash (%)	2.3	3.5		3.5			

Source: *Duke (1981); **Otero (1952); ***Faris and Singh (1990)

Figure 33. Fresh chopped fodder fed to livestock in China. (Photo: RV Kumar).

Figure 34. Powder and broken dal for feeding pigs. (Photo: KB Saxena).

Figure 35. Fresh fodder fed to goats. (Photo: KB Saxena).

Fuel wood. The rapid clearing of forestlands due to agriculture and demand for fuel wood poses a serious environmental threat in many parts of the world. Pigeonpea's dry stems make important household fuel wood in many poor and developing countries (Figure 36). Pigeonpea generally produces about 9 - 10 t ha^{-1} of dry fuel wood. The quality of pigeonpea fuel wood is high, yielding energy at the rate of 4350 K-cal kg^{-1} (Yude et al. 1993).

Soil ameliorants. In addition to food uses, pigeonpea has outstanding soil amelioration and conservation properties (Figure 37). The growth habit facilitates soil protection, as the canopy continues to expand for four months after other crops are harvested. The plant can fix atmospheric nitrogen through symbiosis until the mid-pod-fill stage. This is around 88% of the total nitrogen content of the plant at that stage of growth. The residual effect can be as much as 40 kg N ha^{-1} (Nene 1987). Pigeonpea grows well in soils with low phosphorus levels. The crop is deep-rooted, so their ability to release more phosphates means that valuable nutrients are being brought up from the deeper soil layers. The release of phosphorous benefits not only the crop, but also the subsequent crops grown in the same field (Ae et al. 1990; IAD 1992). Pigeonpea has been used successfully under coffee plantations as a cover crop to improve soil properties, reduce weed competition as well as act as a food source for predators (Venzon et al. 2006). Maize yields have been increased by 32.1% in West Africa by using pigeonpea as a cover crop (Sogbedji et al. 2006).

Folk medicine. Pigeonpea finds wide application in traditional medicine. Diarrhea, gonorrhea, measles, burns, eye infections, ear ache, sore throat, sore gums, toothache, anemia, intestinal worms, dizziness and epilepsy

Figure 36. Dried pigeonpea stalks as fuel wood. (Photo: RV Kumar).

Figure 37. Dried biomass underneath pigeonpea crop. (Photo: RV Kumar).

are treated with leaf preparations (Morton 1976; Duke 1981; and van der Maesen 2006). In a study conducted in 1995 by the University of the Philippines, the crop could cure diabetes and hyperlipidaemics (persons with a high level of fats in the blood, a condition related to atherosclerotic cardiovascular disease) (Panlasigui 1995). Leaf decoction is use to control nervous breakdown, pulmonary troubles, stomach troubles, kidneys, diuretics, naso-pharyngeal affections, small-pox, chicken-pox, and measles. The roots are said to cure venereal diseases and seeds are used as sedatives (Burkill 1985). In a study conducted by Trinidad et al. (2010), the presence of dietary fibre in pigeonpea provided potential health benefits in the prevention of risks of chronic diseases, and likewise have been considered as a functional food.

Other uses. Pigeonpea stems are used as thatch to enclose livestock pens (Figure 38), to build houses (Figure 39), to make cribs and to weave baskets. The wood is used in light construction such as roofing, thatch, wattling on carts, tubular wickerwork lining for wells, shelter for barns, huts and other crafts from branches and stems. In China, Jianyun and Yun (1998) conducted studies on the processing technology of plywood bond using pigeonpea

Figure 38. Pigeonpea stems as fence to enclose livestock in Nepal. (Photo: RV Kumar).

Figure 39. Pigeonpea as construction material to build houses in Nepal. (Photo: RV Kumar).

glue. The results showed that the bond strength of the plywood was 1.28-1.92 Mpa, which meets the parameters set by the National Standards, and it was higher than that of soybean glue (*Glycine max*). The pigeonpea glue processing technology is relatively simpler and more economical. Other uses are the production of lac (*Kerria lacca* Kerr) (Figure 40), as substrate for mushroom production (Figure 41). Perennial pigeonpea is also used for soil conservation as an erosion control mechanism (Figure 42). In addition, the plant has been observed to be a good source for apiculture (Figure 43). The honey obtained from pigeonpea flowers has a distinctive greenish hue in the comb (www.worldagroforestrycentre.org/Sea/Products/.../SpeciesInfo).

