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Survey of pigeonpea production systems, utilization and marketing in semi-arid lands of Kenya

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In order to assess the status of pigeonpea (*Cajanus cajan* (L.) Millsp.) production in Kenya, two surveys were carried out in Makueni and Mbeere Districts in areas representative of the main agro-ecological pigeonpea producing zone of the country (Mid-altitude ASAL). Participatory Rural Appraisal (PRA) approach was chosen as research method and was completed by household interviews based on a semi-structured questionnaire. The main points developed are the presentation of the different farming systems in which pigeonpea is considered as an important legume crop, the identification of the factors explaining pigeonpea production variations, the quantification of the use of improved varieties and improved production practices, and the analysis of the major patterns and trends in pigeonpea production, consumption and marketing.
Keywords. Pigeonpea, *Cajanus cajan*, farming system, participatory rural appraisal, Kenya.

Étude des systèmes de production, de l'utilisation et la commercialisation du pois cajan dans les régions semi arides du Kenya. Dans le but d'évaluer la situation de la production du pois cajan (*Cajanus cajan* (L.) Millsp.) au Kenya, deux enquêtes ont été réalisées au niveau des districts de Makueni et de Mbeere dans des sites représentatifs des terres semi arides d'altitude intermédiaire qui constituent la principale zone agro-écologique de production du pois cajan au Kenya. La technique du diagnostic participatif en milieu rural a été complétée par la réalisation d'enquêtes auprès des ménages ruraux grâce à l'utilisation d'un questionnaire semi-structuré. Les principaux points développés concernent la présentation des différents systèmes de production dans lesquels le pois cajan est considéré comme une culture importante, l'identification des facteurs pouvant expliquer les variations de production observées entre ces systèmes, la quantification de l'usage de variétés sélectionnées et de pratiques culturales améliorées et l'analyse de ses principaux modes de production, de consommation et de commercialisation.
Mots-clés. Pois cajan, *Cajanus cajan*, systèmes de production, enquête participative en milieu rural, Kenya.

1. INTRODUCTION

Pigeonpea (*Cajanus cajan* (L.) Willsp.) is the third most important food grain legume in Kenya after bean (*Phaseolus vulgaris* L.) and cowpea (*Vigna unguiculata* L.) (Kimani *et al.*, 1994). As a multiple purpose drought-tolerant crop it provides many benefits to resources-poor families: protein-rich grain, fuel, fodder, fencing material, improved soil fertility and control of soil erosion (Siambi *et al.*, 1992). With more than 150,000 ha under cultivation, mostly located in the dry regions of the Eastern part of the country, Kenya is the main producer of pigeonpea in East-Africa and the second highest producer in the world, after India (Johansen *et al.*, 1993). Farmers predominantly grow local pigeonpea types that take up to 11 months to mature in the field. These late maturing genotypes produce rather low yields (between 300 to 500 kg·ha^{-1}) and are generally intercropped with cereals (maize, sorghum, millet) and other food legumes (bean and cowpea) (Omanga *et al.*, 1996). Improved long (9 months), medium (6 months) and short (4 months) duration pigeonpea cultivars were developed and released in Kenya during the last twenty years by University of Nairobi (UoN), Kenyan Agricultural Research Institute (KARI) and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) (Kimani, 1991). Although these varieties showed high potential under research environment, their performances under farmer conditions are poorly documented.

The purpose of this work was to assess the situation of pigeonpea production in the Arid and Semi-Arid Lands (ASAL) of Kenya. To reach this objective, surveys were conducted in two districts which are representative of the main agro-ecological zone of Kenyan ASAL and where pigeonpea is important. During these surveys, data were collected to characterize the pigeonpea based farming systems on factors affecting pigeonpea production, to quantify the adoption of selected varieties and improved production practices and to analyse the major trends in pigeonpea production, consumption and marketing. The data gathered will permit to assess the impact of pigeonpea research in the country and to identify priorities in future investigation programs.

2. MATERIAL AND METHODS

After reviewing secondary information available and discussions with local extension staff of Ministry of Agriculture, Livestock development and Marketing (MOALM), two sub-locations, Thavu (Kathonzweni division) and Karaba (Mwea division), were selected respectively in Makueni and Mbeere districts to have an overview of the main pigeonpea based farming systems in Kenyan ASAL. Both districts are major pigeonpea production areas in Kenya and present agroclimatic conditions that reflect those of other main pigeonpea growing areas. These sites were also chosen for their adequacy to assess the reaction of small farmers to improved pigeonpea varieties that were already released in the country. The surveys were subdivided into one week of Participatory Rural Appraisal (PRA) and one week of individual household interviews.

