PROSPECTS FOR PIGEONPEA CULTIVATION IN DROUGHT-PRONE AREAS OF SOUTH AFRICA

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Abstract

Pigeonpea (*Cajanus cajan* [L] Millsp.) is an important food-legume crop, grown in over 4m ha of the tropics and sub-tropics. In southern and eastern Africa, pigeonpea constitutes an important component of dry land production systems where its dry, whole seeds are used for making soup mixed with or without meat and the green, mature seeds as a vegetable. Although pigeonpea is not a field crop in South Africa, approximately 120-150 tonnes of decorticated, dry, split-peas (locally known as "oil-dhal") are imported monthly to meet the demand of the local Asian community.

Pigeonpea is a drought tolerant plant, and its seeds and forage have over 20% protein. Experience in several Asian and other African countries have shown the importance of pigeonpea in sustaining rain-fed and semi-arid cropping systems. In South Africa, only 10% of the total arable area receives an annual precipitation of more than 750 mm. Maize, the major cereal produced in South Africa is the staple food of the majority of its population. Although maize production is technically advanced among commercial farmers, the semi-arid environment and marginal soils found in areas where disadvantaged smallholder farmers operate, results in frequent maize crop failure. The crop failure coupled with nutritional inadequacies of the maize based diet for the rural households result in poverty and malnutrition. Under these circumstances pigeonpea could find a place to enhance sustainability and profitability of the drought-prone cropping systems and to alleviate rural poverty.

With these objectives, the provincial Department of Agriculture of Mpumalanga initiated efforts in 1998 to evaluate performance of improved pigeonpea cultivars introduced from ICRISAT. Locally adapted varieties with high and stable yields up to 1900 kgha^{1} were identified based on these studies, and land-use efficiency was found to have been enhanced up to 70% by intercropping maize with pigeonpea. Pigeonpea has the potential to provide excellent fodder to grazing animals and its use as animal feed is on the increase around the world. Lack of facilities to process the grain to "dhal" locally, crop losses to insect-pests and the lack of awareness on the nutritional importance of the crop are the major problems identified. It will be absolutely necessary to increase research and developmental inputs for the successful introduction of pigeonpea on a commercial footing, and for effectively utilizing its diverse uses across the drought-prone, frost-free areas in South Africa.

Introduction

The Technology Development Sub-Directorate of the Provincial Department of Agriculture and Land Administration (DALA), Mpumalanga has the mandate to carry out research to improve the sustainability and profitability of farming systems in the province. The Lowveld Research Unit (LRU), one of its sub-stations concentrates mainly on the smallholder farming sector by developing relevant technology to improve the crops grown traditionally by them, and by identifying potential alternative crops and crop-enterprises for inclusion in their existing cropping systems. Pigeonpea (*Cajanus cajan* (L.) Millsp.) was identified as a potential alternative crop for inclusion in the cropping systems of the resource poor, dryland farmers, taking into account its versatility and marketing potential. An overview on the efforts taken to introduce pigeonpea production in South Africa is presented in this paper.

Agriculture in South Africa

The Republic of South Africa covers an area of 122.3 million hectares and, 13% of these are used for crop production. High potential arable land comprises of only 22% of the total arable land and approximately 1.2 million hectares are under irrigation. The most important factor limiting agricultural production is the availability of water. Rainfall is distributed unevenly across the country, with humid sub-tropical conditions occurring in the east and dry, desert conditions in the west. Only 10% of the total area receives an annual precipitation of more than 750 mm. Varying climatic zones and topography enable the production of various types of crops, resulting in South Africa being self-sufficient as far as most major food crops are concerned.

Agriculture in South Africa is unique with its dual nature of having well-developed, large-scale, commercial farms existing along with a large number of smallholder resource poor African farming units. Extreme diversities exist in ownership, scale of operation, technology used etc. Eighty-seven percent of arable land is owned by around 53,000 white farmers in the commercial sector which is highly sophisticated and successful. In contrast, around three million resource poor and emerging African farmers and their households cultivate the remaining predominantly marginal areas characterised by low and erratic rainfall and sandy soils with limited organic matter and low nutrient content. In the mild sub-tropical environment, these smallholder farmers usually grow maize, groundnuts, bambaras, dry beans etc. with the limited resources available to them. The average yields are low due to the unfavourable environment, especially the lack of well-distributed rainfall, and financial constraints.