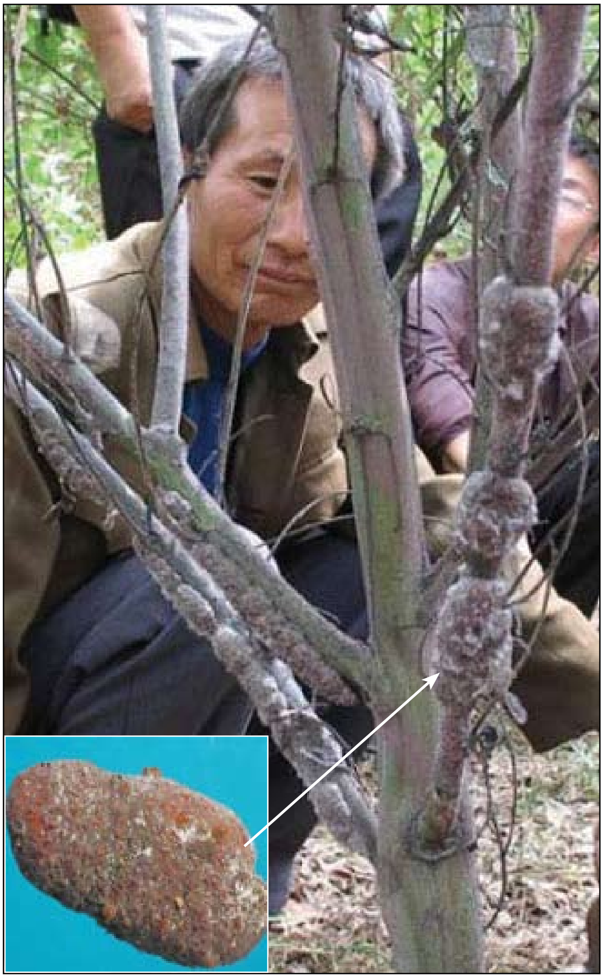

Figure 40. Pigeonpea plant as source for lac production in China. (Photo: KB Saxena).

Figure 41. Pigeonpea used as substrate for mushroom production in China. (Photo: KB Saxena).

Figure 42. Pigeonpea cultivated as soil erosion control mechanism along river banks in China. (Photo: KB Saxena).

Figure 43. Honey bees collecting nectar from pigeonpea flowers. (Photo: RV Kumar).

Commercial Potential of Pigeonpea

As is the case with the promotion of any food crops, market and profit are primary considerations. On this note, final arguments for the promotion of pigeonpea as a major crop for the Philippines drylands comes to the fore because of its suitability in the vagaries of climate variability. Since pigeonpea is a crop that is fast becoming a crop of worldwide economic importance, it does make sense for the Philippines to cash in, to maximize the productivity of its vast drylands and improve the economy especially of the marginal communities. However, to keep pace with the competitive market, agricultural productivity has to be at par with the demands of the international markets. An effective extension mechanism for farmers and processors is important to create better opportunities for them in the world market through the production of higher quality commodities. Specific opportunities in this regard may come through research for development and marketing of products as well as from farmer-driven improvements in agricultural systems. The emphasis on high-value products and market competitiveness aims at addressing livelihood security by supporting research that can provide small farm holders and traders with increased cash income.

Strategies for Expanding Pigeonpea Cultivation in the Philippines

Target areas and potential adoption

As mentioned in the previous section, pigeonpea can be cultivated in all the 17 regions of the Philippines irrespective of the differences in soil type. The different pigeonpea cropping systems practiced by major growing areas such as Myanmar, India and Africa are also suitable under Philippine conditions. These include: rice-fallow cropping system, hillside farming (Figure 44), crop diversification, pigeonpea-livestock (Figure 45) and poultry integration, and pigeonpea-aquaculture integration (Figure 46). These farming systems should not be seen as an attempt to replace conventional farming of the

Figure 44. Hillside farming of pigeonpea in Tanauan, Batangas, Philippines. (Photo: F Sugui).

Figure 45. Pigeonpea-livestock integration. (Photo: ICRISAT).

Figure 46. Pigeonpea-aquaculture integration. (Photo: ICRISAT).

country, but as a means of complementing what is existing. The integration of pigeonpea maybe regarded as a reasonably unique and stable element of the farm enterprise that a household can manage according to well-defined practices taking into account physical, biological, and socio-economic environments as well as household's goals, preferences, and resources (Shaner 1987).

Seed production system

In comparison to cereals, the seed system for legume crops is currently not well established, which has led to poor seed supply thus pushing the farmers to use their own seeds year-after-year or obtain these from other farmers or local seed outlets. For pigeonpea, the seed system is hardly in place unlike other crops like soybean, green gram, cowpea etc where the genetic purity of their seeds does not deteriorate rapidly due to high level of self-pollination.

