

COWPEA

Post-harvest Operations

 INPhO - Post-harvest Compendium



Food and Agriculture Organization
of the United Nations

COWPEA: Post-Harvest Operations

Organisation: Food and Agriculture Organization of the United Nations ([FAO](#)), Rome, Italy

Author: Carlos Gómez

Edited by AGST/FAO: Danilo Mejía, PhD, FAO (Technical),

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Preface

The present work provides information related to cowpea crops and mostly on cowpea post-harvest operation in developing countries. It is intended to be a reference for rural zones of West and Central Africa and East Asia where cowpea is widely grown. In South America, Brazil is the only country growing cowpea; in dry zones of Central America cowpea represents a high potential for cowpea culture.

Particularly in Nicaragua, with 73 percent of rural poverty and 53 percent of rural indigence cowpea crops (known as "alazín") are promoted by certain NGOs to improve soil and to prevent soil erosion. That is why cowpea crops could be an interesting alternative for grain and forage in dry zones of this country and Central America regions. (FAO/PESA NICARAGUA, 1999).

Cowpea is a legume that is extensively grown throughout sub-Saharan Africa. It is a subsistence crop, often intercropped with sorghum, maize and pearl millet. The grain provides valuable protein and the leaves are used as a nutritious vegetable. (IPM CRSP, 2000).

Millions of african farmers grow cowpea, some two hundred million africans consume cowpea, many, maybe a majority of these farmers are women. Cowpea grain, nutritious and inexpensive, serves as a source of cheap protein for both rural and urban consumers. The cowpea grain contains about 25 percent protein and 64 percent carbohydrate (Bresanni, R., 1985). Even the goats and the cattle benefit from cowpea, this genuinely african crop, for the hay left over after the grain is harvested as a high-value nutritious forage.(A BIOTECH, 2002).

Cowpea is an indigenous crop that has evolved from the native wild types and its genetic diversity is greater than that of any other crop in the dry african savannah. (IFAD, 2000). In semiarid zones of West and Central Africa, farmers traditionally cultivate two main types of cowpea: early maturing varieties grown for grain and late maturing varieties that are grown for fodder production. (Inaizumi, H. *et al.*, 1999)

There are three recognized specific groups of cultivated cowpeas. Two of these are grown in Australia with most varieties grown for grain, forage and green manure. The other type, the yardlong bean, is a minor vegetable. (Imrie, B., 2000)

In industrialized countries as the United States and Australia, varieties of cowpea types are cooked, canned or frozen to make them ready to serve. (Quinn, J. 1999). Currently, cowpea forms part of "good-luck meal southern" traditionally prepared for New Year Day celebration. (Bean/Cowpea CRSP West Africa, Social Science Report April-Sept., 1998).

As with many other grain crops grown in the semi-arid tropics, the cowpea post-production system in developing countries is an important constraint. In particular, weevils - post-harvest pests - can destroy a granary full of cowpea in two or three months. (A BIOTECH, 2002)

1. Introduction

Cowpea is one of the most ancient crops known to man. Its origin and domestication occurred in Africa near Ethiopia and subsequently was developed mainly in the farms of the African Savannah. (Duke, cited by UC SAREP). Nowadays it is a legume widely adapted and grown throughout the world (Summerfield *et al.*, cited by Aveling, T., 1999), however, Africa predominates in production as is shown in Fig. 1.

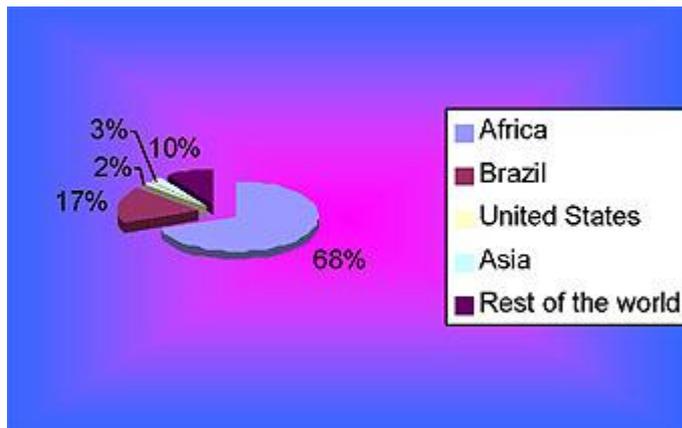


Fig. 1. Cowpea production throughout the world (dry grains).

Source: Compiled by the author from FAO (1990-2000) and other sources.

Cowpea is one of common names in English: cowpea, bachapin bean, black-eyed pea, southern, crowder pea, china pea and cowgram; in Afrikaans: akkerboon, swartbekboon, koertjie; in Zulu: isihlumaya; in Venda: munawa (plant), nawa (fruits) imbumba, indumba; in Shangaan: dinaba, munaoa, tinyawa. (Tindall, cited by Aveling, T. 1999). It is also known internationally as lubia, niebe coupe or frijol. However, they are all species *Vigna unguiculata* (L) Walp., which in older reference may be identified as *Vigna sinensis* (L) (Quinn, J., 1999)

It is an annual herb with a strong principal root and many spreading lateral roots in surface soil. The root system having large nodules is more extensive than those of soybean. (McLeod, cited by UC SAREP).

Bradyrhizobium spp are the specific symbiotic nodular bacteria. Growth forms vary and may be erect, trailing, climbing or bushy, usually indeterminate under favourable conditions. Leaves are alternate and trifoliate usually dark green. The first pair of them is simple and opposite. Stems are striate, smooth or slightly hairy, sometimes tinged with purple. (Aveling, T., 1999).

Flowers are self-pollinating and may be white, dirty yellow, pink, pale blue or purple in colour. They are arranged in raceme or intermediate inflorescences in alternate pairs. Flowers open in the early day and close at approximately midday, after blooming they wilt and collapse. Pollinating insect activities are beneficial in increasing the number of pod set, the number of seeds per pod or both; however, there are no recommendations for the use of pollinating insects on cowpeas. (McGregor, S. E., 1976). Fig. 2 illustrates a graphic design of a cowpea plant.



Fig. 2. Graphic design of a cowpea plant

Fruits are pods that vary in size, shape, colour and texture. They may be erect, crescent-shaped or coiled. Usually yellow when ripe, but may also be brown or purple in colour. There are usually 8-20 seeds per pod. Seeds vary considerably in size, shape and colour. They are relatively large, 2-12 mm long and weigh 5-30 g/100 seeds. Seed shape could be reniform or globular. The testa - the coat covering the grain - may be smooth or wrinkled; white, green, red, brown, black, speckled, blotched, eyed (the hilum - central line - is white surrounded by a dark ring) or mottled in colour. (Aveling, T., 1999). Fig. 3 shows a handful of cowpea grains.