Maize is the major component of the smallholder cropping systems in many parts of the semi-arid areas in South Africa. Although maize production is technically advanced among commercial farmers, the semi-arid environment and marginal soils found in areas where disadvantaged smallholder farmers operate, results in frequent crop failure. Without the use of fertilizers, and other high cost inputs, it is very hard for them to increase maize productivity. Although the commercial sector produces most of the staple food in large quantities, affordability and accessibility to these by the rural mass have lead to around 50% of them living in conditions of severe poverty and malnutrition.

Maize, the basic ingredient of the daily diet of all in South Africa, is deficient in essential amino acid lysine, as well as being low in protein. To the resource poor households, animal protein sources such as meat, eggs etc. are too costly. The diets of the rural and the urban poor remain deficient in calories as well as protein (both quality and quantity), vitamins and minerals. Women and children, who make up the major section of the people living in poverty, usually suffer the most from these deficiencies. It is strongly believed that the lack of quality diet is one of the major factors contributing to the prevalence of many chronic and fatal diseases such as Tuberculosis, AIDS etc. among these people. A healthy and nutritionally well-fed population is indispensable for strong economic growth and development.

An important, but under-utilized strategy, for resource poor smallholders is to integrate legumes into the cropping system. However, smallholder farmers need a strong

economic incentive if they are to adopt alternative cropping strategies and this can only be provided through the integration of dryland legumes that can both be consumed, and the surplus sold for cash. Pigeonpea is a very relevant choice in this regard as it can be both consumed and traded thereby contributing to household security and income (Freeman and Jones, 1998).

Pigeonpeas

Pigeonpea is an important grain legume crop of the tropics and sub-tropics. Endowed with several unique characteristics, it finds an important place in the farming systems adopted by smallholder farmers in a large number of developing countries and, it is used in more diverse ways than others (Nene and Shiela, 1990). According to FAO statistics and other reliable sources, pigeonpea occupies about 5,377,970 ha in Asia, Africa and America. India is the largest producer with about 4,600,000 ha cultivated in almost all-major agricultural regions. Myanmar (251,700 ha), and Nepal (25,000 ha) are the other major pigeonpea producers in Asia. In South America, it is grown in a number of countries on about 52,000 ha while in southern and eastern Africa, it occupies about 500,000 ha (Saxena, 1999). India produces about 3 million tonnes of pigeonpea annually, but the production is always short of the demand.

Pigeonpea duration types

Maturity duration is a very important factor that determines adaptation of varieties to various agro-climatic areas and cropping systems, (Sharma *et al.*, 1981). Pigeonpeas have been broadly classified into three major duration-groups as shown in Table 1.

Table 1. Duration groups and days to maturity of pigeonpeas

Duration group	Approximate days to maturity
1. Extra-short-duration (XSD)	<100 days
2. Short-duration (SD)	100-150
3. Medium-duration (MD)	151-180
4. Long-duration (LD)	>180

Flowering in pigeonpea is stimulated by changes in day-length and temperature. A basic understanding of how the crop is affected by the environment is important so that the appropriate duration group is selected for a specific area. Short-duration varieties are relatively photo-insensitive and can be grown in frost-free areas successfully. The long and medium duration types are photosensitive and flower during the short-day periods.

Pigeonpea in Africa

In Africa, pigeonpea is produced mainly for household consumption and for export as shown in Table 2, (Freeman *et al.,* 1998). Pigeonpea contributes directly to the economic development of Malawi, in terms of food security and nutrition, and its soil ameliorant effect (Soko, 2000).

Table 2. Average pigeonpea production in Africa (1980-97)

Country	Area (ha) 1980-82	Production (Mt) Average 1980-82	Area (ha) 1995-97	Production (Mt) 1995-97
Kenya	66,337	28,845	147,510	44,874
Malawi	127,333	85,000	143,000	98,000
Tanzania	36,667	22,667	56,667	37,333
Uganda	55,000	26,333	71,000	58,333

Traditional and alternate uses of pigeonpea

Pigeonpea is an unusual and versatile crop and this versatility is reflected in a wide variety of products as detailed below.