Pigeonpea is self-fertilized, with 20-40% cross-fertilization. The cross-pollination takes place when the petals of the flowers unfold and insects visit them to collect nectar. The major insect pollinators responsible for cross-pollination in pigeonpea are the bumble bees (*Megachile* spp) and honey bees (*Apis mellifera and Apis dorsata*) (Williams 1977; Brar et al. 1992). However, for the crop to be widely cultivated by farmers, they need to be trained on how to maintain the purity of the seeds to avoid contamination brought about by out-crossing or mechanical mixing. In India, a study conducted by the National Seed Project for over six years revealed that in most cases, farmer-saved seeds were sub-standard in respect of physical purity (about 15-100%), genetic purity (37-80%), germinability (15-100%), and general seed health. Also, farmer seeds gave 2 to 80% lower yields than the certified seeds (ICAR 1993). In spite of poor quality seeds, the farmers' practice of exchanging seed materials continues. However, the problems encountered in the adoption of new varieties do not end with the initial distribution of improved varieties to the farmers. Distribution should be dovetailed with appropriate provisions of being able to maintain genetic purity of these varieties in their large-scale seed production programs year-after-year. Therefore, it is essential that farmers be educated to follow simple procedures to maintain seed purity at farm level to obtain high yield (Figure 47). A key message to farmers is to maintain an isolation distance of about 300 - 500 m for their seed production. The inability of farmers to follow this protocol leads to continuous deterioration of seeds season-after-season.

Figure 47. ICRISAT Director General Dr William Dar (center), BAR Consultant Dr Santiago Obien (left), and ICRISAT Scientist Dr KB Saxena inspect seed production of ICPL 88039 at MMSU, Batac, Ilocos Norte, Philippines. (Photo: KB Saxena).

A group of farmers that were organized as a cooperative were trained in Barangay Bungon, Batac, Ilocos Norte, to produce seed grade pigeonpea (Dr Heraldo Layaoen, MMSU Batac, Personal communication) (Figure 48). The approach involves the production areas to be clustered per variety. Only two varieties are currently produced with support from the Bureau of Agricultural Research (BAR) of the Department of Agriculture (DA). These are ICPL 88039, a short duration variety, and ICP 7035, a medium maturity variety. One cluster area for seed production is situated approximately 1,000 m apart with a natural barrier such as a hill with forest tree vegetation.

According to Saxena (2006), the availability of genetically pure seeds of improved pigeonpea cultivars is considered crucial for realizing good productivity and their adoption to different agro-climatic conditions. It is a fact that the benefits of new improved varieties cannot be fully realized until sufficient quantities of genetically pure and healthy seeds are commercially produced and sold in the areas where these are adopted. The concept and mechanism to maintain and produce genetically pure seeds of the nucleus

Figure 48. Farmer's of Brgy. Bungon, Batac, Ilocos Norte, Philippines are trained to produce seed grade pigeonpea (ICPH 88039). (Photo: H Layaoen).

seeds, breeder seeds, foundation seeds, and certified seeds are presented in the manual entitled *Seed Production Systems in Pigeonpea* by Saxena (2006).

Combating production constraints of pigeonpea

Pest management. In the Philippines, the major pigeonpea insects that cause severe reduction in yields are the pod borers (*Helicoverpa armigera* and *Maruca vitrata*) (Figures 49 and 50). To control these insects, the use of contact and systemic insecticides is recommended. Timely application of the appropriate insecticides is essential. However, to effectively control the damage brought about by these insects, insecticidal spraying during flower initiation, flower opening (second and third sprays should be at 5 to 10 days interval), and pod development is recommended. If pest incidence persists, one or two additional sprays can also be done, based on economic threshold levels. According to Saxena (2006), it has always been observed that farmers apply insecticide after the onset of insect devastation. At this

Figure 49. Pigeonpea pods damaged by Helicoverpa armigera. (Photo: ICRISAT).

Figure 50. Pigeonpea damaged by Maruca vitrata. (Photo: ICRISAT).

stage, grown larvae are not killed by normal insecticide spraying and damage continues at a rapid pace. Regular monitoring of the crop through integrated pest management is the best bet option for the farmers to adopt (Saxena, 2006). In this scheme, complementary methods (mechanical, physical, biological and cultural, and chemical management) can be implemented. A combination of two or more of these methods, which are compatible in terms of controlling the target pest, may be employed.

Disease management. Sterility mosaic virus (Figure 51), phytophthora blight (Figure 52), and fusarium wilt (Figure 53), are the major pigeonpea diseases. According to Saxena (2006), sterility mosaic is caused by a virus transmittable by the eriophyd mite (*Aceria cajani*) (Figure 54). The virus-carrying mites survive on a number of alternative hosts like the

Figure 51. Sterility mosaic virus. (Photo: ICRISAT).