Fig. 3. Cowpea grains

Its geographical range is wide, from Warm Temperature Thorn to Moist through Tropical Thorn to Wet Forest Life Zones. Cowpea cannot be grown for grain as far north as soybean because it is more sensitive to frost. (Duke, cited by UC SAREP). It grows best in hot areas and can produce a yield of one ton seed and five tons hay per hectare with as little as 300 mm of rainfall. Long taproot and mechanisms such as turning the leaves upwards to prevent them to become too hot and closing the stomata, give to cowpea an excellent drought tolerance. (Van Rij, N., 1999)

Cowpea is considered more tolerant to drought than soybean or mung bean because of its tendency to form a deep taproot. It has a competitive niche in sandy soils, does not tolerate excessively wet conditions, and should not be grown on poorly drained soils.

One of the most remarkable things about cowpea is that it thrives in dry environments; available cultivars produce a crop with as little as 300 mm of rainfall. This makes it the crop of choice for the Sahelian zone and the dry savannahs, though cultivars that flourish in the moist savannahs are available as well. (Bean/Cowpea CRSP West Africa Mission).

Varieties of cowpea are said to be tolerant of Aluminium and to be adapted of poor soil if Ph is between 5.5 and 6.5. On the whole, it is less tolerant of alkaline and salinity condition, but intolerant of excess amount of Boron. (Duke cited by UC SAREP). Cowpea crop often responds favourably to added Phosphorus, although there was non-significant increase in cowpea grain yield up to Nitrogen application rate of 30 kg/ha (Agbenin *et al*, cited by UC SAREP).

Length of growing season varies with type: 100 days in determinate type, 110 days in semi-determinate, 120 days in ranking type. The climate will also have an effect on the length of the growing season: the hotter the weather, the shorter the maturity period. (Van Rij, N., 1999) Fig. 4 shows a determinate type cowpea cultivated under irrigation.

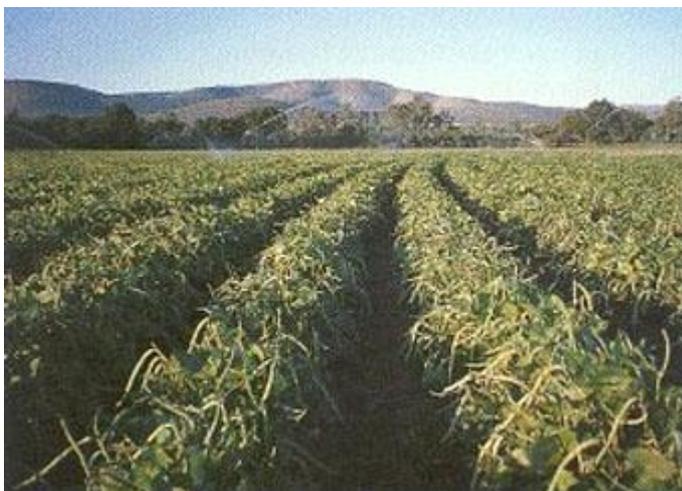


Fig. 4. A fine stand of an irrigated cowpea crop

1.1 Economic and Social impact

Cowpea is the most economically important indigenous african legume crop. (Langyntuo, A.S., *et al.*, 2003). Cowpeas are of vital importance to the livelihood of several millions of people in West and Central Africa. Rural families that make up the larger part of the population of these regions derive from its production, food, animal feed, alongside cash income. (**)

Food habits in West and Central Africa are mainly based on tuber crops (cassava, yam) and cereal (maize, rice, millet). Although they have a high nutritional value, grain legumes are a minor component of food diet. That is the reason why tentative efforts have been made to introduce soybean in african food habits and farmer activities, but with little success because

of its undesirable taste and cooking difficulty. Unlike soybean, cowpea is appreciated and different traditional African meals and seasonings are prepared from cowpea, among them homemade weaning foods. (Lambeth, C., 2002)

Fig. 5a. Farmers stack dry cowpea fodder in traditional structures for storage



Cowpea is a most versatile African crop: it feeds people, their livestock and the next crop. In the Americas, also known as "black-eyed peas", cowpea is a high protein food, and very popular in West Africa. The plant itself can be dried and stored until needed as fodder for livestock. As a nitrogen-fixing legume, cowpea improves soil fertility, and consequently helps to increase the yields of cereal crops when grown in rotation.



Fig. 5b. Farmers stack dry cowpea fodder in trees out of reach of wild antelopes

Cowpea is referred to as the "hungry-season crop" given that it is the first crop to be harvested before the cereal crops are ready. It is a crop that offers farmers great flexibility. They can choose to apply more inputs and pick more beans, or - if cash and inputs are scarce - they can pick fewer beans and allow the plant to produce more foliage. This means more fodder for livestock, so that lower bean yields are balanced by more livestock feed, which in turn translates into more meat and milk. This flexibility in use that makes cowpea an excellent crop under the challenging climatic conditions faced by African farmers. (Okike, I., 2000). Figs. 5a and 5b show two different ways to stack cowpea forage in difficult conditions of sub-Saharan region.

According to Blade et al cited by Aveling, T., 1999, ninety-eight percent of cowpea grown in Africa has been intercropped for a long time with other crops. It can be

also intercropped with large taller plant such as maize particularly in rainfall areas because of the exceptional shade tolerance. (Johnson cited by Aveling, T., 1999).

Traditionally in West and Central Africa, cowpea is grown on small farms, often intercropped with cereals such as millet and sorghum. The cowpea and cereal are usually planted in alternating rows, although recent research at IITA has shown that planting four rows of cowpea to two rows of cereal is more productive. The cereal is planted first, followed by the cowpea.

The fast growth and spreading habit of traditional cowpea varieties suppress weeds, and soil nitrogen is increased which improves cereal growth. The two crops are harvested at different times, distributing available labour force.



Fig. 6. Intercropping of sorghum with traditionally cowpea

Figs. 6 and 7 show the differences between traditional and improved cowpea varieties intercropped with sorghum.



Fig. 7. Intercropping of sorghum and IITA-improved cowpea variety.