Human food

Protein content of pigeonpea seed samples ranges from 18.5 to 26.3%, with an average of 21.5% (Hulse, 1977). Pigeonpea seed has a relatively tough seed coat and as a result it takes long time to cook. In Africa, Central America and Indonesia, whole dry seeds are cooked alone without removing the seed coat or together with meat. Over 90% of the crop is consumed mainly as de-hulled, split cotyledons known as “dhal” or “oil-dhal” or “tur Dhal" to make a thick soup primarily for mixing with rice (Kurien, 1981). Dhal is popular because the de-hulling process greatly reduces its cooking time and improves appearance, texture, palatability, nutritional quality and digestibility. The immature seed of pigeonpea can be used as a vegetable, which is more nutritious than the dry seeds, (Faris and Singh, 1990). It is also a rich source of iron and calcium (Singh *et al*., 1984). For vegetable purposes, the pods are picked when the seed has reached physiological maturity. A yield of around 15 tonnes per hectare (35% dry matter) has been reported by Sallette and Courbois (1968). The green vegetable pigeonpeas have a good market in the west and frozen and canned peas are exported from the Caribbean Islands. In parts of Java, very young pods are harvested before the seeds are distinct and cooked like French beans in curries or used to make relishes. The other food produced is fresh sprouts, tempe, ketchup, noodles and various extruded food products (Faris *et al*., 1987).

Animal feed or fodder

Indian farmers have used pigeonpea plants and grains as animal fodder or feed for centuries. Even today, plants are left in the field to be browsed by animals after the crop has been harvested. Dry pigeonpea leaves are valued as fodder and the threshing from crop used as feed for the dairy cattle. The by-product of seed coats, broken bits and powder from dhal mill form a valuable feed for cows, poultry and pigs (Whiteman and Norton, 1981). High biomass produced by the pigeonpea crop can be used as quality fodder. Studies conducted in Australia, Colombia, China and India reported production of 40-50 t ha^{-1} fodder yields. The fodder contains 20-24% crude protein, 36% crude fibre and significant amounts of minerals. Seed and pod meal contain 5-10% crude protein and 2-4% fat and ash. The experiments conducted in Hawaii indicated that the stock-carrying capacity of pigeonpea stands ranged from 1.2 to 3.7 head ha^{-1} with average live-weight of 0.7 to 1.25 kg $head^{-1}$ day^{-1} (Faris and Singh, 1990).

Fuel wood

Pigeonpea dry stems are important household fuel woods in many countries. A normal pigeonpea crop produces about 10-12 t ha^{-1} of dry fuel wood. The quality of pigeonpea fuel wood has been estimated to be excellent, yielding energy @ 4350K-cal kg^{-1} (Yude *et al*., 1993).

Conservation Agriculture

Pigeonpea has an important role in conservation agriculture as it is known to provide several benefits to the soil in which it is grown. Its deep, well-developed and laterally spread root systems acting as a “biological plough” coupled with its dense canopy effectively reduces erosion (Subudhi and Senapati, 1995;Tyagi *et.al.,* 1999). In China, pigeonpea is grown in about 60, 000 ha of hilly wastelands for soil conservation, which helps in arresting deforestation (Saxena, 2000). Alley cropping with pigeonpea was also found useful to reduce soil erosion. Pigeonpea is outstanding in the depth and lateral spread of its root systems, which enables it to tolerate drought. The deep (3 m) root system allows optimum utilisation of moisture. Leaf-fall not only adds to the organic matter to the soil, but also provides additional nitrogen. Studies carried out in the hilly areas of Nepal showed that the organic matter content, infiltration and improvement of water retention were the highest in plots under pigeonpea (Sherchan *et al.,* 1997). Being a legume, the residual nitrogen available to the subsequent crop is estimated to be around 40 kg ha^{-1} (Singh and Verma, 1985). Pigeonpea has special mechanisms to extract iron, aluminium and calcium-bound phosphorus as its root exudates contain

organic acids which solubilise phosphorus (Ae-N *et al*.,1991). It has been reported that the uptake of nitrogen and phosphorus by finger millet increased when intercropped with pigeonpea (Reddy and Haavangi, 1992). The allelopathy of pigeonpea was found effective in controlling *Cyperus rotundus* in Guatemala (Heperly *et al*., 1992).