As other Rapid Rural Appraisal methods, PRA consists of a series of techniques for quick research of information that generate results of less apparent precision, but greater evidential value, than classic quantitative survey techniques (Chambers, 1992). It emphasizes the importance and relevance of situational local knowledge, and the necessity to identify rightly key element than achieving spurious statistical accuracy. It is based on listening research and on a creative combination of iterative methods and verification, including "triangulation" of data from different sources using two different methods to view the same information. The PRA part of the surveys was conducted by a multi-disciplinary team including local technical extension officers and specialists of both genders from the following disciplines: agronomy, entomology, plant pathology, plant breeding, home economics, soil and water management. The main PRA techniques used were as follows: community sketch map, time line, time trends, transect, daily gender calendars, livelihood diagram, Venn diagrams, seasonal calendar, problem listing and analysis, problem ranking and opportunity assessment (Lelo *et al.*, 1995).

The second week of the surveys was dedicated to household interviews using a semi-structured questionnaire in order to complete the PRA data. In each targeted site, a single random sample of 48 farmers was selected in six villages (eight farmers per village). Household interviews were conducted by eight teams of one to two enumerators with at least one of them speaking the local language. The questionnaire contained 20 pages with predefined questions and answers. Time to fill in the questionnaire ranged from 50 minutes to 3 hours.

Data obtained during the two parts of the survey were compared and a synthesis of the information gathered is presented here.

3. RESULTS AND DISCUSSIONS

3.1. Agro-socio-economic characteristics of the target sites

Figure 1 shows the geographical location of Karaba and Thavu sub-locations. These sites are both located in midland semi-arid areas at about 1000 m altitude. They are characterized by very erratic bimodal rainfall systems. According to the site and the year, rainfall during the long rain (from March to May) ranges from 150 to 350 mm while rainfall during the short rain (from October to January) are more reliable and varies between 100 and 450 mm. Globally, Karaba sub-location receives more annual rainfall than Thavu (700 mm against 600 mm). Moreover, permanent water points (dams, water tanks, streams) are rather frequent in Karaba sub-location which make it less sensitive to water supply problems. Average temperature is high with maxima ranging from 30 to 35°C and minima varying from 17 to 21°C (FAO, 1984).

Soils in Thavu sub-division are mainly developed on quartzites and are excessively drained to well drained, shallow to very deep, dark reddish brown to yellowish brown loamy sand to sandy clay loam. Their fertility is rather poor (Republic of Kenya, 1996a) . In Karaba sub-location, soil fertility is poor to fair. Soils are mainly developed on Tertiary basic igneous rocks and are well drained, shallow to deep, dark reddish brown to dark brown soils (deep red sandy loam and black cotton soils). Texture is friable to firm (Republic of Kenya, 1996b). The climacic vegetation in both sites is a woody savannah.

Three ethnic groups are present in Karaba sub-division (Kikuyu, Kamba and Mbeere) while Thavu is populated only by Kambas (Republic of Kenya,

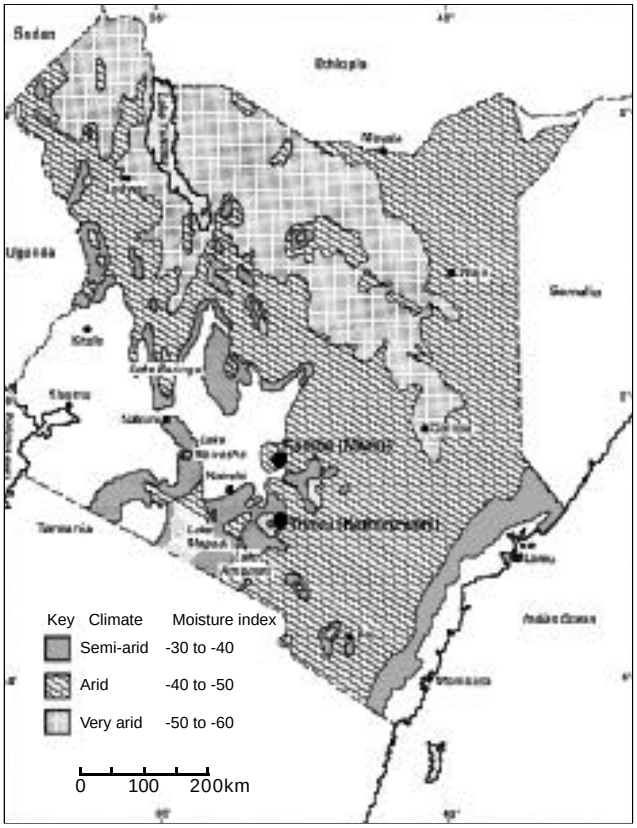

Figure 1. Location of Thavu (Kathonzweni) and Karaba (Mwea) sub-locations — *Localisation des villages de Thavu (Kathonzweni) et de Karaba (Mwea)* (Adapted from Rowland, 1993).