Cowpea also contributes to the sustainability of cropping systems and soil fertility improvement on marginal lands through nitrogen fixation, provision of ground cover and plant residues, which minimize erosion and subsequent land deterioration. (**). The deep root systems of cowpea help to stabilize soil, and the ground cover

it provides preserves moisture; these traits are particularly important in the drier regions where moisture is always needed, soil is fragile and subject to erosion. (Bean/Cowpea CRSP West Africa Mission).

In Coachella Valley, California, in addition to decreasing total weed population, summer cowpea mulch improved the soil temperature regime by acting as buffer temperature. (Ngonagjio, M. *et al.*, 2000)

In Nigeria the major constraints to the adoption of dry season dual-purpose cowpea include insect attack both in the field and in storage, insufficient water, nematodes, lack of land, and lack of seed. The magnitude of these problems also varies with location. (Inaizumi, H., *et al.*, 1999). Fig. 8 shows a dual-purpose cowpea variety.



Fig. 8. IITA improved dual-purpose cowpea: grain and fodder

Cowpea is a crop well suited to Niger's climate and soils and well adapted to Niger's generally extensive agriculture. Strangely, cowpea is hardly consumed at all by Niger's population.

The protein in cowpea seed is rich in amino acids, lysine and tryptophan in comparison with cereal grain;

however, it is deficient in methionine and cystine in comparison with animal protein. Table 1 shows chemical composition of different parts of cowpea plant. (Davis, W. *et al.*, 1991)

Table 1. Chemical composition of cowpea (%)

	Seeds	Hay	Leaves
Carbohydrate	56-66		8
Protein	22-24		4.7
Water	11	18	85
Crude fibre	5.9-7.3	9.6	2
Ash	3.4-3.9	23.3	
Fat	1.3-1.5	11.3	0.3
Phosphorous	0.146	2.6	0.063
Calcium	0.104-0.076		0.256
Iron	0.005		0.005
Source: Kay, 1979; Tindall, 1983; Quass, 1995			

The comparative cost of protein in selected food items in Nigeria is shown in Table 2. This data reveals that soybean is the cheapest protein source compared with other protein-rich foods such as beef. Compared with other sources of plant protein, cowpea is - after soybean - more nutritious and the crop has a wider ecological adaptation. (Osho, S.M and Dashiell, K., 1997)

Table 2. Comparative cost of protein in selected food sources in Nigeria

Source	Commodity	Protein	Protein cost
	US\$/kg	%	US\$/kg
Pork	1.45	12	12.20
Beef	1.83	20	9.15
Egg	0.92	13	9.02
Poultry	1.28	20	6.40
Milk powder	4.51	36	12.54
Cowpea	0.43	20	2.13
Soybean	0.55	40	1.38
Source: Osho, S.M and Dashiell, K. 1997			

Production costs for cowpea vary depending on the technology used in particular varieties, fertilizer, tillage and pest management. Bean/Cowpea CRSP studies and other sources have established that labour often accounts for over 70 percent of the total cost of production. (Langyintuo, A.S., *et al.*, 2003). In Africa, cowpea production appears generally profitable, but return varies widely from place to place as it is shown in Table 3.

Table 3. Cowpea sample budgets in selected countries of West and Central Africa in 1999 (US\$ ha⁻¹)¹

	Benin	Burkina Faso	Côte d'Ivoire	Ghana	Senegal	Nigeria
Physical inputs ²	53.6	8.4	13.4	89.5	33.7	22.3
Labor inputs	148.3	43.9	111.5	89.4	79.8	90.2
Capital ³	9.9	1.0	12.5	57.0	2.8	3.0
Total Costs	211.8	53.3	137.4	235.9	116.2	115.6
Total revenue	564.8	180.0	192.0	523.2	237.0	158.5
Net profit	353.0	126.6	54.6	287.3	120.8	42.9
¹ Exchange rate in December, 1999: Ghana, 1US\$ =2500; Nigeria, 1US\$ = 82 Naira; CFS zone, 1US\$ =500 fcfa. ² Seed, fertilizer and insecticides costs ³ Charge or tractor use and depreciation of manual tools.						
Source: Langyintou, (1999, 2000, 2001) and Faye (2001)						

1.2 World Trade

The Americas

Of the developed countries, only the United States is a substantial producer and exporter. (Imrie, B., 2000). However, cowpea areas and production figures for the United States as a whole are not well known but considering the production during 1990s, it can be classified into three categories:

- about 21 000 hectares of cowpea were grown annually for commercial dry grain mainly in California and Texas with approximately 41 000 tonnes;
- about 11 000 hectares of cowpea were grown for frozen and canned southern peas, mainly in the south eastern part of the United States;
- about 30 000 hectares of cowpea were grown in home gardens mainly for fresh southern peas. (Hall and Frate, cited by Langyintou, A.S., et al., 2003)

The United States exports around 2 000 tons per year of very high quality cowpea. "In a shop anywhere in the world, if there is very large cowpea (> 25 grams per 100 grains) with white testa and very black eyes, it is probably a California product". (J. Lowenberg-DeBoer, personal communication, 2003)

The largest commercial application is for types most frequently marketed as black-eyed peas, which are harvested and then sold after cleaning and drying. In the south of the United States there is a substantial production of a variety of cowpea types, that after drying are sold to processors which in turn cook and soak the dried product, to make it ready to heat and serve. These products may be either canned or frozen and are referred to as "southern peas". Price for dried black-eyed purple hull peas fluctuates due to normal production and demand factors, but range from \$0.55-0.66 per kilogram for the canned market and \$0.55-0.88 per kilogram for the dry seed market (Quinn, J. 1999)

With crops such as dried black-eye or purple-eye peas, it is generally preferable to have a contract for growing the crop before planting. However, this market is fairly well established throughout the south and in California, so it may be possible to sell the crop successfully

without having a production contract. Growers are advised to identify their markets as early as possible, rather than waiting until after harvest. It may be possible to direct market dried black-eye, or purple-eye peas to a food broker or retailer in Indiana. (Quinn, J. 1999)

In the United States dry cowpea productions are likely to occur costs similar to the costs of dry edible bean production. Fresh green cowpea requires a specialized pea harvester, therefore, growers may need a contractual relationship with a processor/harvester for those services. Small areas of cowpea may be hand harvested and may find a niche in a specialty/gourmet market. Hand harvesting for a fresh green cowpea market will require considerably greater labour and management inputs.

Prospective growers need to investigate potential markets prior to planting. The distance to market, availability of labour and short-term storage along with vagaries of the market and of the grower's individual situation should be considered. (Davis, W. *et al.*, 1991).

