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# Evaluation of Pigeonpea Germplasm for Important Agronomic Traits in Southern Africa

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Additional information is available at the end of the chapter

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## 1. Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is an important grain legume that originated in the Indian sub-continent. It is now grown in many parts of the world including southern Africa particularly the region encompassing Kenya, Mozambique, Malawi and southern Tanzania (Høgh-Jensen *et al.*, 2007). This region is considered as a secondary centre of diversity for pigeonpea. The diversity associated with the pigeonpea germplasm from the region was documented widely (Songok *et al.*, 2010; Mligo and Craufurd 2005; Silim *et al.*, 2005).

The crop is grown for its multiple benefits mainly by smallholder growers and is useful in providing household food security in the region. The crop provides highly nutritious food for human consumption (Amarteifio *et al.*, 2002) and fixes considerable amounts of atmospheric nitrogen (Mapfumo *et al.*, 1999), thus improving soil fertility. Considerable quantities of the grain are traded within the region and in international markets particularly in the Indian sub-continent thus generating income for farmers. In addition, the stover is used for fuelwood and building material in some of the rural communities in the region (Silim *et al.*, 2005). Pigeonpea is also useful for controlling soil erosion in those areas prone to floods. The crop is also relatively tolerant to drought (Kumar *et al.*, 2011) thus making it suitable for cultivation in the semi-arid agro-ecological conditions prevalent in the region.

However, the average grain yield obtained by farmers in the region is generally low. In Tanzania, growers obtained 0.4 t/ha (Mligo and Myaka, 1994). This is partly because some of the smallholder pigeonpea growers cultivate largely unimproved landraces in mixed cropping systems (Fig. 1) partly because of the pressure of limited land for cultivating crops as well as the need to minimize the risk of crop failure. In addition, typical smallholder farmers are subsistent. Therefore, the broad objective of the study reported in this Chapter was to evaluate improved pigeonpea germplasm for agronomic performance across the region under rain-fed

field conditions. The specific objectives were to evaluate the germplasm for (i) sensitivity to photoperiod (ii) reaction to fusarium wilt (iii) reaction to insect pests and (iv) grain quality traits that are preferred by end-users.



**Figure 1.** A mixed cropping system consisting of pigeonpea (foreground), corn, sorghum and cowpea.

## 2. Pigeonpea types

A significant proportion of the smallholder farmers in the region largely grows traditional landraces. The landraces are characterized by late maturity, inherently low grain yield and dark seeds. However, the landraces are adapted to the local biotic and abiotic stresses. In particular, they are tolerant to severe droughts that occur in the region. On the other hand, the improved cultivars fall into either short-duration (SD) or medium-duration (MD) or long-duration (LD) types. This classification is based on the duration to maturity.

The short-duration types require about 90 days in order to mature. Therefore, they mature in the middle of the rainy season (in the region) when post-harvest handling is difficult. This renders the grain susceptible to spoilage by fungal diseases in particular. Consequently, this type of pigeonpea is poorly preferred by farmers in the region. On the other hand, medium duration (MD) types require about 150 days in order to attain maturity while long-duration (LD) types can require up to 240 days to mature fully. The majority of the landraces in the

region fall into this category. In general, late maturity in pigeonpea is attributed to sensitivity to day length (or photoperiod).

### 3. Production limitations

The production of pigeonpea in southern Africa is constrained by a range of abiotic and biotic factors. In particular, the crop is sensitive to photoperiod. The crop is also threatened by fusarium wilt (Gwata *et al.*, 2006; Kannaiyan *et al.*, 1989) and a broad range of insect pests (Minja, 1997; Minja *et al.*, 1996).

#### 3.1. Sensitivity to photoperiod (day length)

When the crop is grown in high latitude areas (>10° away from the equator), it is sensitive to photoperiod and temperature (Silim *et al.*, 2006) with plant height, vegetative biomass, phenology and grain yield being affected most (Whiteman *et al.*, 1985). Consequently, the delayed flowering and maturity lead to increased susceptibility to terminal drought that frequently occurs in southern Africa. Therefore, the cultivation of the late maturing LD types in the region pauses many challenges for the smallholder farmers. For instance, the winter season (which commences in June in the region) is associated with frost and generally low temperatures, to which pigeonpea is susceptible. Furthermore, after harvesting the main crops (during May), the small-holder farmers traditionally release their domestic livestock to graze freely (or unattended) in the fields. Such livestock interfere with late maturing crops that may still be growing in the fields. In addition, the delay in crop maturity may interfere with the timing of the succeeding crop. Therefore, this makes it difficult for farmers to develop consistent crop management practices and predictable cropping systems. In terms of marketing, the pigeonpea grain from the region is exported mainly to international markets in the Indian sub-continent where the prices are attractive before the glut in November. Therefore, the pigeonpea growers in southern Africa require pigeonpea types that can flower and mature early in order to have ample time for processing the grain for export to these distant markets when demand is at a peak.