Figure 52. Phytopthora blight. (Photo: ICRISAT).

Figure 53. One row of pigeonpea damaged by Fusarium wilt. (Photo: ICRISAT).

Figure 54. Electron micrograph of eriophyd mite (Aceria cajani), a vector of the pigeonpea sterility mosaic disease. (Photo: ICRISAT).

pigeonpea plants and stubble left in the field after harvesting the main crop. Phytophthora blight is caused by *Phytophthora drechsleri* f. sp. *Cajani*. The disease is prevalent only during the rainy season (Saxena 2006). However, the pathogen can survive for several years in the soil. Another important disease affecting pigeonpea is wilt. Wilt is caused by a soil-borne fungus *Fusarium udum* Butler, which can survive in the field for three years or more (Saxena 2006). Therefore, to avoid the damage that may be caused by these different diseases, the use of resistant varieties, selection of fields with no history of the identified diseases, appropriate crop rotation, planting in raised seedbeds to ensure good drainage, uprooting of infected plants at an early stage of disease development and destroying them, and applying fungicides if warranted, are recommended.

Natural calamity. Typhoons and droughts are phenomena of nature. During typhoons, pigeonpea plants are damaged and highly susceptible to water logging conditions (Figure 55). The most prevalent disease during this condition is phytophthora blight. To minimize its occurrence, pigeonpea must be grown on ridges with provision of good drainage. Pigeonpea, which is tolerant to drought, may withstand terminal drought by planting short-duration varieties immediately after the main crop is harvested. The moisture present in the soil can be sufficient for the requirement of the crop's early vegetative phase.

Figure 55. Pigeonpea damaged by typhoon in 2009 at Dingras, Ilocos Norte, Philippines. (Photo: F Sugui).

Human resource development

One of the best ways to upscale a project (specifically with reference to cashing in on the potential of pigeonpea) is to build on the capacity of a critical mass to include representation from the different stakeholders (researchers, farmers, and partner agencies). Dovetailing training with improved means of extension education such as the use of information technology (IT) driven-media materials (Figure 56), demonstration farms (Figure 57), and farmers' orientation/forums (Figure 58) and visits (Figure 59) can increase awareness towards a more successful uptake of the initiative.

Initial investments of ICRISAT on building human capacity prove to be the greatest resource for upscaling. Implemented through partnership, ICRISAT enhances the participation of the national agricultural research and extension system, various non-government organizations, state universities, and other non-traditional partners. In the Philippines, through DA-BAR and PCARRD, about 24 agricultural technical staff from various regions including two farmer-leaders, have undergone training in ICRISAT (Table 7). Research fellows who were trained in ICRISAT from 2005 onwards are currently

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Figure 56. Driven-media materials. (Photo: F Sugui).

Figure 57. Pigeonpea seed production demonstration farm in Dingras, Ilocos Norte, Philippines. (Photo: F Sugui).

Figure 58. Farmer's orientation in Limay, Batangas, Philippines. (Photo:F Sugui).

Figure 59. Philippine Research Fellows from Regions 1,5,6,7,8,9 and 10 attend 1 month training on legumes at ICRISAT-Patancheru, India. (Photo: ICRISAT).

involved in the implementation of a pigeonpea national program. They have also been tapped as resource persons for creating the interest and adoption of pigeonpea cultivation.

Table 7. List of Filipino scientists trained in ICRISAT from 1984-2009.

No. of Scientists	Category	Year	Duration (Weeks)	Crop
7	Felllow	2009	4	pigeonpea, groundnut, chickpea
2	Fellow	2009	1	pigeonpea, groundnut, chickpea
1	Fellow	2008	4	pigeonpea
1	Fellow	2006	4	pigeonpea
1	Fellow	2006	2	pigeonpea
2	Scholar	1996	3	pigeonpea
2	In service Training	1992	1	sorghum, pearlmillet, pigeonpea, groundnut, cowpea
1	Scholar	1989-1990	16	pigeonpea
1	Scholar	1989	3	pigeonpea, chickpea, groundnut
3	In service Training	1988-1989	24	pigeonpea, groundnut
2	In service Training	1988	2	pigeonpea, chickpea, groundnut
1	In service Training	1987	2	pigeonpea, chickpea, groundnut
2	In service Training	1984	24	pigeonpea

Demonstrations and field days

There is no better method to change the attitude or practice of the farmers than through field demonstrations where farmers are the implementers and observers of the crop's management system. Showcasing matured technologies through demonstrations (Figure 60) and even field days (Figure 61) provide the initial steps towards their adoption. Field days are essential to arouse interest of key actors in pushing for the cultivation of the crop.