Brazil is the second largest producer of cowpea in the world, but most of that product seems to be consumed within Brazil. Little cowpea is exported from Brazil. Cowpea is also produced in small quantities in several Latin American countries, but import/export data are not available. (J. Lowenberg-DeBoer, personal communication, 2003)

East Asia

In the 1990s Myanmar exported annually around 30 000 tons to India and Middle Eastern Countries and India imported annually some 15 000 to 20 000 tons of cowpea mainly from Myanmar. (J. Lowenberg-DeBoer, personal communication, 2003)

Africa

Since the FAO stopped publishing cowpea statistics in mid of 1980 s, there is no reliable source of international statistics on cowpea production or marketing. Many cowpea scientists need such statistics. Biological scientists need them to explain and justify their programs. Statistics are the basic elements for socio-economic research. (Bean/Cowpea CRSP West Africa, Social Science Report April-Sept., 1998)

In Africa, information on cowpea marketing and trade is lacking and data on cowpea production economics scattered, because marketing research has focused on export crops such as cocoa, coffee, cotton, groundnut and to a lesser extent cereals. (Van der Laan cited by Langyintou, A.S., *et al.*, 2003)

The two main sources of data are: FAO (FAO, 2000) complemented by the statistical service department of various countries, and information collected by the socioeconomics groups of the Bean/Cowpea CRSP. Production data provided by individual governments can be inconsistent because:

- many consider cowpea as a minor crop and cowpea data are aggregated with that of common bean;
- in some african countries, a hectare of millet-cowpea intercropped with millet is usually counted as one hectare of each crop in the national statistics;
- in other african countries, cowpea area statistics are adjusted to a "monocrop equivalent";
- data from Nigeria, Niger, Mali, Senegal, Mauritania and Burkina Faso are regularly submitted to the FAO but those from Ghana, Benin, Togo, Côte d'Ivoire and Cameroon are not. (Langyintou, A.S., *et al.*, 2003)

However, FAO estimates that 3.3 million tonnes of cowpea dry grain were produced worldwide in 2000. (IITA Research, 2001), but only a small proportion enters international trade.

More than 8 million hectares of cowpea are grown in West and Central Africa. Also it is known that Nigeria is the largest producer with 4 million hectares. Other producers are Niger, Mali, Burkina Faso and Senegal. (**).

The largest production is in Africa with Nigeria and Niger predominating, but Brazil, West India, Myanmar, Sri Lanka, Australia, the United States, Bosnia and Herzegovina all have significant production. (Quinn, J., 1999)

About 87 percent of that area is in Africa, 10 percent in the Americas and the rest in Europe and Asia. Nigeria is the largest producer accounting with 45 percent of the total, followed by Brazil that produces 17 percent on 1,15 million hectares annually. (Pereira *et al* cited by Langyintou, A.S., *et al.*, 2003). Around 3.7 millions tonnes of cowpea are produced annually on about 8.7 million hectares, throughout the world (Table 4).

Table 4. Supply and demand for cowpeas in selected countries of West and Central Africa (1990-1999)¹

	Harvested area (x 1000 ha)	Average yield (t ha ⁻¹)	Production (x 1000 t) (dry grain)	Consumption Kg per capita per year	Demand ² (x 1000 t)	Surplus/deficit ³ (x 1000 t)
Nigeria	3 425	0.494	1 691	18	2 160	-469
Niger	3 268	0.110	359	1.5	16	343
Mali	322	0.244	79	1.5	16	63
Burkina Faso	201	0.777	156	1.5	16	140
Togo	135	0.284	38	9	41	-3
Benin	100	0.635	64	9	55	9
Senegal	95	0.341	32	1.5	14	18
Ghana	85	0.663	57	9	169	-112
Mauritania	52	0.331	17	2.5	25	-8
Côte d'Ivoire	40	0.500	20	1.8	28	-8
Chad	44	0.489	21	1.5	11	10
Cameroon	38	0.827	31	1.5	14	17
Toral (Africa)	7 804	0.4745	2 565	-	2 565	0
United States ⁴	21	1.95	41			
Asia (97-01) ⁵	127	0.7412	94			
World	9 738 ⁶	-	3 731	-		-

¹ FAO 2000, PPMED (2000), SRID (1999), ONASA (1990-1999), DSID (1999), DSCN (2000), MAES/DISA (1990-2001), ^{International} Financial Statistics (1990-1999), and Ouedraogo et al, 1997.

² Demand includes consumption and demand for seed.

³ Negative figures imply demand exceeds supply

⁴ Hall and Frate, cited by Langyintou, A.S., et al., 2003 (only dry grains)

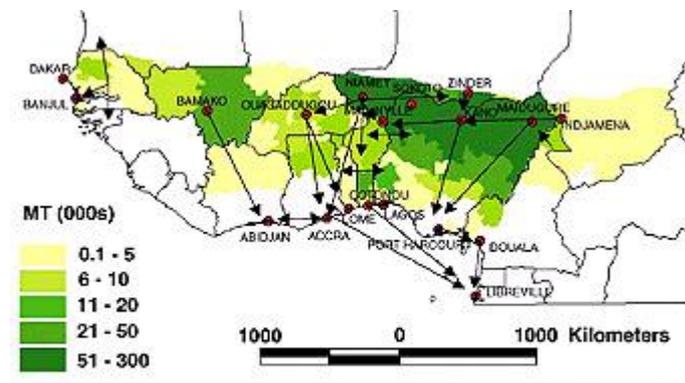
⁵ Record Copyright FAO 1990-2001

⁶ Total may differ from the sum of country estimates because of rounding. Over 570 000 hectares are cultivated in other parts of Africa.

A dense population and oil revenue in West Africa create an enormous effective demand of cowpea. Structured cowpea market in West Africa is part of an ancient trade that links the humid coastal zones with the semiarid interior. In the humid coastal areas, it is relatively easy to produce carbohydrate (e.g. cassava, maize, rice), but because of pests and diseases it is difficult to produce animal or vegetable protein.

On the contrary, lack of rainfall limits grain production in the interior, but it creates good condition for livestock, cowpeas and groundnuts. In the sub-Saharan zone, there is a well-developed network of village buyers who assemble small quantities from individual farmers into 100 kg bags and merchants who transport and store the bags. (Lowenberg-DeBoer, J. *et al.*, 2000)

As a result, in West Africa protein products traditionally move south to the humid area, while carbohydrates move north. Cowpea is actively traded from West to Central Africa because of the comparative advantages that drier areas of West Africa have in protein production. (Langyintuo, A.S, *et al.*, 2003). Fig. 9 illustrates distribution of cowpea production and movement in West and Central Africa.



ources : PPMED (2000); ONASA (1999); DSID (1999); DSCN (1999); MAES/DISA 1998); AAS (1997) ; Service des Statistique Agricoles, Burkina Faso (1999); FAO 2000)

Fig. 9. Distribution of cowpea production in West and Central Africa.