1996a; 1996b). Human settlement in both sites started in the early twenties. Population density is now higher in Karaba than in Thavu.

Karaba is located at 120 km from Nairobi near the Nairobi – Embu trunk road and is, therefore, easily accessible all year round. The roads linking Thavu to Nairobi – Mombasa trunk road and other commercial and manufacturing main focal points of the region are not all weather. Consequently, trade routes in Makueni district are often interrupted during the rainy seasons and it takes much longer to reach the main country markets from Thavu than from Karaba. Thavu belongs to the heart of the main pigeonpea producing district of Kenya while pigeonpea traditionally exists in Karaba but is less important.

In 1983, Karaba was one of the first areas of Kenya where the University of Nairobi medium duration pigeonpea cultivar NPP 670 was introduced (Kimani, 1991). Since then, no other new pigeonpea varieties were released in the area. In Thavu, NPP 670 variety was followed in the early nineties by KARI broad medium duration cultivar Kat 60/8 and in the mid nineties by ICRISAT broad short duration cultivar ICPL 87091.

3.2. Farm economy and characteristics

Main data concerning the farm population and economy characteristics are shown in **table 1** and **2**. Total farm population was slightly higher in Thavu than in Karaba. The average age of the farmers for both locations is 46.5 years with over 40 percent having attended at least 4 years school. Average family size was 8.6 people. Among these, only 4.4 persons, apart from the farmer, regularly work on the farm while children are going to school and some members of the family are employed out of the farm.

Average farm size differs greatly from one district to another. Average farm size in Thavu is much larger (about 10.4 ha with 4.8 ha under cultivation) than in Karaba (less than 4 ha with 2.6 ha under cultivation). However farmer fields tended to be consolidated in Karaba and more fragmented in Thavu. In Karaba, land distribution was organized by the colonial authorities which allocated four hectares to each settler family while in Thavu a progressive shifting of the traditional communal ownership to an individual ownership scheme occurred leading to a higher fragmentation of the fields. The average area available in each district is still relatively high but because of

Table 1. Farm population characteristics in the target sites — *Caractéristiques de la population des exploitations dans les deux zones cibles*.

	Sites	
	Thavu	**Karaba**
Average age of the head of household (year)	48	45
Total number of household members	9.5	8.8
Number of childrens at school	3.6	2.4
Available manpower (men and women)	5.2	5.7
Off-farm employed persons	1.1	1.2

Table 2. Land and main tools available in the investigated farms — *Terre et principaux outils disponibles dans les exploitations étudiées*.

	Sites	
	Thavu	**Karaba**
Total farm size (ha)	10.48	3.92
Land under cultivation (ha)	4.86	2.59
Total number of cattle heads	4.0	4.7
Total number of small ruminants	11.3	4.5
Average number of ox-plough	0.83	0.71
Average number of knapsack sprayer	0.35	0.45
Average number of wheel barrow	0.35	0.32

increasing land pressure marginal lands are beginning to be exploited in both sites.

The main income sources of interviewed farmers were livestock, off-farm work, sale of farm produce and occasionally land rentals. Each farmer in the two districts owns an average of 4 heads of cattle (including 1.5 oxen) and nine small ruminants. Makueni farmers own more livestock than those of Mbeere. Livestock is kept as a source of farm power for land preparation, weeding and transport, milk, meat, manure and cash. Livestock is considered as a financial security to provide cash savings in time of need. More than 70% of farmers in Makueni and Mbeere districts own an ox-plough for land preparation and weeding. Ox-carts are also quite common in Makueni (52%) and Mbeere districts (45%).