Domestic utilization

The importance of pigeonpea in smallholder economy goes beyond the food dimension, since pigeonpea also provides forage, fodder, feeds, fuel, and as medicine (Mergeai et al. 2001). In either form (dry grain or as a green vegetable), it can make an important contribution to food and nutrition security in the diet (Table 1) of resource poor farmers (Appendix 1).

Figure 60. Demonstration farm showcasing various pigeonpea cultivars at ICRISAT. (Photo: ICRISAT).

Figure 61. DG William Dar together with KB Saxena of ICRISAT with Filipino scientists and farmers view the pigeonpea crop during the Farmers Fields Day at the Cagayan Valley Integrated Agricultural Research Center (CVIARC), Ilagan, Isabela in April 2006. (Photo: KB Saxena).

Pigeonpea milling

Value addition of pigeonpea seeds presents the biggest potential for its commercial production. With the donation of the *Dal* milling machines by ICRISAT to the Republic of the Philippines, processing of pigeonpea seed into

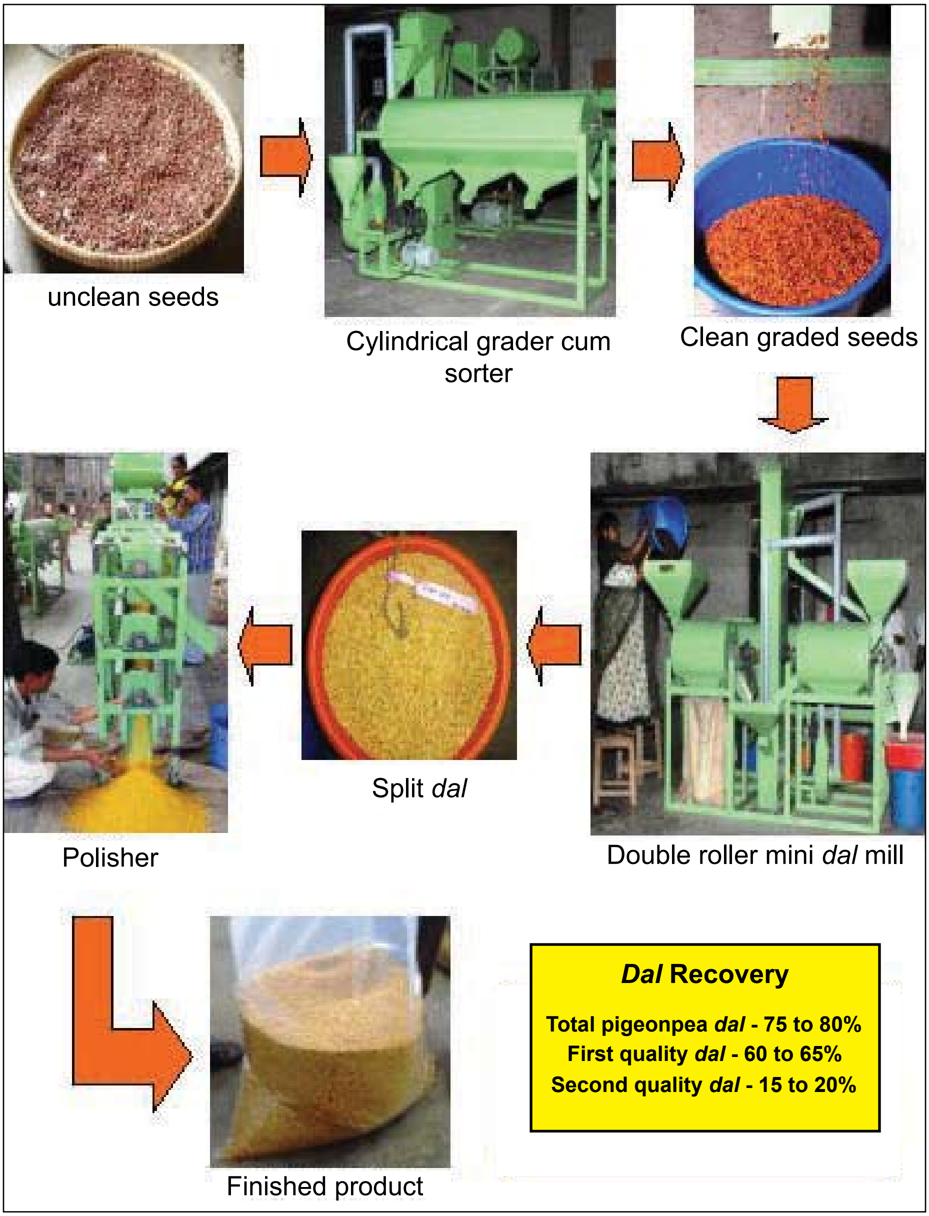

Figure 62. Process flow for producing pigeonpea dal. Source: Mula et al. 2010.