At least, 285 000 tons of cowpea are shipped among countries in the region each year. This is probably an underestimate because the official sources on which the estimate is based do not collect data on all flows. In 1998 Burkina Faso imported about 8 000 tons from Niger and exported a total of 5 500 tons to Togo, Côte d'Ivoire, Ghana and Benin.

Table 5. Estimated cowpea imports and exports among selected West African Countries, 1998/1999. (metric tonnes)¹

Exporter	Importer								
	Benin	Burkina Faso	Côte d'Ivoire	Gambia	Ghana	Mauritania	Nigeria	Togo	Gabon
Benin	-	-	-	-	-	-	NA	56	2
Burkina Faso	165	-	2 800	-	3 000	-		339	-
Cameroon	-	-	-	-	-	-	NA	-	33
Chad	-	-	-	-	-	-	NA	-	-
Cote d'Ivoire	-	-	-	-	NA	-	-	-	-
Ghana	-	-	-	-	-	-	-	10	-
Mali	-	-	1 400	-	-	-	-	-	-
Niger	NA ²	8 000	-	-	7 000	-	262 000	NA	-
Nigeria	NA	-	-		-	-	-	NA	12
Senegal	-	-	-	100	-	NA	-	-	-
Togo	-	-	-		334		-	-	20

¹ These figures may be regarded as underestimates
² There are shipments between the countries, but data not available.

Source: Langyintou (1999), DSID (1999) and SAFGRAD (1998)

It is estimated that Nigeria's average annual imports of 260 000 tons per year from Niger accounts for about 73 percent of Niger's surplus production. Cowpea trade between Nigeria and Benin is bilateral. Togo and Ghana, and Ghana and Benin trade bilaterally as well. Gabon depends on Cameroon, Togo, Benin and Nigeria for cowpea. Mauritania, Gambia and Guinea Bissau rely on Senegal. (Table 5).

Cowpea trade in West and Central Africa is clustered around Senegal and Nigeria. Senegal exports to its neighbours to the north and south. In contrast, Nigeria imports from its neighbours more than it exports.

Market structure in West and Central Africa

Grain marketing is organized in formal and informal places. Formal market places are designated locations managed by public organizations. Informal markets are not officially recognized and therefore, not subject to most government controls. An informal market may be a group of women who assemble every week in the centre of a village or who buy from farmers on roadsides. Farmers usually accept lower prices because they are not aware of the market prices or because they lack the time, money or means to transport cowpea grains to the market.

Cowpea passes from farmers to consumer through various market channels. Farmers usually sell their surpluses to rural assemblers, who in turn sell to urban wholesalers directly or through commission agents.

Large wholesalers hold large stocks for sale to retailers when prices are high enough to pay for cost of procurement, storage, handling and a margin for profit. They may also be involved

in the import and export of maize, groundnut and other grains. Small wholesalers handle smaller volumes and use markets in their homes neighbourhood and acquire the grains from wholesalers and commission agents for sale to consumers in smaller quantities.

In Nigeria, Ghana, Burkina Faso, Togo and Benin grain traders constitute themselves into commodity-based associations to promote better marketing conditions and discuss general guidelines for grain prices. Traders discuss grain pricing during association meetings but prices are fixed by individual traders. Factors influencing price setting are: grain quality, selling time, transport, storage, market tolls, taxes and taxes.

Prices

At harvest, traders tend to heap their measures; it is common to observe 5-10 percent more grains (on a standard bowl of 2.5 kg or on a 100 kg bag) than the average depending on the relationship between seller and buyer. This is often the reverse during those months of the year when prices are high. In Niger, Benin, Nigeria and Ghana, prices tend to rise above the average in February through September when grains are scarce.

The general price trend in Fig. 10 explains that price series tend to move together. However, the series from Niger, a major surplus producer is consistently lower than those of Benin, Nigeria and Ghana. Prices in Gabon are about 100 percent higher than those in Cameroon, which is the main source for the Gabonese market.

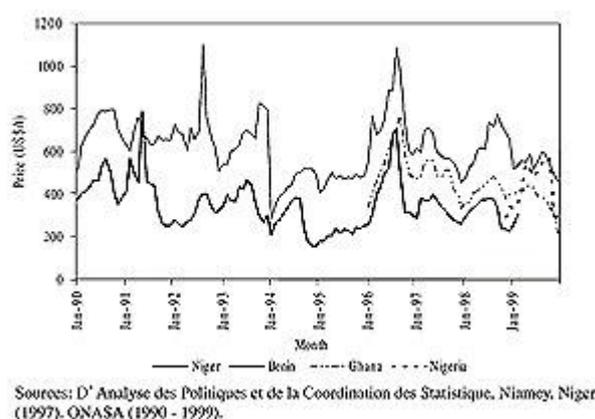


Fig. 10. Cowpea prices in selected West African countries

Marketing margins for cowpea

Cowpea trade is only possible if traders earn enough to cover their costs. In Ghana, about 70 percent of consumer expenditure for domestically produced cowpea goes to pay the cost of production and farmers' returns. Six and 4 percent contribute to transport cost and marketing cost respectively, while traders receive 20 percent as remuneration for their services (Table 6). (Langyintuo, A.S. *et al.*, 2003)

Table 6. Marketing margins for cowpea in selected countries in West and Central Africa (US\$ t⁻¹)

Country	Source of grain	Purchase price	Transport Cost ¹	Marketing Cost ²	Selling price	Marketing Margin ³	Traders' Profit margin
Ghana (Accra)	Tamale (Ghana)	31.6	2.8	1.7	44.8	13.2	8.8
	Ouagadougou (B.F.)	35.2	3.6	2.0	56.0	20.8	15.2
Benin (Cotonou)	Glazoue (Benin)	41.7	3.2	0.3	53.3	16.7	13.3
	Lome (Togo)	36.7	10.0	0.3	58.3	21.7	11.4
Gabon (Libreville)	Lome (Togo)	42.9	15.5	1.5	71.4	28.6	11.6
	Yaounde (Cameroon)	40.6	17.3	1.5	68.6	28.6	9.1
Côte d'Ivoire (Bouake)	Bouake (Côte d'Ivoire)	30.0	3.2	1.5	56.7	26.7	21.9
	Ouagadougou (B.F.)	25.0	4.4	7.2	56.7	31.7	20.1
Source: Langyintou (1999, 2000, 2001) and Faye (2001)							
¹ Transport cost includes truck charges, loading and off-loading charges							
² Marketing cost includes taxes, duties and market tolls.							
Marketing margin: selling prices - purchase price							

Nigeria

The production trend of cowpea in Nigeria shows a significant improvement with about 440 percent increase in area planted and 410 percent increase in yield from 1961 to 1995 (Ortiz, R. 1998). The development within the two decades is attributable to the significant advances made on cowpea seed improvement in the drylands by the IITA. (**).

