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The potential of pigeonpea (*Cajanus cajan* (L.) Millsp.) in Africa

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Abstract

Pigeonpea is a tropical grain legume grown mainly in India. Though largely considered an orphan crop, pigeonpea has a huge untapped potential for improvement both in quantity and quality of production in Africa. More than any other legume adapted to the region, pigeonpea uniquely combines optimal nutritional profiles, high tolerance to environmental stresses, high biomass productivity and most nutrient and moisture contributions to the soil. The legume can be utilized in several diverse ways while the high genetic variability that exists within the cultivated and wild relatives remains to be explored for further uses. This article highlights the need for popularizing pigeonpea as a major legume crop in Africa. The main constraints to productivity are discussed and recent breeding efforts in Africa highlighted. Important opportunities for improvement are further provided.

Keywords: Semi-arid tropics; Drought-tolerance; Climate change; Food security, Poverty alleviation; Pigeonpea; Africa.

1. Introduction

The 2006 United Nations Conference on Climate Change (6–17 November) in Nairobi highlighted the increased threat to agricultural production in Africa due to global warming. For the continent with the fastest population growth, home to some of the world's poorest population which relies heavily on inefficient agricultural production, the current climate change predictions paint a bleak future. The soils are already depleted (Drechsel *et al.*, 2001) and the situation is worsened by increasing effects of soil erosion (Lal, 2003) as a result of deforestation (Stiles, 1984). The UN Millenium Project (2005) has indicated the potential for poverty alleviation in Africa through appropriate irrigation technology. However, increasing the use of water for farming conflicts with the need to increase water use for industrial and domestic use. Breeding for drought tolerance in crops widely used in Africa as well as promoting traditional drought-tolerant crops are potential ways of mitigating the impacts of climate change in this continent. Ironically, some of Africa's native drought-tolerant crops are also some of the least researched worldwide and are thus referred to as "orphan crops". (Naylor *et al.*, 2004).

One such crop is pigeonpea (*Cajanus cajan* (L.) Millspaugh). The drought tolerant legume is grown mainly in the semi-arid tropics though it is well adapted to several environments (Troedson *et al.*, 1990). Pigeonpea is a diploid (2n = 22) belonging to the *Cajaninae* sub-tribe of the tribe *Phaseoleae*, which also contains soybean (*Glycine max* L.), field bean (*Phaseolus vulgaris* L.) and mungbean (*Vigna radiata* L. Wilczek) (Young *et al.*, 2003). It is the only known cultivated food crop of the 32 species that fall under the *Cajaninae* sub-tribe. The crop represents about 5% of world legume production (Hillocks *et al.*, 2000) with more than 70% being produced in India (Figure 1). There is also substantial pigeonpea production in Eastern Africa and the Americas. Global annual production of pigeonpea is about 3.6 million tonnes (Mt) valued at around US$ 1,600 million (FAOSTAT 2007).

In terms of legume breeding programmes, pigeonpea lags further behind field beans (*Phaseolus vulgaris* L.) and soybean (*Glycine max* L.). The latter legumes are among the most researched crops worldwide even though, unlike pigeonpea, they are not as drought tolerant. Research of drought tolerant legumes will be especially important for Africa where rapid expansion of water-stressed areas has been projected (Postel, 2000). There is great potential for expansion of the crop in the semi-arid regions of Africa where it would also counteract the declining soil fertility (Hillocks *et al.*, 2000). This article focuses on the relevance, production, utilization, constraints to productivity and options for improvement of pigeonpea production in Africa.

2. Distribution and production in Africa

The true origin of pigeonpea is still disputable. However, the crop was most likely introduced into East Africa from India by immigrants in the 19th century who moved to