Medicinal value

There is considerable folk medicine listing on the curative effect of the various parts of pigeonpea plant from different countries (Faris and Singh, 1990). Pigeonpea seeds are used to treat a wide range of ailments of the skin, liver, lungs, and kidney (Dihua *et al.,* 1985)

Major cropping systems

Pigeonpea plants can adapt to a wide range of soil types from gravely stones to heavy clays, provided there is no standing water in the soil surface. Pigeonpea can tolerate salinity and alkalinity but not excessive acidity i.e. pH below 5.0. Pigeonpea is grown in a wide range of cropping systems. The long-duration (9-10 months) types sown around the longest day of the year, are always grown as mixed crop or intercrop with one or more other species. The medium-duration (6-7 months) types are also sown as either mixed crop or intercrop with cereals and legumes. This type of production system is prevalent at lower latitudes of southern and central India.

Farmers like to intercrop medium- and long-duration varieties with faster growing cereals because there is very little competition between crops. Short-duration pigeonpeas are not well adapted to intercropping. Despite the slow above ground growth, the pigeonpea plant sends out a deep tap-root which allows the plant to exploit moisture reserves at depth. Short-duration varieties do not have such a deep rooting system, but are also very hardy. Both long-and medium-duration types when intercropped results in better utilisation of resources and higher combined yields are obtained than if the crops are grown separately. These production systems provide stability and food security to smallholder dryland farmers. Saxena *et al.,* (1998) found that a combination of 75% maize and 25% pigeonpea had an 8% advantage in LER (write out in full) compared to sole cropping. For vegetable purpose the pigeonpea is often cultivated as sole crop.

Pigeonpea in South Africa

An over-view of pigeonpea production, utilisation and research in South Africa is given below.

Production

Pigeonpea is not a field crop in South Africa. It is grown either as single plants or as a hedge in or around the home gardens mainly in Kwazulu-Natal, Limpopo and Mpumalanga Provinces. Migrant workers from Mozambique and Malawi may have introduced these plants into the eastern provinces (Mpumalanga) and the Indian immigrants to the coastal Kwazulu-Natal. Intercropping with sugarcane proved unsuccessful in Kazulu-Natal, and this could be attributed to the long-duration types used.

Utilisation

Almost all the locally produced crop is used either as green vegetable by the Asians or for making soup with or without meat, using the whole dry seeds by the African community. Pigeonpea has also been tried recently as a grazing crop in South Africa. A long-duration local accession from Mozambique was planted over 50 hectares in 2000-01 season for grazing in a private game farm in Mpumalanga as a perennial source of fresh fodder for the wild animals raised at the farm.

Marketing

The green, mature pods are available from June to December, and most of these are supplied by the household producers in Kwazulu-Natal province and one or two small-

scale producers in Limpopo. At times, it is imported from Kenya or from as far as India to meet the local demand. The entire demand for dhal is met through imports from Malawi. An informal survey showed that around 120-150 tonnes of 'oil dhal' is imported monthly from Malawi at a cost of around R5000.00 (US$500-650) per tonne (Mathews *et al.,*2001a). Thus, the total cost of imported 'dhal' amounts to 6-8 million Rand annually.

Research

Pigeonpea is basically a low input, subsistence crop and as a result, the National Research Institutes (Agricultural Research Council-ARC) of South Africa did very little to popularise the crop among the South African farmers in the past. The effort was limited mainly to the collection of pigeonpea germplasm. A total of 621 are maintained at ARC-RFI (Range and Forage Institute), Roodeplaat, Pretoria. Of these, 497 are from ICRISAT, 92 from CSIR and 32 from local donors, which includes 9 landraces (van den Heever and Trytsman, 2000). Pigeonpea was included in the research programmes of LRU taking into account its drought tolerance, versatility and its performance in other African countries. Evaluation of pigeonpea was thus initiated formally in 1998 with eight short-, five medium-and three long-duration cultivars from ICRISAT. The performance of these cultivars in Mpumalanga was encouraging and additional varieties and advanced breeding lines from ICRISAT were obtained and evaluated during the following seasons.