Although Nigeria is the largest producer of cowpea in the world producing about 56 percent of the world production, it is also the largest consumer of cowpea in the world. (NAQA, 2001). That is the reason why substantial amounts of cowpea come to Nigeria from neighbouring countries especially Cameroon and Chad. A large proportion of cowpea from Burkina Faso and Mali are sold into Côte d'Ivoire. (Lowenberg-DeBoer, J. *et al.*, 2000) In Nigeria the organization of traders in Kano's Dawanau market - the largest cowpea market in the world - differs from other trading organizations. Traders are organized into a formal market union, "Dawanau Market Development Association" comprised of smaller associations such as Dawanau Farm Produce Merchant Association, Restaurant Owners Association, Transport Operator Associations, etc. The main role of the major association is to negotiate with the government over issues such as taxes and market infrastructure. (Langyintuo, A.S. *et al.*, 2003)

Niger

Development of cowpea production, which concerns 5 regions of Niger (Zinder, Maradi, Tahoua, Tilaberi and Dosso) is principally justified because of its good export market value. Cowpea is exported unfinished. The crop is however difficult to store, and requires insecticides to protect against weevils when stored more than 6 months. State intervention in the cowpea industry mainly concerns the marketing and sale of output, which at present is operated by specialty traders (about 30 principal players), and by many active, informal distribution and sales channels

Production data indicates that cowpea is the third-largest food crop produced by Niger, after millet and sorghum. Cowpea is a crop well suited to Niger's climate and soils and well adapted to Niger's generally extensive agriculture. Strangely, cowpea is hardly consumed at all by Niger's population (less than 15 percent of production is consumed by the country).

Cowpea export is mainly to the following countries:

- Nigeria (strong demand, continued growth);
- Ghana;
- Benin and Togo (lower export levels and market growth).

Prices and production vary widely from one year to the next. (European Union, 2002)

Niger trade's potential and constraints

Development potential for the Niger cowpea industry is essentially dependent on agricultural and ecological factors and on market evolution in the West African region. In particular, the following potential can be noted:

- cowpea crop is well entrenched as a traditional production of Niger's peasant farmers. Varieties cultivated are best adapted to the climate and soils under extensive cultivation and are able to resist drought and vermin. Cowpea production has become a cash crop, as well as a subsistence crop, notably for animal fodder;
- utilization of helm as a source of fodder also explains why cultivation of cowpea is expanding, because cowpea helm is protein-rich and economizes the draw on forage during the dry season;
- Niger's production of cowpea, as an export commodity to regional countries, enjoys strong and sustained demand. Prices in these markets, outside the harvest season are attractive;
- export industry organization for cowpea production is strongly dominated by exporter trading entities, which control most channels for the centralization of supplies and their subsequent sale. The keys for the continued market power of export traders is their control of warehousing and storage facilities and treatment of cowpea stocks, enabling them to gain the best prices on sales in consumer markets, in off season periods.
- Constraints impeding on more rapid development of Niger's trade and industry are mainly of financing:
- concerning production, low or no access to credit and loans in rural areas very often forces peasant farmers to sell their production immediately after harvest, that is when prices are at their lowest levels;
- concerning commercial trading, little access to credit and loans, or at least loans at reasonable interest rates, prevents traders from intervening in the market in the sense of stabilizing seasonal fluctuations in final markets and their prices.

Ghana

Ghana is major producer of cowpeas but in addition it imports about 10 000 t annually. About 30 percent of the Ghanaian imports come from Burkina Faso and the rest from Niger. In

Accra, the large, rough coated Nigerian cowpeas are sold for a premium, but they need to be marketed quickly because they do not store well in the humid coastal climate. (Faye, M. *et al.*, 1990)

Senegal

In northern Senegal as climate grew drier and the ground parastatal declined, cowpeas have increasingly replaced groundnut as the legume of choice. Some cowpeas are exported to Mauritania and Gambia, but the transportation cost and lack of market links limit access of Senegalese cowpeas to the large market in Ghana, Nigeria and elsewhere along the African coast.

Senegal is the only country in the region with a substantial cowpea processing industry. It has identified five companies producing cowpea-based weaning food, cowpea flour and cowpea-based crackers. All products are made from recipes developed by ISRA's Food Technology Institute (IITA). In addition, there is a cracker manufacturer in Nouachott, Mauritania, that uses primarily cowpeas from Senegal. (Faye, M. *et al.*, 1990)

Cameroon

A preliminary study of the structure of the cowpea market in northern Cameroon was completed. The general objective of this study was to characterize the marketing of cowpea produced in Northern Cameroon, including analysis of marketing costs. Sixty participants were interviewed in the markets where cowpea price and quality data were collected (Maroua, Salak, Mokolo and Banki), including farmers, local retailers, wholesalers and rural intermediaries. Main results were:

- Nigerian merchants are a major buying presence only in the border market of Banki. In the other markets Nigerian merchants are seen only when cowpea shortages drive prices in Nigeria very high;
- cowpea storage capacity in Maroua is about 25 000 to 30 000 tons. Annual production of cowpea in the far north province of Cameroon in the last decade varied from 15 000 to 45 000 tons. Thus, if the Cameroon government cowpea production figures are accurate, a high proportion of cowpea production in the far north province can be stored by Maroua merchants.
- some 15 000 to 20 000 tons are shipped from Maroua each year to markets in southern Cameroon, principally Douala and Bafoussam. In southern Cameroon markets some cowpea are resold to merchants from Gabon and Congo.
- marketing costs to southern Cameroon include: Trucking from Maroua to Douala or Bafoussam, 40 000 to 50 000 FCFA/ton or 3000 to 4 000 FCFA/sack; storage in Douala or Bafoussam until sale, about 300 FCFA/sack, about 30 FCFA/sack for taxes and other fees and 50 FCFA/sack for each time a sack is loaded or unloaded. Typically, the seller or his representative will accompany a load of cowpea to the south. This adds about 400-500 FCFA/sack. Total marketing cost is estimated at 3 830- 4 930 FCFA/sack.
- typical price differences for the same period between Maroua and southern Cameroon suggest that the cowpea trade can be modestly profitable. Price difference between harvest and latter periods indicate returns to capital invested of about 50 percent. (Bean/Cowpea CRSP West Africa Mission). Table 7 shows the variability of cowpea prices depending on periods and locations in Cameroon.