#### 3.2. Susceptibility to fusarium wilt

Apart from sensitivity to photoperiod, pigeonpea is threatened by the fusarium wilt disease caused by the fungal pathogen *Fusarium udum* Butler (Kannaiyan *et al.*, 1989). It is the most devastating disease of pigeonpea in the region. The pathogen lives in the soil. Between crops, it survives in residual plant debris as mycelium and in all its spore forms (Agrios, 1997). The germ tube of the mycelium or spore penetrates seedlings through root tips, wounds or point of formation of lateral roots. The mycelium advances through the xylem causing vascular plugging followed by wilting of stems during flowering and pod-filling stages thus causing yield loss ranging from 30 to 100% (Reddy *et al.*, 1990). Once a field is infested, the pathogen may survive in the soil for several years. The fungal spores can be disseminated to new plants

by farm equipment, water, wind or animals, including humans. The use of cultivars resistant to the fungus is the most effective measure for controlling the disease.

### 3.3. Susceptibility to insect pests

Pigeonpea is susceptible to a wide range of insect pests that attack the crop at both the vegetative and reproductive stages (Minja *et al.*, 1999). Among the pests, the pod borer is regarded as a major threat to pigeonpea because of its destructiveness and extensive host range while pod sucking bugs and thrips can cause up to 78% (Dialoke *et al.*, 2010) and 47% (Rotimi and Iloba 2008) yield loss respectively.

Currently, the production area of this pigeonpea is expanding to non-traditional areas such as the semi-arid belt of the Limpopo River Basin (LRB) in southern Africa. However, the occurrence of insect species of economic importance in pigeonpea has not been investigated in the LRB.

### 3.4. End-use qualities

In southern Africa, pigeonpea is consumed mainly as whole fresh green peas. Usually, these fresh beans are boiled after or before shelling. In general, end-users in the region prefer large (100-grain weight =  $15.0 \pm 2.0$  g). Where the dry peas are utilized for human consumption, the end-users prefer the large white (cream) bold types that are easy to cook. In contrast, landraces originating from central Africa possess small hard seeds which have no commercial value in the regional markets since end-users prefer large-seeded types that are easier to cook. Favourable end-use qualities also influence cultivar adoption by growers. Therefore, grain color and size measurements were evaluated as integral components of the field studies reported in this Chapter.

## 4. Field evaluation studies

Pigeonpea germplasm was evaluated under rain-fed field conditions across the region. The specific genotypes were selected on the basis of preliminary information obtained from previous large-scale screening of many pigeonpea genotypes in the field (Mogashoa and Gwata 2009), seed availability as well as local farmer-preferences in the area represented by each testing location.

### 4.1. Evaluation for photoperiod sensitivity

The major objective of this study was to evaluate pigeonpea germplasm that was developed previously for production in high latitude areas ( $>10^\circ$  away from the equator) for adaptation as measured by the agronomic performance. The evaluation was conducted under rain-fed conditions initially at Chitedze (Malawi;  $14^\circ$  S) and subsequently at Thohoyandou (South Africa,  $22^\circ$  S) testing locations.

#### 4.1.1. Field evaluation at Chitedze

Six elite genotypes and two check cultivars were used in the study conducted at Chitedze. The experiment was arranged as a randomized complete block design replicated three times. At the beginning of the cropping season (in early December), seed of each genotype was sown manually in field plots, each measuring 5.0 m in length and containing five rows spaced at 1.2 m apart with 0.5 m between plants in the row. Standard agronomic management recommendations for pigeonpea were followed throughout the season. In each season, no chemical fertilizers were applied on the crop in consistency with other similar studies (Silim *et al.*, 2006). In particular, inorganic N fertilizer was deemed unnecessary for the crop since pigeonpea can symbiotically fix about 40-160 kg/ha of N per season (Mapfumo *et al.*, 1999). Pigeonpea is also able to access forms of phosphorus that are normally poorly available in the soil (Ae *et al.*, 1990). This is achieved through the presence of piscidic acid exudates that solubilize phosphorus in the rhizosphere (Ae *et al.*, 1990).

During the evaluation, four key indicators for agronomic performance namely the number of days to 50% flowering (50% DF), the number of days to 75% physiological maturity (75% DM), grain size as measured by 100-grain weight (100-GW) and grain yield were measured (Table 1). Statistical analysis of data sets using statistical analysis system (SAS) procedures (SAS Institute, 1989) was applied. Tukey's method (Ott, 1988) was applied to separate the trait means obtained for each respective set of the five genotypes.

Cultivar Code	Mean				
	50% DF (d)	75% DM (d)	Grain color	100-Grain Weight (g)	Grain Yield (t/ha)
01144/13	86 b	115 c	White	13.7 a	2.7 a
01160/15	112 a	167 a	White	14.4 a	2.4 a
01480/32	102 ab	166 a	White	13.8 a	3.0 a
01162/21	102 ab	163 ab	White	14.9 a	2.6 a
01167/11	96 ab	166 a	White	15.5 a	2.2 a
01514/15	84 b	153 bc	White	14.4 a	2.9 a
Mean	97	161	-	14.0	2.7
Royes*	83 b	173 a	White	13.7 a	1.0 b
MtawaJuni**	119 a	172 a	Brown	16.8 a	1.1 b

Means in the same column followed by the same letter are not significantly different at the 0.05 probability level by Tukey's test. \*Commercial cultivar in Malawi; \*\*Unimproved traditional landrace popular in Malawi.