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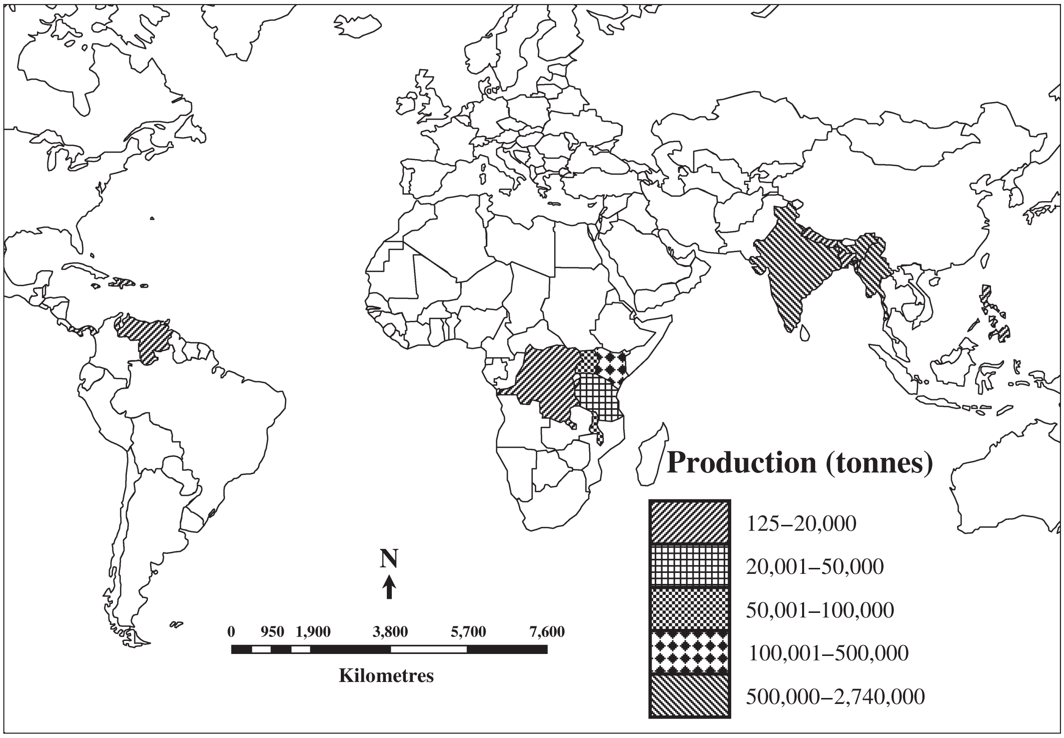

Figure 1. World pigeonpea production.
Source: FAOSTAT (2007).

Africa to become railway workers and storekeepers (Hillocks *et al.*, 2000). It thereafter moved up the Nile valley into West Africa and eventually to the Americas. The legume is increasingly becoming an important subsistence crop in the whole of Africa with production reported in more than 33 countries (Johansen *et al.*, 1993). Bulk production is however concentrated in Eastern Africa (Figure 1). Due to the subsistence nature of the crop, production area and figures from Africa are gross underestimates (Shanower *et al.*, 1999).

The current official Food and Agriculture Organisation (FAO) data record production from only six African countries (FAOSTAT, 2007). However, cultivation of pigeonpea has also been reported in Nigeria (Aiyeloja and Bello, 2006), Niger, Mali, Benin (Versteeg and Koudokpon, 1993), Ethiopia, Zimbabwe (Kamanga and Shamudzarira, 2001), Zambia (Boehringer and Caldwell, 1989), Botswana (Amarteifio *et al.*, 2002), and South Africa (Swart *et al.*, 2000). Pigeonpea in Africa is primarily a subsistence crop though some countries have been reported to export significant amounts (Shanower *et al.*, 1999). Production in this region contributes 9.3% of world production, which is very little compared to the 74% contribution from India alone (Figure 1).

Production trends seem to be increasing since the turn of the century, perhaps with the decreasing quantity of rainfall in the region. The increase in production is largely a result of area expansion rather than increase in yields (Jones *et al.*, 2002). The average yield of 718 Kg/ha (±171) and the maximum recorded yield (1087 Kg/ha) (FAOSTAT, 2007) over the last 16 years are far lower than its potential yield under research conditions (1500–2500 Kg/ha) (Mergeai *et al.*, 2001). Lack of quality seeds have left the poor farmers with no option but to grow local landraces that are low yielding and late maturing (Mergeai *et al.*, 2001). In total, about 483,701 ha (FAOSTAT, 2007) of African land are estimated to be under pigeonpea production although this figure is also probably an underestimate.