Table 7. Cowpea price ranges at selected markets within Cameroon by period

Period and Locations	Price Range, FCFA/100 kg sack
Rural Markets Around Maroua	
October-December	10 000-12 500
January-March	14 500-17 500
April-July	19 000-21 000
Maroua Market	
October-December	13 000-14 000
January-March	15 000-19 500
April-July	21 000-22 500
Douala or Bafoussam	
October-December	17 000-19 000
January-March	22 500-24 000
April-July	24 000-28 000
Source: Oumarou, 1998.	

Australia

Cowpea are grown as a green manure crop in coastal sugarcane areas, as a forage or dual-purpose grain/forage crop in coastal land sub coastal southern Queensland, and a grain crop from central Queensland to central NSW.

The predominant grain type traded is the "black-eyed pea", - a large white seed with a black patch around the hilum - although markets exist for seed with a range of sizes and colours. Small red-seeds cowpeas are sometimes substituted for adzuki beans in Japan (Imrie, B., 2000). Table 8 shows production of cowpea dry grain in Australia.

Table 8. Production of cowpea dry grain in Australia (1987 to 1992)

Year	Area (hectares)	Production (tonnes)
1987-88	10 317	3 730
1988-99	5 981	2 038
1989-90	3 886	1 717
1990-91	4 578	1 791
1991-92	9 321	4 423
Source: Australian Bureau of Statistics		

Sri Lanka

Cowpea is an important legume crop in Sri Lanka. Cultivated areas and production are shown in Table 9. (***)

Table 9. Area and Production in Sri Lanka (1997 to 2001)

Year	Area (hectares)	Production (tonnes)
1997	16 209	13 971
1998	14 827	13 399
1999	13 149	12 106
2000	12 947	12 121
2001	10 976	19 072

1.3 Primary product

In Southern Africa, cowpea is at present planted primarily for fodder, although it is also used for grain production, green manure, weed control in forestry plantations and as a cover or anti-erosion crop. Summerfield *et al* cited by Aveling, T., 1999 reported that in Nigeria the cowpea seeds are sometimes used as a coffee substitute and the peduncles of certain cultivars are used for fibre production.

In some areas of Africa, cowpeas are cooked as green pods and the swollen beans are consumed. These fresh cowpea pods, together with fresh green leaves, are the earliest foods available at the end of the "hungry time". Fig. 11 shows an example of succulent leaves that can be harvested as soon as 21 days after planting and cultivars that produces harvestable grain after only 60 days after planting. (Bean/Cowpea CRSP West Africa Mission)



Fig. 11. Green pod and succulent leaves of cowpea

Cowpea can be used at all stages of growth as vegetal crop. The tender green leaves are an important food source in Africa and are prepared as potherb, like spinach. Immature snapped pods are used in the same way as snapbeans often mixed with other food. Green cowpea seeds are boiled as a fresh vegetable. Dry mature seeds are also suitable for boiling and canning.

In June 1996, a survey conducted by ISRA/CRSP reported that improved cowpea varieties, including CB5, are grown mainly for the green pods,

which are available two or more weeks before those of the traditional varieties. Green pods are an important source of food for farm families during the period before cereal crops are mature.

In many areas of the world, the cowpea is the only available high quality legume hay for livestock feed. Digestibility and yield of certain cultivars have been shown to be comparable to alfalfa. (Davis, W. *et al.*, 1991). In Niger, the haulm (or halm) of the plant is consumed as dietary habits and traditions, and cowpea plants are widely used for animal fodder.

They are also a source of cash income when they can be marketed along the roadside to passing travellers. Women handle most of the cowpea green pod marketing. However, green pod area is limited because it is labour intensive and green pods must be consumed fresh

(there is no canning industry, as in the southern United States). To achieve greater impact, improved varieties would need to be used for dry cowpea production. (Bean/Cowpea CRSP West Africa, Fy 97 Annual report October 1995-April, 1997)

In the United States the major market of cowpea as a dried seed is black-eyed pea and pink eyed/purple hull. They are often cooked with water and canned or frozen to make them ready to heat and serve. (Fig. 12)



Cowpea seeds are available in several varieties and market classes. "Coronet," the most common Missouri variety, is a pink-eye type shown in upper right. Also shown are "clay peas," a forage type in upper left, "Arkansas blackeye" in lower left, and "Battersnap southernpea", a cream type in lower right.

Fig. 12. Some seed of available cowpea varieties in the United States

However, some cowpeas are harvested while the seed are high moisture and sold fresh. Both cases are referred to as "southern peas". (Quinn, J. 1999).

1.4 Secondary and derived product

In Africa, particularly in Ghana, the growth in the dietary share of cowpea has been constrained by high preparation time and labor requirement, undesirable product characteristics including beanie flavour, low digestibility and abdominal upset as well as post-harvest grain losses caused by insect pests.

Cowpea is prepared for consumption in grain, split and ground forms. The ground form has traditionally been a favourite of rural households in Northern Ghana because cowpea flour is less susceptible to post-harvest pest damage and can be used in many different dishes thus enhancing food security between harvests. (Bacho cited by Nyankori, J., 2000).

Food and nutrition technologies developed in the last thirty years promise to increase the cowpea share of Ghanaian food consumption through improved grain milling, more efficient nutrient extraction and new cowpea based-food products. Table 10 establishes a comparison between traditional and mechanized processing of cowpea flour.

Table 10. Comparison of traditional and mechanized processing of cowpea flour

Mechanized Processing				
Operation	Equipments	Equipment	Throughput	Power
Cleaning	Hand	Cleaner	Up to 1000 kg/hour	0.3-0.75 KW
Washing	Containers			
Dehulling	Pestle/ mortar	Sheller		2.5 KW
Drying	Sun drying	Sun drying. Solar dryer		
Winnowing	Winnowing Basquet	Grain winnower	Up to 466 kg/hour	
Grinding	Millstone	Plate mill	90-260 kg/our	

Source: INPhO (FAO)

The cowpea products is a nascent industry, apparently in stage two of the product life cycle; the introduction stage is characterized by a limited number of competing firms, low profitability, and high prices. (Nyankori, J., 2000)

Cowpea flour is sold whole or mixed, mainly in bulk or packaged in unbranded packets similar to Fig. 13.