3.3. Crops and cropping systems

Data on the relative importance of main crops in terms of area and yield are presented in **table 3**. Pigeonpea, maize, *Phaseolus* bean, cowpea and sorghum are planted by almost every farmer in both districts. Greengram, cotton and dolichos are less common while millets are cultivated only by a few farmers in Thavu but not in Karaba. Maize is, in terms of land allocation and yield, the main crop in both sites and is mostly intercropped (> 90%) with the other crops. Pigeonpea constitutes the second most important crop in terms of land allocation in Thavu and the third, just after cotton, in Karaba. The proportion of land occupied by pigeonpea is about the same in both districts (about 10%).

Table 3. Land allocation, yield estimation and cropping system in the target sites — *Affectation des terres, estimation des rendements et systèmes de culture dans les deux zones cibles.*

	Number of Respondents		**Area** (ha)		**Pure-stand** (%)		**Yield** (kg.ha^{-1})	
	November[(1)]	April	November	April	November	April	November	April
Maize								
Thavu	47	48	3.20	2.95	2	2	756	445
Karaba	48	48	1.70	1.70	8	8	756	623
Sorghum								
Thavu	38	36	0.40	0.57	46	46	979	467
Karaba	36	38	0.16	0.16	14	14	778	890
Pearl millet								
Thavu	4	5	0.61	0.36	86	86	667	489
Karaba	0	0	0.00	0.00	0	0	0	0
Finger millet								
Thavu	20	10	0.5	0.5	40	40	578	534
Karaba	0	0	0.00	0.00	0	0	0	0
Bean								
Thavu	47	43	0.81	1.01	6	6	600	297
Karaba	46	44	0.49	0.49	2	2	289	267
Cowpea								
Thavu	46	47	0.53	0.49	2	2	400	378
Karaba	40	37	0.16	0.16	8	8	378	600
Pigeonpea								
Thavu	47	7	1.13	0.40	6	6	289	534
Karaba	47	12	0.40	0.49	26	26	578	378
Greengram								
Thavu	24	22	0.24	0.32	15	15	511	578
Karaba	23	22	0.40	0.49	5	5	289	289
Dolichos								
Thavu	8	4	0.20	0.16	29	29	445	133
Karaba	9	5	0.24	0.12	27	27	578	578
Cotton								
Thavu	20	5	0.53	0.20	47	47	959	1245
Karaba	12	1	0.53	0.81	66	66	722	988

(1) planting time

In Thavu, pigeonpea is the main cash crop of the region, followed by cotton, bean, cowpea, greengram and sorghum. In Karaba, green gram is the most important cash crop, followed in descending order by pigeonpea and dolichos.

Due to the better reliability of the precipitation during the short rainy season, planting is usually made in a much larger scale in November than in April.

About one third of the surveyed farmers are not self sufficient for the main staple crops (maize, cowpea, pigeonpea, etc) while another third produces enough surplus for sale. Farmers indicated that food shortage period occurs in these areas from December to February.

3.4. Characteristics of pigeonpea production

Table 4 shows land allocation, cropping systems and main production features for traditional and improved pigeonpea varieties in Thavu and Karaba. All farmers in Makueni district and almost all farmers in Mbeere district grow pigeonpea. Most of the farmers plant traditional varieties while improved varieties are less common. About 77% of farmers in Makueni and 31% in Mbeere plant at least one improved cultivar. In Thavu, about three farmers out of ten (31%) grow simultaneously traditional and improved early maturing pigeonpea varieties. This ratio increases to six to ten (57%) in Karaba. Farmers from Mbeere district seems thus to have successfully adopted the improved variety NPP670 released in the region in 1984 by the University of Nairobi. However, they continue to plant traditional cultivars. The level of adoption of improved varieties in Makueni district is lower but increasing, probably because they were exposed later, in the mid 1990's.

The proportion of pigeonpea in the total cropped area of a farm is usually less than 25%. The average area under local pigeonpea cultivars in Makueni and Mbeere districts was 0.97 and 0.3 ha respectively, with low variations between farms. The proportion of cultivated land planted with improved pigeonpea varieties is three times higher in Karaba (9%) than in Thavu (3%). In Makueni, local pigeonpea varieties are mainly planted in strip-cropping or in mixed-intercropping with cereals and other legumes. In Mbeere district, where the area grown with pigeonpea is lower, traditional varieties are predominantly planted in pure-stand (54%). Main cropping system for improved pigeonpea varieties is pure stand in Karaba (63%) while the proportion of monocrop (46%) and intercrop (54%) fields is more balanced in Thavu.