dal can take place. The cost of these machines is approximately US$ 5,500 each. The village-type processing technology consisting of three machines will transform pigeonpea seeds into quality *dal* (Figure 62). Details on how to operate the machines is presented in the Pigeonpea *Dal* Mill brochure by Mula et al. (2010). It is anticipated that the mill will make possible value addition because the *dal* will be the raw material for producing cakes, bread, cookies, noodles, snack items, and other condiments like vinegar. The *dal* makes an ideal supplement to traditional cereal, banana or tuber-based diets of resource poor farmers and consumers. This process will demonstrate to farmers the bright prospects of pigeonpea cultivation as a means to ensure their livelihood security.

Exploiting the crop's export potential

ICRISAT's improved varieties have made a significant impact globally. A wide range of high yielding materials including germplasm has been provided to various countries. To encourage these countries to grow pigeonpea and earn valuable foreign exchange, the following marketing channels are envisaged.

India. The present pigeonpea production of 2.5 MT is insufficient to meet the domestic market and a considerable amount of seed is imported every year. In 1995-96, India imported 82,000 t, while in 1996-97 it increased to 132,000 t. India's pigeonpea deficit is projected to continue to grow and the estimates for the 1998-99 season were as high as 200,000 t. In 1999, Africa exported more than 60,000 t of pigeonpea to India (Jaeger 1998). In 2007 and 2008, around 1.5 to 2.8 MT of pigeonpea was imported annually from Myanmar and Africa (CRNindia.com, 2008; economictimes.indiatimes.com, October 2007).

The Americas and Europe. The demographic change in USA is creating a demand for immigrants' traditional foods in their new homes. The large Indian and Afro-Caribbean communities in North America offer new potential markets. The potential of canned or frozen green peas is also high (Figure 63). From the Dominican Republic, about 80% of the annual harvest is exported (Mansfield 1981). The growing pigeonpea export market has led to an increase in pigeonpea area in the Dominican Republic from about 7,000 ha in 1970 to 23,000 ha in 1998. The principal importer and consumer in Europe is the United Kingdom, owing to its large population of Indian and Caribbean descent. Recent research in Europe indicated a significant niche market for high quality pigeonpea grain (Jaeger 1998).

Figure 63. Processed green pigeonpea seeds for canned and frozen by-products in China. (Photo: KB Saxena).

Following in the footsteps of Myanmar

Most of the pigeonpea produced in Myanmar (Figure 64) is exported and it has registered significant growth in pigeonpea area from 62,010 ha in 1970 to 540,000 ha in 2005. The leading country where pigeonpea is exported is India, which has acquired 93.5% of pigeonpea imports in 8 years. In 2007, a total of 78,860 metric tons (mt) have been exported. With an average buying price of $475.83/mt, the total value was estimated at $37,523,954. In 2008, there was a substantial increase in export as compared to the previous year. Myanmar exported a total of 445,520 mt pigeonpea with a street value of $233,898,000 and the majority was shipped to India. In May 2009, a total of 33,775 mt of whole pigeonpea was exported with value of $22,460,375. Yearly, prices of pigeonpea have been increasing from $237.5/mt in 2002 to $665/mt in 2009. Table 8 also presents the different countries where Myanmar has exported pigeonpea grains since 2002 (USDA GAIN Report 2002 to 2009).

Figure 64. Myanmar farmer showing crop of hybrid pigeonpea. (Photo: KB Saxena).

Table 8. Myanmar's export of pigeonpea from 2002 to 2009.

Country	Volume (metric tons)							
	2002	2003	2004	2005	2006	2007	2008	2009
Australia							159	24
Bangladesh			22			247	46	
Belgium	201	115		608	69		106	46
Bahrain							8	
China		3,835		1,200		4,017	17,490	
Dominican Republic			230					
France					28			
India	60,427	27,256	122,566	43,037	64,820	73,800	407,567	30,646
Indonesia							48	
Italy	42		46	24	24		48	
Japan	496	844					2,636	
Korea							248	
Kuwait							148	
Malaysia							79	
Mauritius							48	

Table 8. Myanmar's export of pigeonpea from 2002 to 2009.