Source: Adapted from Gwata and Siambi, 2009.

**Table 1.** Agronomic performance of pigeonpea germplasm evaluated under field conditions at Chitedze (Malawi, 14°S).

The newly developed germplasm showed considerable improvement in terms of duration to flowering and maturity as well as yield potential. For instance, in order to attain 50% flowering, cultivar '01144/13' and the unimproved local landrace MtawaJuni required 86 d and 119 d respectively (Table 1). Cultivar '01514/15' matured significantly ( $P < 0.01$ ) earlier (153 d) than both the commercial cultivar Royes (173 d) and the landrace MtawaJuni (172 d). On average, the time to flowering and maturity among the new germplasm was reduced by 10 d in comparison with that for the unimproved landrace. The highest grain yield (3.0 t/ha) was observed for the cultivar '01480/32' compared with 1.0 t/ha that was observed for the check cultivar 'Royes' (Table 1). This indicated a three-fold higher potential for the new pigeonpea technologies in the region.

#### 4.1.2. Field evaluation at Thohoyandou

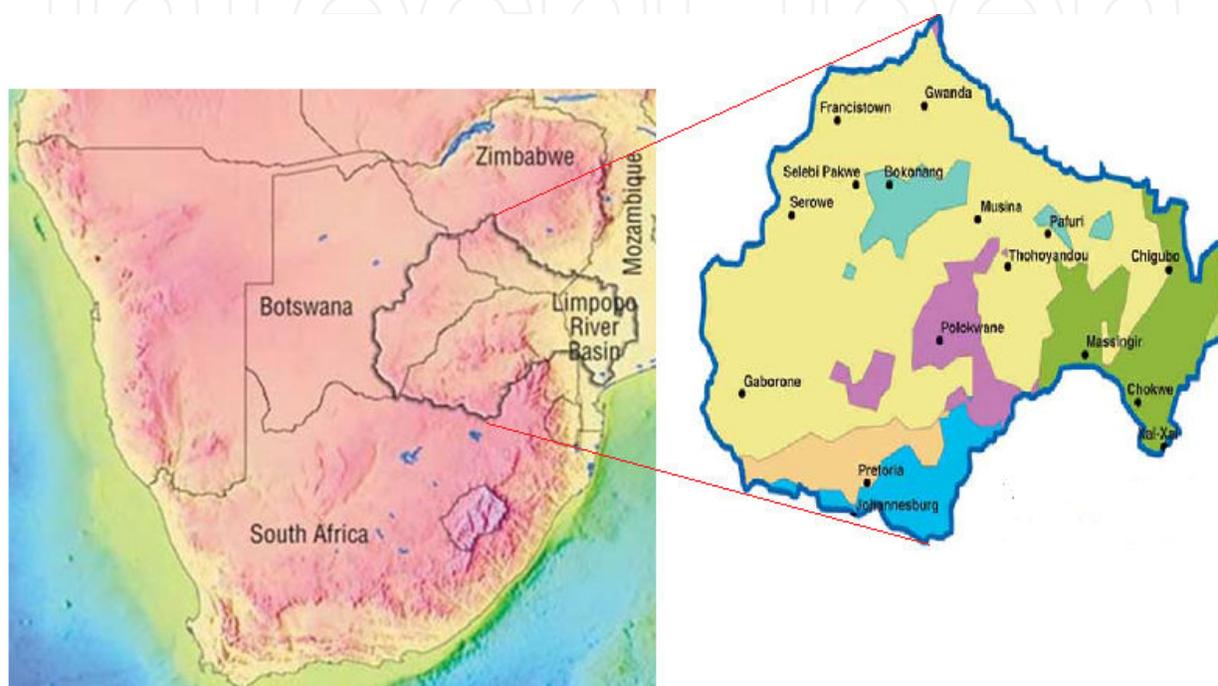
The germplasm was subsequently introduced to non-traditional areas in the semi-arid LRB (Fig. 2) as represented by the testing location at Thohoyandou (Limpopo, South Africa) which is a typical ecotope representing the agro-ecological conditions in the region (Mzezewa *et al.*, 2010). The soils at the location are predominantly deep (>150 cm), red and well drained clays with an apedal structure. The clay content is generally high (60 %) and soil reaction is acidic (pH 5.0).

The daily temperatures at the location vary from about 25°C to 40°C in summer and between approximately 12°C and 26°C in winter. Rainfall is highly seasonal with 95% occurring between October and March, often with a mid-season dry spell during critical periods of crop growth (FAO, 2009). Mid-season drought often leads to crop failure and low yields (Beukes *et al.*, 1999). This spatial and temporal variability in annual rainfall experienced in the area imposes several major challenges for smallholder farmers mainly because their crop choices must take into consideration the challenges imposed by moisture stress during the cropping season. In this regard, the use of drought tolerant crops such as pigeonpea as a means for achieving sustainable crop production in the area is merited.