In both sites, spacing pattern in pure-stand for local and improved varieties varies from 0.7 to 0.9 m between rows and from 0.2 to 0.5 m within rows. In intercropped fields, the spatial arrangement varies greatly from a farm to another. Main intercropping patterns are one row of pigeonpea for two rows of maize in Thavu (50%) and Karaba (30%). The distance between two rows in the field usually ranges from 0.7 to 1 m while the distance between two plants within a row varies from 0.3 to 0.9 m in Mbeere and from 0.3 to 1.5 m in Makueni.

Yields calculated from farmer and on average pigeonpea producing plots are rather low (200 to 500 kg·ha^{-1}) compared to what can be obtained with improved varieties in the research stations (from 1500 to 2500 kg·ha^{-1}). According to these data, Mbeere farmers grow the two types of pigonpea cultivars more intensely (higher proportion of pure-stand plots and better yields) than in Makueni.

Table 4. Pigeonpea cropping systems and production features (November planting) in the target sites — *Systèmes de culture du pois cajan et caractéristiques de production (semis en novembre) dans les deux zones cibles.*

	Local cultivars		**Improved cultivars**	
	Thavu	**Karaba**	**Thavu**	**Karaba**
Respondents	43	37	13	35
Area (ha)	0.97	0.30	0.30	0.40
Cropping system				
Pure-stand	1 (2.3 %)	20 (54.1%)	6 (46.2%)	22 (62.9%)
Strip-cropping	22 (51.2%)	17 (45.9%)	4 (30.8%)	2 (5.7%)
Mixed intercrop	20 (46.5%)	0 (0.0%)	3 (23.1%)	11 (31.4%)
Yield (kg·ha^{-1})	222	356	400	534
Total production (kg)	215	107	120	214
Self sufficiency in dry seed				
Deficit	18 (43%)	20 (54%)	8 (61%)	14 (40%)
Self-sufficient	20 (46%)	11 (30%)	4 (31%)	6 (17%)
Market surplus	5 (11%)	6 (16%)	1 (8%)	15 (43%)

The low grain yield was partly because a significant part of the production is consumed before pod maturity, and very high losses due to pest incidence. In both districts, the farmers interviewed during the PRA estimated that, on an average, about 25% of the whole pigeonpea production were harvested before pod maturity.

Almost half of the farmers do not produce enough pigeonpea dry grain to cover the needs of their family. Significant marketable surplus are obtained mainly with improved pigeonpea varieties in Karaba (43%). In Thavu, only one farmer out of ten is able to sell a part of his pigeonpea grain on the market. During the PRA, farmer communities interviewed in Thavu and Karaba estimated that surplus sold on the market in normal years was about 60% of the total production.

Major reasons given for growing only local pigeonpea varieties are lack of seed of improved variety (55%) and lack of information about the availability of improved cultivars (35%).

Main preferred characteristics of local varieties are their high yield potential (34%), the availability of seed (27%) and low susceptibility to insect pests (23%). Early maturity (82%), high yield potential (48%), good marketing price (33%) and possibility to make two harvests a year (13%) are the main preferred characteristics of improved varieties.

In Thavu and Karaba, farmers usually use their own seeds or seeds purchased in the local market to grow traditional pigeonpea varieties. Some seeds are also obtained from neighbours or relatives. In Thavu, improved varieties are just being introduced and as such a minority of farmers (33%) used seeds produced from their own farm. The rest of the farmers got their seeds from neighbours (56%), local market (22%), extension service (11%) or from ICRISAT and KARI project (11%). In Karaba, most farmers purchased the seeds of NPP670 on the local market.

A higher proportion of Thavu farmers (77%) apply farm yard manure on pigeonpea than in Karaba (44%) but mineral fertilisers are not used.

Most important products of pigeonpea are dry grain, green pods and fodder. Secondary uses such as fuelwood and fencing material are not very common.

Table 5. Constraints ranking for local and improved pigeonpea varieties — *Classement des contraintes pour les variétés locales et améliorées*.