Achievements so far:

Pigeonpea Interest Group

Farmers and Researchers were unaware that a potential market, both internal and external, for pigeonpea existed in South Africa. In addition, the rural communities were not aware of the nutritional deficiencies in a diet composed mainly of maize. Therefore, efforts to popularise the crop among all role players were initiated. A pigeonpea interest group made up of farmers and Extension officials was formed in Nsikazi District (Mpumalanga) in May 1999 to promote the crop locally. The group, during a field visit to the trials with MD and LD cultivars, showed their preference for ICEAP00040 and ICEAP00053 based on visual observations on the growth habit of plants, seed and pods. The small seeded ICPL87119 was the least popular with them. At a later meeting, the group tasted five local preparations made from the dry whole seeds. Over 80% of the participants considered the taste of pigeonpea to be similar to that of beans and cowpeas. Twenty per cent preferred its taste to the other legumes and none disliked it.

Pigeonpea Workshop

In 2000, DALA organised a pigeonpea workshop for the first time in South Africa to promote the crop among the scientific community in South Africa. The workshop was attended by over 60 participants representing six Provincial Departments of Agriculture, the National Department of Agriculture, Universities, Agricultural Research Council and NGOs. A follow–up workshop was organised in April 2003 to assess the progress made since the first workshop and to formulate the future Programmes. The South African Pigeonpea Network (SAPNET) was formed during the course of the first workshop to initiate and efficiently co-ordinate the pigeonpea development programmes in South Africa. The major activities and achievements by the Network coordinated by DALA so far are summarised below.

Identified varieties adapted to the region

Based on the studies carried out by the LRU–DALA in Mpumalanga during 1998-2002 and across three other provinces (Eastern Cape, Northern Cape and North West) during 2000-01 seasons, the following pigeonpea varieties were recommended for wider adoption in South Africa (Mathews, 2003). Preliminary studies also showed the potential of ICPL87 as a vegetable type.

Table 3. Pigeonpea varieties recommended for South Africa

DURATION	VARIETY	DAYS TO MATURITY	AVERAGE YIELD kg ha^{-1}
Extra-Short	ICPL85010	110-120	1834
Short	ICPL87	120-130	1905
Medium	ICPL87051	170-180	1695
Long (Spreading)	ICEAP00040	230-240	1354
Long (Compact)	ICEAP00053	230-240	1296

Planting dates

It was observed that late planting of the LD-MD varieties after December resulted in smaller canopy and lower yields. The SD types planted later in the season (after January) led to poor establishment, early flowering, smaller canopy and lower yields, probably due to below optimum temperature.

Development of pigeonpea based cropping systems

The preliminary results from the pigeonpea / maize-intercropping trials showed that intercropping could significantly increase land-use efficiency, (Mathews *et al*., 2001b). The Land Equivalent Ratio (LER) ranged from 1.24 in SD cultivars to 1.77 in LD-MD cultivars. The efficiency was greater with LD/MD varieties than with the short-duration (SD) types probably due to the higher competition between the crops (maize/pigeonpea-SD type). An intercropping trial with cotton was initiated by ARC-Rustenburg during the 2002-03 season. Studies with various spatial (pigeonpea/maize) arrangements are in progress in Mpumalanga.

Stimulated interest on pigeonpea research

The workshop was effective in stimulating research on pigeonpea by a number of tertiary Institutes across the country. Thus, research programmes on pigeonpea have been initiated at the Universities of Free State, Natal and Venda and the Institute for Industrial Crops (ARC-IIC), Rustenburg. An achievement in this regard has been the publication of the first-country report on the incidence of pigeonpea leaf rust *(Uredo cajani)* in South Africa (Swart *et al.,* 2000).

Survey on insect pests of pigeonpea

A survey on the insect pests on pigeonpea was carried out in Mpumalanga and the major and minor insect pests on pigeonpea were identified and published, (Mathews *et al.,* 2001c). The major insects identified were the pod borer (*Helicoverpa armigera*) and pod sucking insect (*Clavigralla* spp.). Significant yield reduction especially on the short-duration types was caused by these two insect pests.