Nineteen exotic MD genotypes of pigeonpea (obtained from the International Crops Research Institute for the Semi-Arid Tropics, Nairobi, Kenya) as well as one unimproved landrace obtained from Limpopo [designated Limpopo Local (LL)] were used in the study. The evaluation was conducted over two cropping seasons (2008/2009 and 2009/2010) at Thohoyandou (596 m a.s.l.; 22° 58'S, 30° 26'E) in Limpopo Province (South Africa) following the method described above (Section 4.1.1). In each season, the experiment was laid out as a 5x4 lattice design replicated three times. At physiological maturity, yield attributes and the grain yield were measured.

The results showed that at least five cultivars produced >1.5 t/ha with cultivar '01508/10' obtaining the highest (2.36 t/ha) grain yield at this testing location. Apart from the local check cultivar, 30% of the cultivars evaluated in the field trial produced <0.5 t/ha indicating that they were low yielding under the agro-ecological conditions at Thohoyandou (Limpopo). However, the average grain yield obtained from the trial was about 1.01 t/ha. The average grain yield among the best five performing cultivars (1.98 t/ha) represented at least 70.0% more productivity relative to the trial mean. In comparison with the local check, cultivar '01508/10'

produced almost ten-fold more grain yield indicating the potential increase in pigeonpea productivity in the area. In contrast, cultivar '01480/32' produced a low ( $< 0.6$  t/ha) grain yield compared to 3.0 t/ha that was observed for this cultivar at Chitedze. This was expected since grain yield is a quantitative trait that is influenced by the environment. Subsequently, partly because of their high yield potential, appropriate time to maturity and good grain attributes, these cultivars were adopted widely by growers in the region.



(Source: <http://www.fao.org/docrep/008/y5744e/y5744e05.htm>. Accessed 16 November, 2012).

**Figure 2.** The Limpopo River Basin in southern Africa.

#### 4.2. Evaluation for reaction to fusarium wilt

The objective of this study was to evaluate selected pigeonpea germplasm under high disease pressure across the southern Africa region in order to identify resistant cultivars that produce optimum yields under high disease pressure.

Selected local and exotic pigeonpea genotypes were evaluated in three countries in eastern and southern Africa (Table 2). The genotypes used at each testing location were selected on the basis of preliminary information obtained from previous large-scale screening of many pigeonpea genotypes in the field, seed availability as well as local farmer-preferences in the area. The evaluation of the germplasm was conducted in wilt-sick plots (Bayaa *et al.*, 1997) at testing locations where the disease pressure was considered to be high. At the beginning of the cropping season, seed of each genotype was sown in field plots using the same method as described above (see section 4.1.1).

At physiological maturity, the percent incidence of fusarium wilt (% FW) was determined. Initially, individual plants in each plot were scored for wilting (as a symptom of *F. udum*) followed by visual examination of the cross-section of the stem of each candidate plant in order to confirm the presence of a brown ring of discoloured xylem vessels. During harvesting, grain size as measured by 100-grain weight (100-GW) and grain yield were measured. Data sets were analyzed using standard analysis of variance procedures followed by mean separation as described above (see section 4.1.1).

Both the highest (92.0) and lowest (1.7) % FW scores were observed at Ngabu (Malawi) for '00068' and '00020', respectively (Table 2). The disease incidence in the local cultivar (Royes) was 90.2% compared with <5.0% for cultivar '00040'. However, the disease incidence in '00040' was consistently low (<20.0%) at all three locations. Grain yield was influenced by the location. Nevertheless, at least 1.5 t/ha of grain yield was obtained for '00040' compared with <1.0 t/ha for the susceptible genotype (Table 2). At Ilonga testing location, the unimproved traditional landrace (Ex-Loguba-1) attained a low grain yield (1.3 t/ha) as well as size (100-GW = 10.1 g) but the elite genotypes ('00020' and '00040') averaged 2.7 t/ha.

Cultivar Code	Type	Mean Percent Fusarium Wilt (%)	Mean Grain Yield (t/ha)		
			Kenya (Kiboko)	Malawi (Ngabu)	Tanzania (Ilonga)
00040	Improved, resistant	12.4	2.2 c	1.9 b	3.0 b
00020	Improved, moderately resistant	13.9	1.6 b	1.7 b	2.4 b
00068 (Check)	Improved, susceptible	90.1	0.6 a	0.1 a	0.1 a
Royes (Check)	Improved, susceptible	-	-	0.6 a	-
Ex-Loguba-1 (Check)	Unimproved, landrace	-	-	-	1.3 b

Means in the same column followed by the same letter are not significantly different at the 0.05 probability level by Tukey's test.