The legume is grown purely under rainfed conditions with varying temperatures, altitudes and latitudes (Silim *et al.*, 2006). It is reported to have a wide adaptability to different climates and soil (Troedson *et al.*, 1990) though it is mainly grown in regions of Africa that receive between 500–1000 mm of rain in two seasons (Nieuwolt, 1977). Traditional African pigeonpea production involves medium and late maturing cultivars either intercropped with cereals (Sakala *et al.*, 2000) or other short duration legumes and vegetables (Atachi and Machi, 2004).

3. The perfect drought-tolerant legume for nutrient-depleted soils of Africa

Drought poses one of the most important environmental constraints to plant survival and productivity (and hence food security) in the tropics (Speranza *et al.*, 2007). Pigeonpea remains one of the most drought-tolerant legumes (Valenzuela and Smith, 2002) and is often the only crop that gives some grain yield during dry spells when other legumes such as field beans will have wilted and perhaps dried up (Okiror, 1986). The ability of pigeonpea to withstand severe drought better than many legumes is attributed to its deep roots (Flower and Ludlow, 1987) and osmotic adjustment (OA) in the leaves (Subbarao *et al.*, 2000). The legume also maintains photosynthetic function during stress better compared to other drought-tolerant legumes such as cowpea (*Vigna unguiculata* L. Walp.) (Lopez *et al.*, 1987). Its unique polycarpic flowering habit further enables the crop to shed reproductive structures in response to stress (Mligo and Craufurd, 2005).

Being a smallholder's crop, pigeonpea does not receive significant purchased inputs in Africa. However, it has the ability to fix up to 235 Kg Nitrogen(N)/ha (Peoples *et al.*, 1995) and produces more N per unit area from plant biomass than many other legumes. Nitrogen is one of the most abundant elements on earth (Vance, 2001) yet the most limiting nutrient for increasing crop productivity (Wani *et al.*, 1995; Graham and Vance, 2003). The N-fixing ability of pigeonpea is desirable for environmentally sustainable agricultural production (Peoples *et al.*, 1995). A recent study (Myaka *et al.*, 2006) in Tanzania demonstrated that the yield of an unfertilized inter-cropped maize (*Zea mays*)-pigeonpea crop generally equalled the yield of a moderately fertilized sole maize yield.

While most legumes require inoculation to optimise their N-fixing ability, pigeonpea rarely needs inoculation because it can nodulate on *Rhizobium* that is naturally present in most soils (Faris, 1983). Even in the event that the legume is inoculated, the effectivity of vesicular-arbuscular mycorrhizae (VAM) fungi has been found to be highest in pigeonpea compared to cowpea and groundnut (*Arachis hypogea* L.) (Ahiabor and Hirata, 1994). VAM improves phosphorus (P) and zinc (Zn) nutrition as well as growth of pigeonpea especially in vertisols (Wellings *et al.*, 1991). Unlike in other legumes where growth has been reported to be limited by P (Ae *et al.*, 1990), pigeonpea is cited as one of the few crop species that can utilize iron (Fe)-bound P efficiently (Ae *et al.*, 1990; Subbarao *et al.*, 1997).

The long duration genotypes (Vesterager *et al.*, 2006) typically grown in Africa (Mergeai *et al.*, 2001) more efficiently utilize various sources of P (Ishikawa *et al.*, 2002) than their short duration counterparts. The critical requirement of P concentration for dry matter production in pigeonpea is low compared to other major protein crops like soybean (Adu-Gyamfi *et al.*, 1989) due to its efficient incorporation of external orthophosphates (Pi) into residue P (Adu-Gyamfi *et al.*, 1990). Compared with other crops, pigeonpea is also more efficient in P uptake when grown on low P soils containing Aluminium (Al) (Ae *et al.*, 1990). Salinity is a major problem under drought conditions and pigeonpea is relatively sensitive to salinity (Troedson *et al.*, 1990). Luckily, several wild relatives have been reported to exhibit wide variation in their salinity tolerance (Subbarao *et al.*, 1991) and therefore represent genetic resources for improvement of this trait in cultivated pigeonpea. Its high tolerance to acid soils has also been documented (Ogata *et al.*, 1988).

Pigeonpea offers the benefits of improving long-term soil quality and fertility when used as green manure (Onim *et al.*, 1990), cover crop (Bodner *et al.*, 2007), or alley crop (Mapa and Gunasena, 1995). The legume also has the ability to reduce the level of root-knot nematodes in the succeeding crop when used as green manure (Daniel and Ong, 1990). 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). Pigeonpea is used in alley cropping, and being perennial, it can be ratooned (Sharma *et al.*, 1978) successfully for subsequent crops in no till production systems (Lal *et al.*, 1978).