Country	Volume (metric tons)							
	2002	2003	2004	2005	2006	2007	2008	2009
Netherlands	156		23	480	24	5		
Pakistan		376		240		144	1,142	
Portugal	43			24				
Qatar							24	
Saudi Arabia			115				180	
Singapore	113	462	115	141		72	2,969	638
Tanzania	860							
Thailand		531					1,152	
United Arab Emirates						575	11,390	2,421
United Kingdom			23	22			32	
Total	62,338	33,419	123,140	45,776	64,965	78,860	445,520	33,775
Ave. Export Price ($)	237.5	250	313.33	310	305	475.83	525	665
Total Export Value ($)	14,805,275	8,354,750	38,583,456.2	14,190,560	19,814,325	37,523,953.8	233,898,000	22,460,375

USDA GAIN Report 2002 to 2009.

Looking Ahead

In most developing countries like India, the smallholder dryland farmers derive their protein needs from legumes. In the Philippines, most people derive their protein requirement from livestock and fish. Encouraging Filipino people to eat pigeonpea will not only provide the necessary protein but can also reduce per capita expenses on livestock and fish, which are often unaffordable by resource-poor households. To overcome the domestic requirement of quality protein for the growing population of the country, it is essential that a crop rich in protein like pigeonpea that can be easily grown by resource-poor farmers be introduced and genetically improved.

Pigeonpea fits very well in various production niches. Likewise, resource poor farmers need a crop, which not only provides food security but also improves their soil to sustain moderate levels of productivity. After the success story of pigeonpea introduction in China, where pigeonpea area increased from <100 hectares in 1999 to over 150,000 hectares in 2008 (BioSpectrum 2009), a pigeonpea revolution can also take place in the Philippines. The high export potential of this crop is indeed the best incentive to farmers. With these benefits in view, attempts were made to upscale pigeonpea in the Philippines.

With more than 30 years of adaptation trials on pigeonpea showing good results, the following programs are envisaged:

- Mass seed production of promising pigeonpea cultivars by agricultural research institutes (Department of Agriculture, State, Universities and Colleges); private sector companies; and farmers who are willing to be seed growers.
- Government support to seed growers and institutions with the provision of seed storage facilities and post-harvest equipment.
- Government support to private sectors to be tapped as producer of by-products derived from pigeonpea. Investments in value addition to pigeonpea can be the impetus to catch the export market.
- Identification of market linkages to set up domestic and export outlets by government and private entities.
- Feeding programs in pre- and primary schools to be instituted by the Department of Agriculture (DA), Department of Education (DepEd), and the Department of Social Welfare and Development (DSWD) that can help in the promotion on the nutritional value of pigeonpea.
- Human resource development with emphasis on continuous farmers training on crop cultural management, by-product development to marketing.
- Institutionalization of the pigeonpea breeding programs to sustain the adoption of pigeonpea. Pigeonpea considered as an 'orphan' crop should be incorporated into major breeding program, as the crop holds the key to the future's food security in the rainfed areas of the Philippines.

The full realization of the aforementioned programs may lead to a consideration for the Philippine agricultural R&D to participate in the pigeonpea hybrid revolution, in which the government of India is currently involved to large extent. The reason behind the shift from varieties to hybrid is to prevent low and inconsistent productivity levels obtained from the continuous use of varieties over time. Several studies have shown that pigeonpea hybrids have greater yield (41.6% more), greater biomass (60-70%) and is highly resistant to wilt and sterility mosaic disease.

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APPENDIX 1

Philippine recipes with pigeonpea

1. Pigeonpea *Dal* (thick soup)

Ingredients:

Pigeonpea seeds grounded	- 2 cups
Leafy vegetable (any)	- 50 grams
Green chilies (optional)	- 10 grams
Onion, finely chopped	- 1 piece, small
Garlic, chopped	- 1 bulb (8-10 bulbils)
Vegetable oil (for cooking)	- 2 tablespoons
Fish sauce to taste	

Steps:

Boil the ground pigeonpea seeds (seedcoat removed) until soft. Set aside.
Heat oil, fry garlic, onion and chilies one at a time.
Add boiled pigeonpea seeds and cook for another 3 minutes.
Add fish sauce to taste and add the leafy vegetable (say ampalaya leaves) and cook for another 1 ½ minutes. Remove from pan and serve.

Note: Makes for 4 servings

2. Pigeonpea Burger

Ingredients:

Wheat flour	- 1 cup
Pigeonpea flour	- 2 tablespoons
Carrot	- 1 small
Onion	- 1 small
Bell pepper	- 1 small
Vegetable oil	
Ginisa mix and salt for seasoning	

Steps:

Skin carrot and chop into small pieces or grind in a blender together with the onion and bell pepper. Set aside. Place the wheat flour, pigeonpea flour and ground mixture in a mixing bowl.