Source: Gwata *et al.*, 2006

**Table 2.** Performance of improved pigeonpea cultivars under high disease pressure in eastern and southern Africa.

The results of this study indicated a high level of wilt resistance in the elite pigeonpea germplasm particularly '00040'. The classification of this cultivar as resistant to fusarium wilt was consistent with approaches used in classifying resistance to the disease in other leguminous species. For instance, genotypes showing <10% (Halila and Strange, 1997) and <20% (Bayaa *et al.*, 1997) incidence of fusarium wilt were considered resistant in chickpea (*Cicer arietinum*) and lentil (*Lens culinaris*), respectively. Because of its ability to withstand the high

disease pressure, wide adaptability and high yield potential, '00040' was adopted widely by pigeonpea farmers in the region. Pigeonpea genotypes often exhibit differential host responses to *F. udum* suggesting that probably, at least two different pathogenic races of the disease exist in the region. In chickpea, Tekeoglu *et al.* (2000) reported lines with resistance to one race of fusarium wilt but susceptible to another race, which suggested that different resistance genes confer resistance to different races. Such lines could be useful as race differentials to facilitate identification of races based on host pathogen interactions. The disease resistance observed in this study could be useful as a good source of resistance in pigeonpea breeding programmes in the region.

### 4.3. Evaluation for insect pests

The objective of this study was to identify insect species that occur in pigeonpea and damage the crop particularly at the reproductive growth stage in the LRB. This information would be useful in designing more detailed investigations on the economic impact of such species on the crop. Twenty exotic pigeonpea genotypes were planted in a field experiment at Thohoyandou following the procedure described above (see section 4.1.1). In order to achieve optimum natural infestation, no pesticides or control measures were applied on the crop throughout the season.

Starting at the flower initiation stage through to 50% physiological maturity of the crop, random samples of above-ground insects were collected using the active insect sampling approach that utilizes a combination of scouting and the sweep net technique which has been used successfully in a variety of crops including soybean and cotton (Marston *et al.*, 1976; Spurgeon and Cooper, 2011). Sampling was performed weekly between 14.00 - 15.00 h when insect activity was at its peak. Sampled insects were collected into a specimen jar (15.0 cm in diameter x 25.0 cm) containing ethyl acetate. Individual specimens were identified to the species level in the laboratory using a pigeonpea pest identification handbook (Dialoke *et al.*, 2010; Night and Ogenga-Latigo, 1994). Identification to the species level is necessary since there is a possibility that species within a family and even genera can exhibit differential host plants and natural enemy complexes.

The study showed that a broad range of insect species injurious to pigeonpea was collected from the crop and identified (Table 3). The species included those that are known to be pests in pigeonpea such as blister beetles, pod suckers, flower thrips and the pod borer which is regarded as a serious threat to pigeonpea because of its destructiveness and extensive host range. The range of insects found in the study was in agreement with that reported from the surveys conducted in other parts of Africa confirming that a fairly common spectrum of insect pests occurs in the crop across the African sub-continent (Dialoke *et al.*, 2010; Minja *et al.*, 1999). In addition, most of the insect species identified in this study have been classified as pests of pigeonpea elsewhere (Minja, 2001; Shanower *et al.*, 1999; Rotimi and Iloba 2008; Yadava *et al.*, 1988). The insect damage on the crop was observed on leaves, flowers, pods and seeds of all the genotypes suggesting potentially high yield losses. In a recent study conducted on pigeonpea in Nigeria, a high (78% ) yield loss in pigeonpea caused by pod sucking bugs was reported (Dialoke *et al.*, 2010). Similarly, a 47% yield loss was attributed to flower thrips (Rotimi

and Iloba 2008). Among the coreids (*Clavigralla* spp.), at least four different species were identified in this study (Table 3). They are considered destructive largely because the adults and nymphs feed on the developing seed while damaged mature seeds turn dark and shrivelled, rendering them unacceptable for human consumption and cannot germinate (Materu, 1970). Similarly, the *H. armigera* identified in the study can lead to significant yield losses. There are no sources of complete resistance to the pod borer that can be manipulated through breeding to develop resistant cultivars. Nonetheless, limited resistance to the pod borer complex was reported recently (Kooner and Cheema, 2010). However, it remains unclear if cultivars possessing resistance to pod borers will be palatable for humans particularly in terms of taste.

Order	Family	Species (Common Name)
1. Coleoptera	Meloidae	(i) <i>Mylabris oculata</i> (CMR beetle)
		(i) <i>Mylabris tincta</i> (Blister beetle)
2. Diptera	Agromyzidae	(i) <i>Melanagromyza</i> spp. (Podfly)
3. Heteroptera	Coreidae	(i) <i>Clavigralla</i> spp. (Tip wilter)
		(ii) <i>Anoplocnemis curvipes</i> (Black tip wilter)
		(iii) <i>Petalocnemis</i> spp. (Tip wilter)
		(iv) <i>Acanthocoris</i> spp. (Tip wilter)
	Alydidae	(i) <i>Riptortus</i> spp. (Broad-headed bug)
	Pentatomidae	(i) <i>Nezara viridula</i> (Green stinkbug)
4. Homoptera	Aphididae	(i) <i>Aphis craccivora</i> (Black cowpea aphid)
	Cicadellidae	(ii) <i>Empoasca fabae</i> (Leaf hopper)
5. Hymenoptera	Megachilidae	(i) <i>Megachile</i> spp. (Leaf-cutter bees)
6. Lepidoptera	Noctuidae	(i) <i>Helicoverpa armigera</i> (Pod borer)
7. Orthoptera	Pyrgomorphidae	(i) <i>Zonocerus elegans</i> (Elegant grasshopper)
8. Thysanoptera	Thripidae	(i) <i>Megalorothrips</i> spp. (Flower thrips)

Source: Kunjuku and Gwata, 2011

**Table 3.** Range of insect species occurring in the pigeonpea crop grown at Thohoyandou in the Limpopo River Basin during the 2008/09 season.