Determinate varieties are less able to compensate for insect damage than indeterminate varieties. Indeterminate varieties flower and pod over a longer period than determinate types, and so even if the first set of flowers/pods are damaged, the plant will continue to flower and set pods. Within determinate types, some are more susceptible than others. Apart from the differences between duration groups, and between varieties within duration groups, the level of insect pest activity also varies between locations within seasons. In general, pest incidence is lower during the dry season and in cooler environments. Long-duration varieties, maturing during the dry and cool winter season tend to escape pest damage.

Promotion of the crop

Seeds of improved varieties were distributed among several farmers in South Africa and a number of them, especially in Mpumalanga and Limpopo provinces have started producing the crop on a limited scale mainly for their own consumption. About 200 kgs of

seeds were supplied to Swaziland Department of Agriculture and COSPE, a leading NGO in Swaziland for their use in their conservation Agriculture and Food Security projects.

Discussion

In most developing countries, smallholder, dryland farmers derive their protein needs from legumes. The resource poor farmers of the regions need a crop, which would not only provide food security but also improve their soil to sustain moderate levels of productivity. In the harsh, semi-arid tropical environments, the choice of the cultivars is limited to a few crops only. Among these, pigeonpea occupies a prime place due to its drought tolerance and multiple uses. In the African continent, the dryland farmers are reaping the benefit from this crop in Malawi, Kenya, Tanzania, Uganda and Mozambique. In South Africa, large extents of rain-fed drylands are available and pigeonpea could find a place in the existing cropping systems. It can provide nutritious food for the rural mass and fodder to the domestic animals. In addition, it will help protecting environment from soil erosion, enhance productivity of marginal lands and make available valuable fuel wood. Experience so far has shown the usefulness of pigeonpea to the local dryland cropping systems to enhance profitability, alleviate rural poverty and effect savings on foreign exchange. The short and extra short-duration types could be successfully produced in frost-prone areas in South Africa by selecting suitable varieties. Pigeonpea, with its rich source of lysine, minerals and vitamins would be an affordable means of improving the quality of the cereal-based food for the economically disadvantaged section of the population.

Recent market research in Europe indicated a significant niche market for high quality grain (Jaeger, 1998). Pigeonpeas grown in Northern Tanzania are sought by European buyers because of their favoured bold cream-coloured grain. The principal importer and consumer in Europe is the United Kingdom (UK), owing to its large population of Indian and Caribbean descent. Imports of other European nations are negligible, other than those by Portugal to supply the Cape Verde Islands. The principal supplier of dried pigeonpeas and tur dhal to the UK is Malawi. The UK imports approximately 1,500 metric tons from Malawi annually. Other markets for split pigeonpeas include North America, mainly for the large Asian immigrant population in the US and Canada. The entire requirement of dhal in South Africa is also imported from Malawi.

India is the world's largest producer, importer and consumer of all types of dried and processed pigeonpea products. Domestic consumption of pigeonpea reached two million metric tons in 1996-1997. In 1999, Africa exported more than 60,000 tons to India (Jaeger, 1998). These exports came largely from smallholder farmers growing traditional long-duration varieties that are harvested in August-September and then exported. There is great scope for expansion of these export sales. In 1995-96, India imported 82,000 tons, while in 1996-97 this rose to 132,000 tons. India's pigeonpea deficit is projected to continue to grow (Jaeger, 1998). Almost all imported grain is whole grain for dhal production.

The demand for organic foods in the United States, Europe and elsewhere is growing rapidly as a result of health and other concerns (Thompson, 1998) and offers another potential market opportunity. Pigeonpea is an attractive primary and rotational crop for organic production because of the soil fertility benefits that it brings and essential where inorganic fertilizers are not permitted. The potential market for frozen and canned pigeonpeas has not yet been fully assessed and at present no such processing is being done in Africa.

Major constraints

Lack of awareness

Pigeonpea is an entirely new crop to most farmers and researchers in South Africa. They are not aware of its potential as a food crop within South Africa, and its great demand that exists outside.

Insect-pests and diseases

The major insect pests observed were the pod-sucking bug (*Clavigralla* spp), and pod borers (*Helicoverpa armigera*). The SD types are severely affected by these insect-pests. The whole crop could be lost to these insects unless an effective spraying programme is carried out. However, it is doubtful if the smallholder farmers have the financial resources to spray without access to credit. The MD / LD types seem to be less affected by insects probably due to late flowering in winter.