	Constraints	Rank	Frequency of mention
Local pigeonpea varieties			
Thavu sub-location	Drought	1	18 (38%)
	Pests	2	12 (25%)
	Wilt	3	8 (17%)
	Lack of seeds	4	1 (2%)
	Low yields	4	1 (2%)
	Low prices	4	1 (2%)
	Don't know		7 (15%)
Total			**48 (100%)**
Karaba sub-location	Pests	1	11 (27%)
	Drought	2	8 (20%)
	Wilt	3	6 (15%)
	Low prices	4	4 (10%)
	Low yields	5	2 (5%)
	Lack of seeds	6	1 (2%)
	Lack of capital	6	1 (2%)
	Late maturity	6	1 (2%)
	Termites	6	1 (2%)
	Lack of land	6	1 (2%)
	Don't know		5 (12%)
Total			**41 (100%)**
Improved pigeonpea varieties			
Thavu sub-location	Pests	1	4 (27%)
	Lack of seeds	2	2 (13%)
	Drought	3	1 (7%)
	Wilt	3	1 (7%)
	Don't know		7 (47%)
Total			**15 (100%)**
Karaba sub-location	Pests	1	10 (26%)
	Lack of seeds	2	5 (13%)
	Wilt	2	5 (13%)
	Drought	4	4 (10%)
	Low prices	5	2 (5%)
	Low soil fertility	6	1 (3%)
	Grain bitter taste	6	1 (3%)
	Blight	6	1 (3%)
	Lack of land	6	1 (3%)
	Don't know		9 (23%)
Total			**41 (100%)**

3.5. Major pigeonpea production constraints

Major production constraints of local and improved pigeonpea varieties were ranked by farmers in the two districts (**Table 5**). Drought and pest are ranked as the main production constraints of local pigeonpea cultivars. They are followed in both districts by *Fusarium* wilt. Improved varieties are very susceptible to insect pests which constitute, according to the farmers, their most important production constraint. The lack of good quality seed for planting is ranked as second limiting factor for the diffusion of improved varieties in both sites. *Fusarium* wilt and drought are the other main constraints in both districts. The already available short duration cultivars are appreciated for their ability to escape drought but are generally as sensitive to *Fusarium* wilt as the landraces.

Cercospora leafspot due to *Mycovellosiella cajani* was only mentioned as a constraint in Mbeere district where it causes in wet years greater damage than *Fusarium* wilt.

3.6. Pest incidence and control methods

According to the farmers, pest incidence is generally higher on improved varieties than on local cultivars (**Table 6**). Landraces have a more indeterminate growth habit which allow them to compensate partially the damage caused by insect pests. They also flower at the end of the long rainy season when pest pressure is lower. Insect pest control methods are more developed in Karaba where respectively 65% of local and 73% of improved pigeonpea varieties are grown than in Thavu with respective values of 40% and 79%.

Main reason given by farmers for not controlling insect field pests are: the high cost of chemicals (48%), the ignorance of control measures (40%), the lack of sprayers (19%) and the poor supply of insecticides. Despite these limitations, pesticides are rather commonly used in Karaba on local and improved varieties (by 53% and 76% of the farmers respectively) and in Thavu (by 35% and 67% of the farmers respectively). In both sites, the minority of farmers who do not have a sprayer at their disposal usually hire (24%) or borrow (28%) one from neighbours. Farmers usually spray insecticides one to three times per season. Very limited control methods include application of ashes, smoke and decoction of local plants.

3.7. Consumption, storage and marketing

In both Thavu and Karaba trends in consumption and marketing of pigeonpea were very similar; 25% of the local production is consumed as green pods, 15% is eaten as dry grain and the rest (about 60%) is sold.

The results of the household interviews indicated that 300 kg and 150 kg of dry grain were sold respectively per farm in Thavu and Karaba. These figures are not consistent with the other information collected in Thavu about the average dry grain production per farm (**Table 4**) and the level of pigeonpea self-sufficiency in this sub-location, and one can consider them as over estimated. The answers given in Karaba about pigeonpea marketing seem to be more reliable considering the importance of the near located Nairobi market.

Green pods are generally not sold in Thavu but a market exists for them in Karaba. After pod maturation, farmers prefer to sell dry grain on local markets. The two main reasons advanced to explain this attitude are: the better taste of green pods and the need to pay school fees at this period of the year.

A large majority of the households investigated (70%) purchased dry pigeonpea grains. The reminder were self-sufficient or prefer to buy substitutes in the market (bean, green gram, cowpea).

Most of the purchased pigeonpea was dry grain (93%) and a small proportion was green pods (7%). Main sources of dry grain are women in local market (65%), shopkeepers in town (40%) or neighbours (31%). Sources of green pods are mainly neighbours (60%) and local market (33%).

Pigeonpea green pods are the preferred legumes consumed in the two districts while common bean is preferred as dry grain for consumption.

Seed storage practices are given in **table 7**. Dry seeds are generally stored after shelling (86%). Only a minority of the farmers stores dry pods. About one half of the farmers select the seed they store (57% for local

Table 6. Field pest incidence and control methods— *Incidence des ravageurs et méthodes de contrôle*.