Rotation farming and intercropping are common practices by small-scale farmers in Africa (Sakala *et al.*, 2000) and pigeonpea has been reported to be best suited for both. Other than transferring fixed N to the inter-planted crop, pigeonpea has the ability to bring minerals from deeper soil horizons to the surface also improving soil air circulation (Kumar Rao *et al.*, 1983) to the benefit of the accompanying crop. Pigeonpea's initial slow growth reduces competition for light, water and soil nutrients when intercropped (Dalal, 1974) thereby minimizing any negative impact on the main crop. Under rotation farming, the residual effect of N fixed by pigeonpea on a following cereal crop can be as much as 40Kg N/ha (Nene, 1987). There is also the potential of using pigeonpea in the control of *Striga* (*Striga* spp.) weed, which is a major problem in Africa. Rotation with pigeonpea in *Striga* infested soils of western Kenya showed pigeonpea as one of the most productive crops with a remarkable decrease of *Striga* populations in maize planted after pigeonpea (Oswald and Ransom, 2001).

4. Pigeonpea is highly nutritious

The high nutritive value of pigeonpea is perhaps the most important reason why it should find an important place among the smallholder poor farmers in Africa. Pigeonpea is wonderfully abundant in protein, making it an ideal supplement to traditional cereal-, banana- or tuber-based diets of most Africans which are generally protein-deficient. The protein content of commonly grown pigeonpea has been reported to range between 18–26% (Swaminathan and Jain, 1973) while up to 30% has been reported in other closely related *Cajanus* spp. (Reddy *et al.*, 1979). Researchers at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India have developed high protein lines (HPL) with up to 32.5% protein content and significantly higher sulphur-containing amino acids (cysteine and methionine) (Singh *et al.*, 1990; Saxena *et al.*, 2002). Pigeonpea is therefore a good source of amino acids (Elegbede, 1998).

Anti-nutritional factors such as protease (trypsin and chymotrypsin) inhibitors, amylase inhibitors and polyphenols, which are a known problem in most legumes, are less problematic in pigeonpea than soybean, peas (*Pisum sativum*) and field beans (Singh and Eggum, 1984; Singh, 1988; Faris and Singh, 1990). Within pigeonpea cultivars, anti-nutritional factors are mainly found among dark-seeded genotypes (Faris and Singh, 1990) that are typically grown in Asia. The native African pigeonpea types are largely cream or white seeded with relatively less anti-nutritional factors.

The supplementation of cereals with protein rich legumes is considered as one of the best solutions to protein-calorie malnutrition in the developing world (Chitra *et al.*, 1996). Pigeonpea flour has been tested and found to be suitable as a protein source for supplementing baked products such as bread, cookies and *chapatties* due to its high level of protein, iron (Fe) and P (Harinder *et al.*, 1999). It has therefore been recommended in school feeding programs and vulnerable sections of the populations in developing nations. The protein-rich seeds have also been incorporated into cassava flour to produce acceptable extruded products (Rampersad *et al.*, 2003).

Pigeonpea is a rich source of carbohydrates, minerals and vitamins. The seeds contain a range of 51.4–58.8% carbohydrates (Faris and Singh, 1990), 1.2–8.1% crude fibre and 0.6–3.8% lipids (Sinha, 1977). It is a good source of dietary minerals such as calcium (Ca), P, magnesium (Mg), Fe, sulphur (S) and potassium (K) (Sinha, 1977) and water soluble vitamins especially thiamine, riboflavin and niacin (Salunkhe *et al.*, 1986). Pigeonpea contains more minerals, ten times more fat, five times more vitamin A and three times more vitamin C than ordinary peas (Foodnet, 2002).

In Africa, pigeonpea seeds are mainly eaten green unlike in India, where dry dehulled split-pea (*dhal*) is most popular. Such green seeds are a richer source of Fe, Cu and Zn than the mature seed (Singh *et al.*, 1984) and have a greater edible portion (72% vs 53%), more protein, carbohydrates, fibre, fat, minerals and vitamins than *dhal* (Faris *et al.*, 1987). An estimated 30% of children under the age of five in sub-Saharan Africa are reportedly underweight due to deficiencies in energy and nutrients. Wide adoption of pigeonpea in Africa thus stands to play an important role in food security, balanced diet and alleviation of poverty.