These results suggested that effective insect pest control measures would be necessary for the crop in LRB since to date, there are no improved commercial cultivars of pigeonpea that possess complete resistance to the common insect pests of economic importance. Therefore, it is necessary to establish the pest status of the various insect species in order to apply effective management strategies that utilize a wide array of natural parasites and predators such as carabids, coccinellids, anthocorids and vespids. Botanical methods (using tephrosia or neem)

have been suggested but the use of broad-spectrum synthetic pyrethroids is discouraged since they can kill non-target organisms such as spiders. The effectiveness of insect pathogens such as the *Helicoverpa nuclear polyhedrosisvirus* which is regarded as relatively more friendly to the environment than chemical pesticides, is still debatable. In contrast, the use of chemical pesticides remains an effective control measure (Muthomi *et al.*, 2007).

The yield loss due to insect pests in the region can also be attributed to lack of knowledge on the part of growers in some countries. For instance, Minja *et al.*, (1999) observed that smallholder pigeonpea growers in some countries in the region did not control insect pests with conventional pesticides in the field. The majority (70% ) used wood ash and about 10% used pirimiphos-methyl (Actellic dust) to protect both the grain and seed. Moreover, according to Minja *et al.*, (1999) some farmers lacked sufficient training to distinguish between the damage caused by the various insect pest groups.

Because of the relative importance of different insect species due to location, flowering time and season, future studies could focus on quantifying the damage caused by each insect type in order to determine its pest status on the crop as well as the economic threshold. In southern Africa, economic thresholds for pigeonpea pests have not been established. In other pigeonpea production regions, one larva (or three eggs) per plant can be considered as the threshold level for applying insecticides (Singh and Oswalt 1992). Likely, determining these economic thresholds would contribute to the regional optimization of the pigeonpea value chain which encompasses input supply, policy makers, farmers, harvesting, storage, processing and marketing.

#### **4.4. Evaluation for end-use qualities**

The main end-use grain qualities of pigeonpea such as grain color and size, were measured in each of the field experiments conducted at Chitedze, Ilonga, Kiboko, Ngabu and Thohoyandou as described above. The results showed that the improved cultivars possessed large (100-grain weight = 14 g), white grain (Table 1) which are preferred by end-users in the region. These types are easier to cook compared to the small-seeded types. In contrast, most of the landraces in the region possess brown (or dark) as observed for MtawaJuni even though the size may be acceptable. Nonetheless, the grain color is relatively easy to change through conventional breeding approaches. These end-use qualities are also important in the adoption of new cultivars by growers in the region (Shiferaw *et al.*, 2007).

## **5. Conclusions**

There is potential for improving the depressed productivity of pigeonpea smallholder cropping systems in the region by using improved cultivars. The results from the various field evaluation studies demonstrated consistently that improved cultivars can produce several fold higher yields than unimproved landraces. In addition, wilt resistant cultivars showed that even under high disease pressure, they can attain optimum grain yields across the region. While inter-cropping is popular among smallholder growers, the crop can be managed better

particularly in terms of pest and weed control if it is planted as a sole crop. Ideally, the crop requires effective control of insect pests. Because of its multiple benefits, pigeonpea offers smallholder farmers in the region realistic opportunities for increasing the production of grain legumes.

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## References

- [1] Ae, N, Arihara, J, Okada, K, Yoshinara, T, & Johnson, C. (1990). Phosphorus uptake by pigeonpea and its role in cropping systems of the Indian subcontinent. *Sci.* , 248, 477-480.
- [2] Agrios, G. N. (1997). *Plant Pathology*. Orlando, Florida, Academic Press.
- [3] Amarteifio, J. O, Munthali, D. C, Karikari, S. K, & Morake, T. K. (2002). The composition of pigeonpeas [*Cajanus cajan* (L.) Millsp.] grown in Botswana. *Plant Foods Hum. Nutr.* , 57, 173-177.
- [4] Bayaa, B, Erskine, W, & Singh, M. (1997). Screening lentil for resistance to fusarium wilt: methodology and sources of resistance. *Euphytica* , 98, 69-74.
- [5] Beukes, D. J, Bennie, A. T. P, & Hensley, M. (1999). Optimization of soil water use in the dry crop production areas of South Africa. *In*: N. van Duivenbooden, M. Pala, C. Studer and C.L. Biielders (eds.) *Proceedings of the 1998 (Niger) (April 26-30 April) and 1999 (Jordan) (May 9-13) Workshops of the Optimizing Soil Water Use (OSWU) Consortium, entitled: Efficient Soil Water Use: The Key to Sustainable Crop Production in the Dry Areas of West Asia, and North and Sub-Saharan Africa*. Aleppo, Syria, ICARDA and Patancheru, India: ICRISAT. , 165-191.
- [6] Dialoke, S. A, Agu, C. M, Ojiako, F. O, Onweremadu, E, Onyishi, G. O, Ozor, N, Echezona, B. C, Ofor, M. O, Ibeawuchi, I. I, Chigbundu, I. N, Ngwuta, A. A, & Ugwoke, F. O. (2010). Survey of insect pests on pigeonpea in Nigeria. *J. SAT Agric. Res.* , 8, 1-8.
- [7] FAO ((2009). Climate and rainfall. <http://www.fao.org/wairdocs/ilri/x5524e/x5524e03.htm> Accessed 26 February 2009).