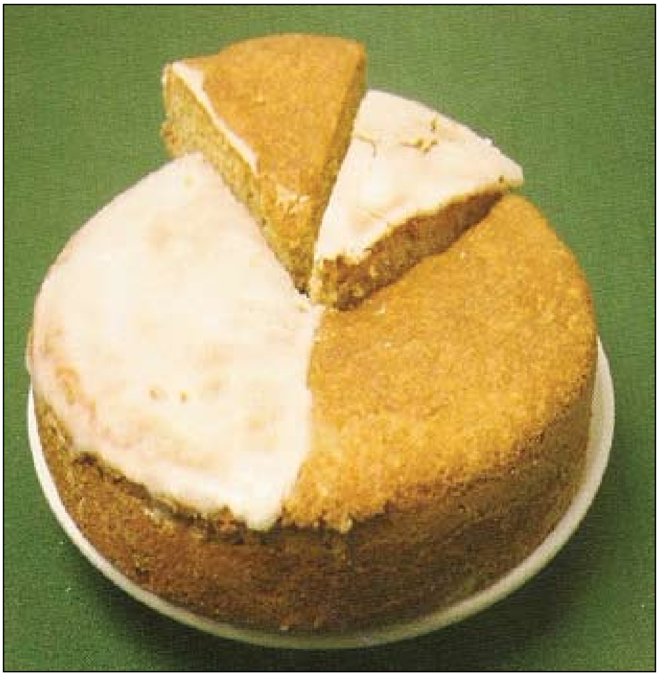
Add ginisa mix or salt to taste. Mix all the ingredients thoroughly until a soft dough is form. Add water if necessary.

Shape the mixture into small thin rounds. Set aside. Heat oil in a frying pan and deep fry the shaped mixture until brown or until cooked. Serve with bread (say tasty bread) or eat with rice.

3. Pigeonpea Cake

Ingredients:

Wheat flour	- 2 cups
Pigeonpea flour	- ½ cup
Baking soda	- ¾ teaspoon
Baking powder	- ¾ teaspoon
Granulated sugar	- ½ cup
Beaten eggs	- 4
Salt to taste	
Margarine (optional), to taste	



Steps:

Combine all the ingredients in a mixing bowl. Mix until soft. Place in baking pan. Preheat oven to 350°F. Place baking pan in the oven and bake for 30-45 minutes. Remove cooked cake from oven. Loosen edge. Remove from pan. Cool cake completely and serve.

Note: Good for 10 persons

4. *Pinakbet* (vegetable dish)

Pinakbet ingredients (All vegetable)

Cowpea green pods (cut into halves)	1/4 kg
Eggplant (cut into 2-3 pcs)	1/4 kg
Bitter gourd (cut into pcs)	1/4 kg
Green seeds patani	1/4 kg
Winged green pods (cut into pcs)	1/4 kg
Raddish green pods	1 cup
Green pigeonpea seeds	1 cup
Tomato (sliced)	1/2 kg
Okra (cut into 2-3 pcs)	1/4 kg
Fish sause and ginger	2 tablespoons
Ginisa mix (MSG) for seasoning.	

Steps:

Mix all ingredients in cooking pan and cook for 15-20 minutes or until cooked. Sprinkle MSG for seasoning/taste.

Note: Serves 15-20 persons

5. Other Pigeonpea Products

'Taste test' of pigeonpea by-products (pigeonpea brewed coffee, pastries, and cakes). (From left to right) Dr William Dar (ICRISAT), Pres. Romeo Quilang (ISU), Dr Jocelyn Eusebio (PCARRD), Dr CLL Gowda (ICRISAT), Dr Heraldo Layaoen (MMSU), and Mr Manuel Palaje (ISU). (Photo: M Palaje)

The various baked pastries, cakes and bread from pigeonpea at the Isabela State University (ISU), Cabagan, Isabela, Philippines. (Photo: M Palaje).

About ICRISAT

ICRISAT
Science with a human face

The International Crops Research Institute for the Semi-Arid-Tropics (ICRISAT) is a non-profit, non-political organization that conducts agricultural research for development in Asia and sub-Saharan Africa with a wide array of partners throughout the world. Covering 6.5 million square kilometers of land in 55 countries, the semi-arid tropics have over 2 billion people, and 644 million of these are the poorest of the poor. ICRISAT and its partners help empower these poor people to overcome poverty, hunger and a degraded environment through better agriculture.

ICRISAT is headquartered in Hyderabad, Andhra Pradesh, India, with two regional hubs and four country offices in sub-Saharan Africa. It belongs to the Consortium of Centers supported by the Consultative Group on International Agricultural Research (CGIAR).

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