5. Pigeonpea can be used in several diverse ways

As human food, pigeonpea seeds can be used in almost any imaginative form. The green pods and seeds are the most utilized form in Africa though dry seeds are increasingly gaining popularity. In Nigeria, for example, the dry seeds are cooked whole until tender then mixed with cooked yam, maize, dried cocoyam grits or freshly cooked cocoyam, sweet potatoes in addition to vegetables, palm oil, salt, pepper and other spices (Enwere, 1998). There are currently major efforts to promote the introduction of dehulling methods used in India in order to increase diversity of pigeonpea use in Africa (Agona and Muyinza, 2005). In many parts of Eastern Africa, *dhal* is becoming a popular meal. Some potential uses of pigeonpea for human consumption in Africa include the production of noodles (Singh *et al.*, 1989), *tempe* (Mugula and Lyimo, 2000) and other fermented products (Onofiok *et al.*, 1996).

Elsewhere, pigeonpea is used as a flour additive to other foods in soups and with rice (Centre for New Crops and Plants Products, 2002). 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). Millet/pigeonpea biscuits are reportedly highly nutritious and provide a cheaper alternative to wheat imports in Nigeria (Eneche, 1999). Although the medicinal value of pigeonpea in Africa has not been fully exploited, there seems to be great potential to that end. Pigeonpea leaves have been used to treat malaria (Aiyeloja and Bello, 2006) in Nigeria, while in Southern Africa, pigeonpea is currently one of the indigenous crops being promoted for potential medicinal use (Mander *et al.*, 1996).

Pigeonpea is also widely used as fodder and feed for livestock (Rao *et al.*, 2002). Its foliage is an excellent fodder with high nutritional value (Onim *et al.*, 1985). The seeds are used as animal feed (Wallis *et al.*, 1986) and its fodder has been demonstrated to increase the intake of low quality herbage resulting in high animal live weight (Karachi and Zengo, 1998). By-products of split and shrivelled seeds are used as livestock feed and as an inexpensive alternative to high cost animal feed sources such as bone meal and fish meal (Phatak *et al.*, 1993; Chisowa 2002). Pigeonpea seed has been recommended as an alternative to maize, soybean meal or groundnut cake in the diets of broilers (Amaefule and Obioha, 2001; Onu and Okongwu, 2006), pullet chicks (Amaefule and Obioha, 2005; Amaefule *et al.*, 2006) and layers (Agwunobi, 2000) in Nigeria.

Tall perennial pigeonpea are often used as live fences (Phatak *et al.*, 1993), windbreaks and in soil conservation in Africa. Ease of establishment and the simultaneous production of food makes perennial pigeonpea a special agro-forestry option in several parts of Africa (Kwesiga *et al.*, 2003), such as Zambia (Boehringer and Caldwell, 1989). These tall perennial pigeonpea types are also favoured for use as fuelwood, basket weaving, and roofing in African villages.

6. There is a considerable market for pigeonpea

A large market exists regionally and internationally for both whole and a range of processed pigeonpea products from Africa (Jones *et al.*, 2002). A study carried out by

ICRISAT (1999) reported that the demand for processed pigeonpea products on the local, regional and export markets in Asia, North America and Europe outstrips supply. Locally, pigeonpea is consumed as a vegetable (green pigeonpea) and this is estimated at about 10% of total production (Lo Monaco, 2003) in Kenya, Uganda, Tanzania, Malawi and Mozambique. Due to the high perishability of green pigeonpea, a large share of its production is consumed by the farm household or sold/shared within the village.

Domestic consumption of dry pigeonpea is negligible (Rusike and Dimes, 2006) in most African countries although Kenya has a significant domestic demand for *dhal* from the ethnic Asian communities and from a few local communities who use it during special occasions (Jones *et al.*, 2002). Dry pigeonpea is mostly exported (Rusike and Dimes, 2006). Kenya and Malawi both have a local industry for processing pigeonpea into *dhal.* Uganda also recently introduced three dehulling machines from Sri-Lanka (Agona and Muyinza, 2005) but processing is still small-scale. Since other countries in the region have no processing facilities, there is a lot of cross-border trade for whole and processed pigeonpea (Jones *et al.*, 2002). This is expected to increase among the East African community members as well as between Malawi and Mozambique.