- [8] Gwata, E. T, & Siambi, M. (2009). Genetic enhancement of pigeonpea for latitude areas in southern Africa. *Afric. J. Biotechnol.* , 8, 4413-4417.
- [9] Gwata, E. T, Silim, S. N, & Mgonja, M. (2006). Impact of a new source of resistance to fusarium wilt in pigeonpea. *J. Phytopathol.* , 154, 62-64.
- [10] Gwata, E. T, & Silim, S. N. (2009). Utilization of landraces for the genetic enhancement of pigeonpea in eastern and southern Africa. *J. Food Agric. Environ.* , 7, 803-806.
- [11] Halila, M. H, & Strange, R. N. (1997). Screening of Kabuli chickpea germplasm for resistance to fusarium wilt. *Euphytica* , 96, 273-279.
- [12] Høgh-jensen, H, Myaka, F. A, Sakala, W. D, Kamalongo, D, Ngwira, A, Vesterager, J. M, Odgaard, R, & Adu-gyamfi, J. J. (2007). Yields and qualities of pigeonpea varieties grown under smallholder farmers' conditions in eastern and southern Africa. *Afric. J. Agric. Res.* , 2, 269-278.
- [13] Kannaiyan, J, Nene, Y. L, Reddy, M. V, Ryan, J. G, & Raju, T. N. (1984). Prevalence of pigeonpea diseases associated with crop losses in Asia, Africa and Americas. *Trop. Pest Manag.* , 30, 62-71.
- [14] Kooner, B. S, & Cheema, H. K. (2010). Evaluation of pigeon pea genotypes for resistance to the pod borer complex. *Indian J. Crop Sci.* , 1, 194-196.
- [15] Kumar, R. R, Karjol, K, & Naik, G. R. (2011). Variation of sensitivity to drought stress in pigeonpea (*Cajanus cajan* (L.) Millsp.) during seed germination and early seedling growth. *World J. Sci. Technol.* , 1, 11-18.
- [16] Kunjeku, E. C, & Gwata, E. T. (2011). A preliminary survey of insect species occurring at the stage in pigeonpea grown in Limpopo (South Africa). *J. Food, Agric. Environ.* , 9, 988-91.
- [17] Manyasa, E. O, Silim, S. N, Githiri, S. M, & Christiansen, J. L. (2008). Diversity in Tanzanian pigeonpea [*Cajanus cajan* (L.) Millsp.] landraces and their response to environments. *Gen. Res. Crop Evol.* , 55, 379-387.
- [18] Marston, N. L, Morgan, C. E, Thomas, G. D, & Ignoffo, C. M. (1976). Evaluation of four techniques for sampling soybean insects. *J. Kansas Entom. Soc.* , 49, 389-400.
- [19] Materu, M. E. A. (1970). Damage caused by *Acanthomiato mentosicollis* Stal and *A. horrida* Germar (Hemiptera: Coreidae). *East Afric. Agric. For. J.* , 35, 429-435.
- [20] Mapfumo, P, Giller, K. E, Mpeperekwi, S, & Mafongoya, P. L. (1999). Dinitrogen fixation by pigeonpea of different maturity types on granitic sandy soils in Zimbabwe. *Symbiosis* , 27, 305-318.
- [21] Minja, E. M, Shanower, T. G, Songa, J. M, Ongaro, J. M, Mviha, P, Myaka, F. A, & Okurut-akol, H. (1996). Pigeonpea seed damage from insect pests in farmers fields in Kenya, Malawi, Tanzania and Uganda. *Int. Chickpea Pigeonpea Newsl.* , 3, 97-98.