Lack of in-country processing facilities

Another major constraint is the long hours required to cook the whole grain as there are no facilities currently available in South Africa to process pigeonpea grains into "dhal". Lengthy cooking time of the whole grain is a deterrent to the consumption of pigeonpea by the rural households.

Conclusions

The studies carried out by the Provincial Department of Agriculture (DALA) Mpumalanga have shown the potential of pigeonpea to sustain productivity and profitability in drought-prone areas where maize production has been a failure. However, the successful introduction of the crop to smallholder farmers will require more than just focusing on production issues alone. For any new crop, it is important to train women in all aspects of processing and utilisation. For the success of the programme it will be necessary to introduce household level processing facilities to begin with, and identify marketing and production niches. For the smallholders wishing to market their surplus production, adequate market research and developmental work need to be undertaken. Therefore, it will be absolutely necessary to increase research and developmental inputs for the successful introduction of pigeonpea on a commercial footing, and for effectively utilizing its diverse uses across the drought-prone, frost-free areas in South Africa.

References

Ae N, Arihara J,Okada K, Johansen C. 1991. Phosphorus uptake mechanisms of pigeonpea grown in Alfisols and Vertisols. In: Ae N, Arihara J,Okada K, Johansen C (Eds.) Phosphorus Nutrition of grain legumes in the Semi-Arid Tropics. (ICRISAT), Patancheru, Andhra Pradesh, India. pp. 91-98

Dihua CI, Huiying I, Hui L. 1985. Research on chemical compositions of pigeonpea leaf. *Chinese Herbal Medicine*. 16 (10): 432-437.

Faris DG, Saxena KB, Mazumdar S, Singh U. 1987. Vegetable Pigeonpea: A promising Crop for India. ICRISAT, Patancheru, A.P., India. P. 3.

Faris DG, Singh U. 1990. Pigeonpea: Nutrition and Products. In: Nene YL, Hall SD, Shiela VK (Eds.) The Pigeonpea. (). ICRISAT, Patancheru 502 324, A.P. India. CAB International, U.K. pp. 401-433.

Freeman H A, Silim SN, Jones RB, Ochere M.A. 1998. Pigeonpea situation and outlook in southern and eastern Africa. ICRISAT, Patancheru, India. (Limited publication) *Mimeo*.

Heperly P, Aguilar EH, Perez R, Diaz M, Reyes C, Rizvi SJH. 1992. Allelopathy: basic and applied aspects, In: Heperly P, Aguilar EH, Perez R, Diaz M, Reyes C, Rizvi SJH. (Eds.) Phosphorus-nutrition-of-grain-legumes-in-the-semi-arid-tropics 91-98.ICRISAT, Patencheru, Andhra Pradesh, India. pp. 357-370

Hulse JH. 1977. Problems of nutritional quality of pigeonpea and chickpea and prospects of research. In: Hulse JH, Rachie KO, Billingsley LW (Eds.) Nutritional Standards and Methods of Evaluation for Food Legume Breeders. International Development Research Centre, Ottawa, Canada. Pp. 88-100.

Jaeger PML. 1998. The Indian market for east African Pigeonpeas (*Cajanus cajan*). ICRISAT, Patancheru, India. (Limited publication) *Mimeo.*

Kurien PP. 1981. Advances in milling technology of pigeonpea. Proceedings of the International Workshop on pigeonpeas. 15-19 Dec. 1980, ICRISAT Centre, Patancheru, Hyderabad, India. Vo 1. pp. 321-328.

Mathews C, Saxena KB, Silim SN. 2001a. Evaluation of short, medium and long-duration pigeonpea cultivars in Mpumalanga, South Africa *International Chickpea and Pigeonpea Newsletter* (ICPN) 8: 37-38.

Mathews C, Jones RB,Saxena KB. 2001b. Maize: Pigeonpea Intercropping systems in Mpumalanga, South Africa*. International Chickpea and Pigeonpea Newsletter* (ICPN) 8: 52-53.