	Local pigeonpea cultivars		Improved pigeonpea cultivars	
	Thavu	**Karaba**	**Thavu**	**Karaba**
Respondents	48(100%)	48(100%)	48(100%)	48(100%)
Pest incidence				
None	2 (4%)	9 (19%)	0 (0%)	1 (3%)
Slight	23 (48%)	11 (23%)	6 (14%)	0 (0%)
High	18 (38%)	18 (37%)	26 (53%)	28 (53%)
Very high	5 (10%)	10 (21%)	16 (39%)	19 (39%)
Methods of control				
No control	29 (61%)	17 (35%)	13 (27%)	10 (21%)
Insect. spray	17 (35%)	25 (53%)	32 (67%)	37 (76%)
Ashes	1 (2%)	4 (8%)	3 (6%)	0 (0%)
Smoke	1 (2%)	1 (2%)	0 (0%)	0 (0%)
Decoctions*	0 (0%)	1 (2%)	0 (0%)	1 (3%)

* Indigenous technology knowledge

Table 7. Seed storage practices — *Modes de conservation des graines*.

	Local pigeonpea cultivars		Improved pigeonpea cultivars	
	Thavu	**Karaba**	**Thavu**	**Karaba**
Respondents	38	27	7	25
Storage form				
Pod	2 (5%)	4 (15%)	0 (0%)	4 (16%)
Grain	36 (95%)	22 (81%)	7 (100%)	20 (80%)
Both	0 (0%)	1 (4%)	0 (0%)	1 (4%)
Treatment method of the harvested grain				
Ash	11 (29%)	14 (52%)	0 (0%)	11 (44%)
Smoke	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Actellic	32 (84%)	12(44%)	6 (86%)	13 (52%)
Decoctions	1 (3%)	2 (8%)	0 (0%)	3 (12%)
No	1 (3%)	6 (22%)	1 (14%)	4 (16%)

varieties and 52% for improved varieties). Main selection criteria for local varieties include: large seed size (62%), high yield (46%), large pod size (43%), earliness (26%), seed colour (23%) insect pest resistance (22%) and resistance to *Fusarium* wilt (15%). The main selection criteria used for improved varieties are: high yield (61%), earliness (57%), large seed size (57%), large pod size (50%), seed colour (18%), insect pest resistance (11%) and wilt resistance (7%). Improved cultivars ICPL 89701 and KAT 60/8 do not meet the farmer preference for large cream seeds and their dry grain has a poor cookability which make them more difficult to market than landrace cultivars.

Most of the local pigeonpea producers (90%) treat their grain before storage (**Table 7**). In Thavu and Karaba the main methods of seed treatments consist in the application of: actellic (84% and 44% respectively), ashes (29 and 52% respectively) and local plant decoction (3% and 8% respectively). The preservation of improved variety seed is mainly based on the application of actellic (pyrimiphos-methyl 2%) powder (86% and 52% respectively). They also use ashes to a lesser extent (29% and 44% respectively) while local plant decoctions are only used in Karaba (12%).

Pigeonpea grain storage last usually less than three months in Thavu and from four to five months in Karaba. The dry grain production of improved varieties is generally sold just after harvest while local cultivar seeds can be marketed from August to December.

Marketing prices are higher in Mbeere district where they vary between 40 Kenyan shillings·kg^{-1} (during the harvest period of long duration varieties) to 100 Kenyan shillings·kg^{-1} (for short duration cultivars during food shortage period). In Makueni district, dry grain average price is about 35 KES·kg^{-1}.

The main market outlets for pigeonpea green pods and dry grain are presented in **table 8**. Most pigeonpea producers sell only a portion of their harvest. They usually eat a part of the production as green pod and sell the dry grain surplus. Green pods of early maturing varieties are available in April–July while long duration local cultivars produce green pods in August–September. The main outlets for pigeonpea green pods are local markets, shopkeepers and neighbours. Some brokers come regularly to Karaba to buy green which are transported and sold in Nairobi, mostly to people of Asian origin.

According to the weather and the site, dry grain of improved pigeonpea varieties are available from May to August. The dry grain production of traditional long duration varieties arrives on the market from August to November. Shopkeepers are the main market outlet for dry grain in Makueni district while in Mbeere district brokers or middlemen from Nairobi come directly to the farms to buy most of the dry grain. The rest is sold to neighbours or on local market.