- [22] Minja, E. M. (2001). Yield losses due to field pests and integrated pest management strategies for pigeonpea- a synthesis. In: S.N. Silim, G. Mergeai, and P.M. Kimani, (eds). Proceedings of the Regional Workshop on Status and Potential of Pigeonpea in Eastern and Southern Africa 2000, Nairobi, Kenya. , 48-54.
- [23] Minja, E. M, Shanower, T. G, Silim, S. N, & Singh, L. (1999). Evaluation of pigeonpea pod borer and pod fly tolerant lines at Kabete and Kiboko in Kenya. *Afric. Crop Sci. J.*, 7, 71-79.
- [24] Minja, E. M, Shanower, T. G, Songa, J. M, Ongaro, J. M, Mviha, P, Myaka, F. A, & Okurut-akol, H. (1996). Pigeonpea seed damage from insect pests in farmers fields in Kenya, Malawi, Tanzania and Uganda. *Int. Chickpea Pigeonpea Newsl.*, 3, 97-98.
- [25] Minja, E. M. (1997). Insects of pigeonpea in Kenya, Malawi, Tanzania and Uganda and grain yield losses in Kenya: a consultant's report, Bulawayo, Zimbabwe: ICRI-SAT, , 65.
- [26] Mligo, J. K, & Myaka, F. A. (1994). Progress of pigeonpea research in Tanzania. In: S.N. Silim, S. Tuwafe and S. Laxman. (eds), Improvement of pigeonpea in Eastern and Southern Africa. Annual Research Planning Meeting. Bulawayo, Zimbabwe. , 51-58.
- [27] Mligo, . . (2005). Adaptation and yield of pigeonpea in different environments in Tanzania. *Field Crops Res.* 94, 43-53.
- [28] Mogashoa, K. E, & Gwata, E. T. (2009). Preliminary indicators of adaptation of pigeon pea (*Cajanus cajan* (L.) Millsp.) to Limpopo (South Africa). In: Proc. Afr. Crop Sci. Soc. 2009 Conf., Cape Town, RSA, 141 p.
- [29] Muthomi, J. W, Otieno, P. E, Cheminingwa, G. N, & Nderitu, J. H. (2007). Effect of chemical spray on pests and yield of food grain legumes. *Afr. Crop Sci. J.* , 8, 981-986.
- [30] Mzezewa, J, Misi, T, & Van Rensburg, L. D. (2010). Characterisation of rainfall at a semi-arid ecotope in the Limpopo Province (South Africa) and its implications for sustainable crop production. *Water SA* , 36, 19-26.
- [31] Night, G, & Ogenga-latigo, M. W. (1994). Range and occurrence of pigeonpea pests in central Uganda. *Afr. Crop Sci. J.* , 2, 105-109.
- [32] Ott, R. L. An Introduction to Statistical Methods and Data Analysis. California, Duxbury Press, (1988).
- [33] Reddy, M. V, Nene, Y. L, & Kannaiyan, J. (1990). Pigeonpea lines resistant to wilt in Kenya and Malawi. *Int. Pigeonpea Newsl.* , 12, 25-26.
- [34] Rotimi, J, & Iloba, B. N. (2008). Assessment of yield losses in tall varieties of pigeonpeas due to the flower thrips, *Megalurothrips sjostedti* Trybom. (Thysanoptera: Thripidae) *Biosci. Res. Comm.* , 20, 305-308.
- [35] SAS Institute SAS user's Guide: Statistics. Cary, NC, SAS Institute, (1989).

- [36] Shanower, T. G, Romeis, J, & Minja, E. M. (1999). Insect pests of pigeonpea and their management. *Annual Rev. Entomol.* , 44, 77-96.
- [37] Silim, S. N, Coe, R, Omanga, P. A, & Gwata, E. T. (2006). The response of pigeonpea genotypes of different duration types to variation in temperature and photoperiod under field conditions in Kenya. *J. Food. Agric. Envir.* , 4, 209-214.
- [38] Silim, S. N, Bramel, P. J, Akonaay, H. B, Mligo, J. K, & Christiansen, J. L. (2005). Cropping systems, uses, and primary *in situ* characterization of Tanzanian pigeonpea (*Cajanus cajan* (L.) Millsp.) landraces. *Genet. Res. Crop Evol.* , 52, 645-654.
- [39] Singh, F, & Oswalt, D. L. (1992). Insect pests of pigeonpea. In: Pest management Skills Development Series ICRISAT, Patancheru, India. (12), 6-20.
- [40] Songok, S, Ferguson, M, Muigai, A. W, & Silim, S. (2010). Genetic diversity in pigeonpea [*Cajanus cajan* (L.) Millsp.] landraces as revealed by simple sequence repeat markers. *Afric. J. Biotechnol.* , 9, 3231-3241.
- [41] Spurgeon, D. W, & Cooper, W R. (2011). Among-sampler variation in sweep net samples of adult *Lygushesperus* (Hemiptera: Miridae) in cotton. *J. Econ. Entomol.* , 104, 685-692.
- [42] Tekeoglu, M, Tullu, A, Kaiser, W. J, & Muehlbauer, F. J. (2000). Inheritance and linkage of two genes that confer resistance to fusarium wilt in chickpea. *Crop Sci.* , 40, 1247-1251.
- [43] Whiteman, E. S, Byth, D. E, & Wallis, E. S. (1985). Pigeonpea In: R.J. Summerfield, R.H. Ellis (eds). *Grain Legume Crops*. Collins, London. , 658-698.
- [44] Yadava, C. P, Lal, S. S, & Sachan, J. N. (1988). Assessment of incidence and crop losses due to pod-borers of pigeonpea (*Cajanus cajan*) of different maturity groups. *Indian J. Agric. Sci.* , 53, 216-218.