Mathews C, Minja E, Saxena KB, Beck BDA, Fowler R. 2001c. Insect pests of pigeonpea in South Africa: Survey report. *International Chickpea and Pigeonpea Newsletter* (ICPN) 8: 48-50

Mathews C. 2003. Pigeonpea variety evaluation in Mpumalanga 1998-2000. Summary Proceedings of the 2nd pigeonpea workshop 2003. 1-11 April 2003, Nelspruit, South Africa. , Department of Agriculture and Land administration, Mpumalanga, South Africa. (Limited publication) p. 19

Nene YL, Shiela VK. 1990. Pigeonpea: Geography and importance. In: Nene YL, Hall SD, Shiela VK (Eds.) The Pigeonpea.). ICRISAT, Patancheru 502 324, A.P. India. CAB International, U.K. pp. 1-14.

Reddy GS,Haavangi GV. 1992. Effect of time of planting and planting patterns on nutrient uptake in pigeonpea/finger millet intercropping system. *Legume Research* 14 (1): 37-44.

Sallettee JE, Courboi JM. 1968. Agronomic aspects of pigeonpea in Marie-Galante. *Proceedings of the Caribbean Society of Food Crop Science*. 6: 32-37.

Saxena KB, Joseph KDSM, Fonseka, HHD Hettiarachchi, K. 1998. Studies on intercropping short-duration pigeonpeas with maize and groundnut. *International Chickpea and pigeonpea Newsletter* (ICPN) 5: 53-55.

Saxena KB. 1999. Pigeonpea in Sri Lanka. International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, A.P. India. p. 98.

Saxena KB. 2000. Pigeonpea in China. International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, A.P. India. (limited distribution). p. 29.

Sharma D, Reddy LJ, Green JM, Jain KC. 1981. International adaptation of pigeonpeas. Proceedings of the International Workshop on pigeonpeas. 15-19 December 1980. ICRISAT Centre, Patancheru, A.P. India, Vol. 1.pp. 71-81.

Sherchan DP, Gurung GB, Gurung BD. 1997. Productivity assessment of red clay soils with legume and cereal combinations in dry, rain-fed hill environments in Nepal. 1997. PAC Technical paper Pakhibas Agricultural Centre, 1991 No 180.p. 9

Singh SB,Verma BS. 1985. Effect of Kharif grain legumes on nitrogen economy in succeeding crop of wheat. *Indian journal of Agronomy* 31: 203-204

Singh U, Jain KC, Jambunathan R,Faris DG. 1984. Nutritional quality of vegetable pigeonpeas (*Cajanus cajan*): Mineral and trace elements. *Journal of Food Science* 49: 645-646

Soko HN. 2000. Pigeonpea Research: Technology Exchange and Seed Production in Malawi. In: Silim SN, Mergeai G, Kimani PM (Eds.) .Status and Potential of pigeonpea in

eastern and southern Africa: Proceedings of a regional workshop, 12-15 Sept. 2000, Nairobi, Kenya. ICRISAT, p. 232.

Subudhi CR,Senapati PC. 1995. Effect of cropping systems on run-off, soil loss and crop productivity. *Indian Journal of Soil Conservation* 23(1):82-83

Swart WJ, Mathews C, Saxena KB. *2000.* First report of leaf rust caused by *Uredo cajani* on pigeonpea in South Africa. *Plant disease* 80: 455

Thompson GD. 1998. Consumer demand for organic foods: What we know and what we need to know. *American Journal of Agricultural Economics* 80:1113-1118.

Tyagi PC, Joshi BP, Sharma NK,Khullar AK. 1999. Perennial pigeonpea as a vegetative barrier in maize-wheat cropping systems in Doon valley. *Indian Journal of Soil Conservation*27(1):41-44

Van den Heever E,Trystman M. 2000. Pigeonpea Research and Developmental Programmes by Agricultural Research Council (ARC). In: Mathews C (Ed.) Proceedings of the First Pigeonpea Workshop, 26 May 2000, Department of Agriculture, Nelspruit, Mpumalanga, South Africa. (Limited publication), p. 25

Whiteman PC, Norton BW. 1981. Alternative uses of pigeonpeas. Proceedings of the International Workshop on Pigeonpeas. 15-19 December 1980, ICRISAT Center, India. Patancheru, A.P., India. ICRISAT. Vol. 1. pp. 365-377.

Yude C, Kaiwei H, Fuji L, Yuanjie initials. 1993. The potential and utilization prospect of 3 kinds of wood fodder resources in Yunnan. Forestry Research 6(3): 346-350.