Table 8. Market outlets for pigeonpea green pods and dry grain — *Débouchés des grains secs et des gousses vertes de pois cajan*.

	Local pigeonpea cultivars		**Improved pigeonpea cultivars**	
	Thavu	**Karaba**	**Thavu**	**Karaba**
Respondents	41	33	7	33
Market outlet for green pods				
Neighbours	0 (0%)	1 (3%)	1 (14%)	1 (3%)
Town brokers	0 (0%)	1 (3%)	0 (0%)	1 (3%)
Local market	0 (0%)	1 (3%)	0 (0%)	2 (6%)
Market outlet for dry grain				
Neighbours	0 (0%)	2 (6%)	0 (0%)	3 (9%)
Town brokers	1 (2%)	28 (85%)	1 (14%)	24 (73%)
Local market	6 (15%)	9 (3%)	1 (14%)	4 (12%)
Shop keepers	34 (83%)	0 (0%)	2 (28%)	0 (0%)
Local brokers	0 (0%)	0 (0%)	0 (0%)	2 (6%)

4. CONCLUSION

Two surveys carried out in representative areas of the main agro-ecological zone of Kenyan arid and semi arid lands (mid-altitude ASAL) have confirmed the importance of pigeonpea in the local farming systems. Pigeonpea is planted by almost every farmers in Mbeere and Makueni districts where traditional and improved varieties co-exist. Intercropping of long duration local varieties with cereal crops (generally maize) is the dominant production system in Makueni district while sole cropping of landraces and improved varieties tend to replace intercropping in Mbeere district where pigeonpea is more and more considered as a cash crop due to its good price on Nairobi markets. The closer the producers are from Nairobi, the better the market price and the more they can afford purchasing inputs and intensifying their production. As a consequence, although yields are still rather low, dry grain needs are well covered in Mbeere district where a significant part of the production is sold every year. At the same time only one farmer out of ten in Makueni district is able to sell a part of his/her dry grain production and more than the half of them are not able to meet their domestic requirements of pigeonpea dry grain.

In both districts, most important products of pigeonpea are dry grain, green pods and fodder.

Secondary uses such as fuelwood and fencing material are not very common. Pigeonpea green pods are preferred to the green pods of any other food legumes and about one quarter of the pigeonpea production is consumed at farm level before pod maturity.

A large gap exists between the production potential of improved pigeonpea varieties in research environment (1500 to 2500 kg·ha^{-1}) and the yield obtained at farm level (200 to 500 kg·ha^{-1}). Drought, pests and *Fusarium* wilt are the main production constraints of local pigeonpea cultivars.

The available improved varieties are NPP 670 (Kenya's first short duration variety developed by University of Nairobi and released in 1984), KAT 60/8 (developed later by the Kenya Agricultural Research Institute, Katumani) and ICPL 87091 (developed by ICRISAT in 1995). All of them are much more susceptible to insect pests than landraces due to their more determinate growth habit and because they start flowering at the same time when pest population is high. The existing short duration improved cultivars are generally as sensitive as traditional cultivars to *Fusarium* wilt and *Cercospora* leaf spot. Beside NPP 670 they do not meet adequately the quality criteria desired by local farmers. The seed size of ICPL 89701 and KAT60/8 is small (11–12 g/100 seeds) and as a result these varieties are more difficult to sell than the large cream coloured seeds produced by the landraces. Despite the limitations, the interviewed farmers have shown strong preference for early maturing pigeonpea cultivars which take 3 to 5 months instead of 8 to 10 months for the landraces.

Seed supply in the two districts is not well developed. Most farmers use their own seeds or seeds from a neighbour or purchased from local markets. Consequently, the lack of good quality seed is mentioned as the second most important constraint to the diffusion of improved pigeonpea varieties in the region. Despite their high price and low availability, pesticides are applied by a majority of farmers in both districts and constitute the main pest control method. However, most of the farmers do not know what active ingredient to use, when to spray and the dosage. These poor pest management practices together with drought and *Fusarium* wilt, are the main cause of the very low yields.

From these results we can conclude that, besides the marketing and seed distribution aspects, the investigations aiming at improving the production of pigeonpea in Kenya should concentrate on :

1) the development of new genotypes combining precocity, high productivity with resistance to wilt, *Cercospora* leafspot, large seed and indeterminate growth habit for both monocropping and intercropping;
2) the development of improved pest management methods that are adapted and acceptable to small farmers who eat large quantities of green pods;
3) the development of improved intercropping systems.

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