Export markets are reportedly the key outlets for pigeonpea commercialization in Africa (Lo Monaco, 2003). India is by far dominating the international market but there is also demand in the European Union (EU), North America and the Middle East provided certain quality and quantity requirements are met (Kunde, 2000). Pigeonpea from Eastern and Southern Africa has been exported to India for at least three decades (Jones *et al.*, 2002). International market demands vary in terms of grain size and quality, for example, Indian millers prefer medium-grained varieties while their European counterparts go for large-sized grains. Even though Myanmar currently exports the highest quantity to India, production from Malawi and Tanzania has superior quality (Rusike and Dimes, 2006).

The well established dairy industry in some parts of Africa indicates a potential market for pigeonpea sales either as fodder or processed as animal feed. The possibility of marketing "organic pigeonpea" in the western world is another area that has not yet been ventured into (to the best of the author's knowledge), but which has a high chances of success. With support from the formal sector and better organization from the farmers' side, these marketing outlets can be exploited to boost pigeonpea production and upgrade it from an orphan to a commercial crop.

7. Constraints to pigeonpea production in Africa

Although pigeonpea breeding has been carried out in Eastern and Southern Africa for over two decades, its production has remained static (Souframanien *et al.*, 2003) over the same period. A major producer such as Malawi only manages an average yield of 450 Kg/ha, which is less than 25% of the potential yield. Although ICRISAT in collaboration with various national programs have developed improved varieties, farmers continue to grow traditional landraces due to ineffective seed distribution channels (Jones *et al.*, 2001). A study on the adoption of a modern variety in Kenya indicated that the demand for seed is higher than supply, meaning the deficit could be met by the formal sector (Jones *et al.*, 2000). However, there is little interest from seed companies to market pigeonpea seeds.

Rusike and Dimes (2006) cite marketing, institutional and policy failures as the major constraints to expanded production of African pigeonpea. Despite an effective market demand regionally and internationally, farmers remain very poor (Jones *et al.*, 2002). They lack access to market information, and their small scattered units of production (Agona and Muyinza, 2005) make it difficult to form valid associations that would help with collective bargaining (Rusike and Dimes, 2006). They therefore end up being price takers in a highly volatile market with the result that they get the least share of the final consumer prices.

The Indian market (Lo Monaco, 2003) is also becoming increasingly inaccessible for African exporters especially with the increasing exports from Myanmar. The higher transaction costs (Freeman and Jones, 2000), inferior quality from some producers, and lack of incentives to the African producers compared to their competitors are to blame. Furthermore, India can still import cheaper alternative pulses from developed countries (Jones *et al.*, 2002) including Australia, France and the USA. Although the market exists for the bold cream-coloured African pigeonpea in Europe, the quality standards are higher than the quality produced by most farmers (Freeman and Jones, 2000).

Poor production practices such as low plant densities, low soil fertility, insufficient weeding and insufficient/inappropriate use of fungicides and herbicides are other constraints. Insect pests feeding on flowers, pods and seeds are pigeonpea's single most important biotic constraint (Shanower *et al.*, 1999). Important field insect pests in this region include the pod boring lepidoptera (*Helicoverpa armigera* Hübner, *Maruca vitrata* Geyer and *Etiella zinkenella* Treitsche), pod sucking bugs (*Clavigralla tomentosicollis* Stål and *Clavigralla horrida* Germar) and podfly (*Melanagromyza chalcosoma* Spencer) (Minja *et al.*, 2000).

Pre-harvest infestation by bruchids (*Callosobruchus* spp.) and weevils (*Callosobruchus chinensis)* may cause only limited damage but have serious implications during storage (Silim Nahdy *et al.*, 1998; Silim Nahdy and Agona, 2000). Chemical treatment of these pests remains unaffordable to the smallholder farmers. Past experience in developing countries has also shown that pesticide use is inappropriate and unsafe (Shanower *et al.*, 1999), as well as highly damaging to the environment. Lack of proper storage facilities and inappropriate dehulling methods (Agona and Muyinza, 2005) worsen the storage pest problem by enhancing cross contamination.

Farmers are therefore forced to dispose of their grains soon after harvest, at which point the prices are very low (Jones *et al.*, 2002), or risk improper storage with devastating results. The locally preferred form, green pigeonpea, is highly perishable and so far, no farmer groups are known to have the technical facility for processing. There is also a growing export market for green pigeonpea (Onyango and Silim, 2000), which at the moment remains largely inaccessible to the smallholder farmers due to lack of proper handling and cold storage facilities.

Though pigeonpea diseases have been reported to be of minor importance in Africa in the past, recent surveys indicate that *Fusarium* wilt (*Fusarium udum* Butler), sterility mosaic disease (SMD), leaf spot (*Mycovellosiella cajani*) and to a lesser extent powdery mildew (*Leveillula taurica*) are diseases of economic concern (Hillocks *et al.*, 2000). *Fusarium* wilt, a soil borne disease, is especially prevalent in East Africa, where field losses of over 50% are common (Marley and Hillocks, 1996). Recently, this pathogen was reported to be spreading to Southern Africa reaching Mozambique (Gwata *et al.*, 2005).

8. Improvement of pigeonpea in Africa — current status and future prospects

Historically, desirable traits in pigeonpea have been selected for by farmers from landraces to suit their production systems and uses. The establishment of ICRISAT in 1972 created a new focus and research interest in pigeonpea improvement the world over. Together with the national programs in Africa, ICRISAT research on pigeonpea has since focused on early-maturity, or tolerance to biotic and abiotic stresses (Omanga *et al.*, 1995). There are now four distinct durations for pigeonpea varieties — extra short (mature in <100 days), short (100–120 days), medium (140–180 days) and long duration (>200 days) — each suited to a particular agro-ecosystem.[1] Specific African *Fusarium* wilt resistant lines have also been released (Gwata *et al.*, 2006). Over the last 10 years, more than 15 improved varieties have been developed for Africa but released in only a few countries. Unless unreported, most cultivation of pigeonpea in all other African countries involves the use of local landraces.

Although varieties released from these breeding programs have served the immediate need of farmers, major deficiencies still exist. There is an urgent call for national programs to focus on more organized breeding schemes that would enable development of cultivars that combine superior agronomic traits. Hybrid pigeonpea production (Tewari *et al.*, 2003), for example, would not only boost production, but also has the potential of involving the private sector. Eastern Africa is a secondary centre of diversity and hybridization of outstanding pure lines from this region with those from the Asian gene pool would result in considerable heterosis (Kimani, 2000).

Selection and identification of unique genotypes for different agronomic traits should continue and possibly extend to other regions of the continent. Farmers will need to be trained and involved in the selection and improvement of local varieties, as well as in promoting local seed production enterprises. Despite the limiting funds, classical breeding will need to be complemented with more sophisticated technologies to enhance efficient development of superior genotypes. Molecular marker technology (Wenzel, 2006) for example, promises to facilitate pigeonpea breeding by providing additional information on genetic diversity (Sharma *et al.*, 2003), predicting and identifying promising genotypes for cultivar development, improving the efficiency of breeding through marker-assisted selection (MAS) as well as molecular tagging of genes of interest.

Markets will need to be strengthened by involving both the formal and informal sector and by doing away with inappropriate regulations that hinder information flow and product development. Innovations that foster transparency in markets and institutions would further reduce transaction costs and improve the competitive position of smallholder farmers and other market intermediaries (Freeman and Jones, 2000).

9. Conclusion

This paper has shown that pigeonpea is an important crop with great potential for success in Africa. While there is no single technological solution to the many problems facing Africa today, increased production of a crop such as pigeonpea can do much towards relieving the suffering of millions in the future. The ability of pigeonpea to provide nutrient rich grain as well as increase soil nutrition should be considered and given research priority by respective stakeholders, as it could promote positive change in the lives of the small-scale poor farmers in Africa. There is also great potential in marketing organic pigeonpea since its production hardly requires any external inputs. As international markets are strengthened, local consumption of pigeonpea by Africans themselves must be encouraged by introducing its use in various forms and creating awareness of its nutritional benefits. Better breeding strategies complemented with modern state-of-the-art technologies will need to be employed to create superior genotypes suitable for African market and climatic conditions.

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