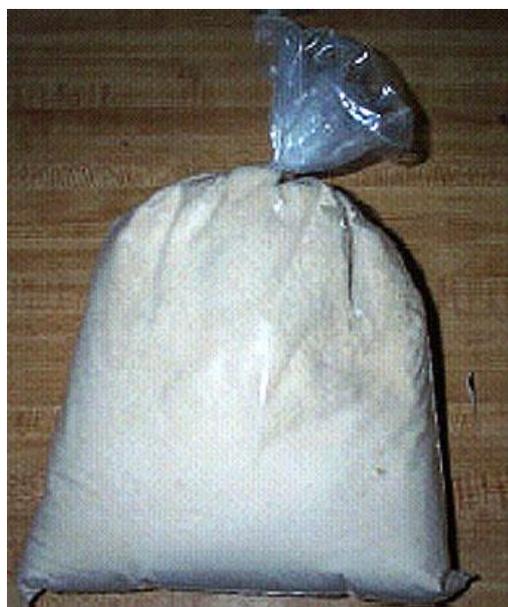


Fig. 13. Packed unlabeled flour product.

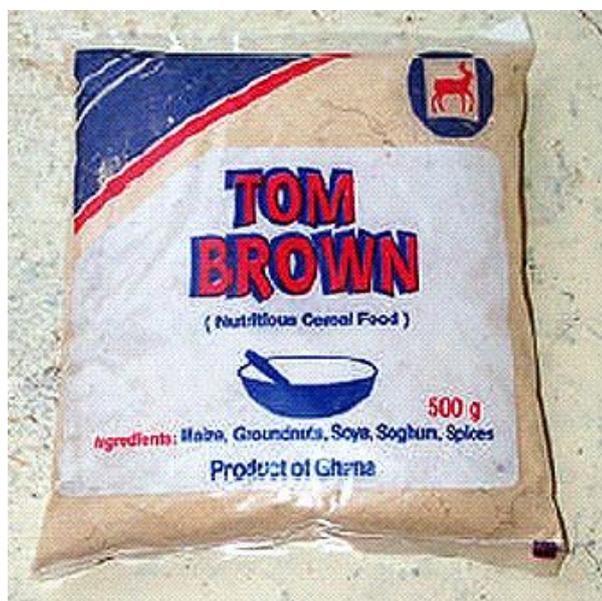


Fig. 14. Branded composite flour product.

Alternatively, there are other competitive flours included branded products like Tom Brown, Selasie and Gary (Fig. 14.)

1.5 Requirements for export and quality assurance

Skin and eye colour and texture grain

Varieties of cowpeas differ in testa characteristics, grain size as well as in skin and eye colour. Although, the number of varieties exported by any country is usually limited to 1 to 2 up to nine may be on sale in domestic markets of West and Central Africa. Table 11 demonstrates that the predominant grain colour in african market is white.

Table 11. Cowpea characteristics in selected markets in West and Central Africa (%)

Country	Grain colour			Eye colour	
	White	Red/brown	Others	Black	Brown/grey
Cameroon	84	13	3	59	41
Ghana	74	16	10	71	29
Mali	64	17	19	79	21
Niger	49	45	6	3	97
Senegal	31	21	48	47	53

Source: Bean/Cowpea CRSP West Africa Economics team.

On the other hand, the importance of testa texture varies by country. In Ghana, the cowpea grains are mostly smooth textured. On the contrary, cowpea sold in Mali, Senegal and northern Cameroon are rough texture.

Cowpea rough skin is linked to the type of food prepared and to storage conditions. Rough skin is easy to dehull and therefore easier to use for those dishes that traditionally require removal of the testa, for example "moin-moin". Smooth skinned cowpeas tend to be more common in humid areas where storage conditions are poor. (Langyintuo, A.S. *et al.*, 2003) A pilot study of cowpea price and quality relationships carried out for CRPS in Maroua, Cameroon during September 1996 is an example of socio-research with regional implications. Results through April 1997 indicate that consumers in Maroua are very aware of seed size differences and that they are more sensitive to cowpea insect damage than previously thought. The Maroua data indicates that a statistically significant price discount may start to be observed when one third of the grains have holes (Bean/Cowpea CRSP West Africa, Fy 97 Annual report October 1995-April, 1997)

Grain size

Analysis reported at the PEDUNE/RENACO/IITA/CRSP Cowpea Review and Planning Meeting, Ibadan Nigeria on March, 1998 indicates that cowpea characteristics vary widely and that grain size is the most important single factor influencing price. (Table 12)

Table 12. Average, minimum and maximum for cowpea characteristics in four markets, northern Cameroon and three markets in northern Ghana

Characteristic	Units	Average	Minimum	Maximum
Cameroon, Sept. 1996-Feb., 1998				
Price	FCFA/kg	229	125	540
Weight/100 Grains	Grams	16.18	10.05	28.42
Number of Bruchid Holes	Number	13	0	102
Ghana, Aug., 1997-Feb., 1998				
Price	Cedis/kg	707	421	1111
Weight/100 Grains	Grams	12	5	20
Number of Bruchid Holes	Number	13	0	68

Product quality

Storage plays a significant role in product quality and thus grain prices. However, quality-price relationships are less significant during the dry season when poor quality products may be sold at a higher price than good quality grain at harvest time. (Langyintuo, A.S. *et al.*, 2003)

According to Cameroon data, bruchid holes have a negative impact on price, but so far this has not been shown to be statistically significant. The level of bruchid damage in the Cameroon samples has been relatively low. The average is only 13 holes per 100 grains and very few samples go over 30 holes per 100 grains. The hypotheses about why this low level of damage is observed focus on:

- a) increasing use of modern storage techniques, both insecticides and CRSP non-chemical methods;
- b) merchants sort out damaged grain to keep the level of damage below some consumer threshold, and
- c) the ample supply of cowpea in 1997 and 1998 which allowed low quality grain to be diverted to animal feeding. (Bean/Cowpea CRSP West Africa, Social Science Report April-Sept., 1998).

In Australia, most crops are traded by members of the National Agricultural Commodities Marketing Association, which has established standards for grain quality. Economic return is dependent on seed quality, being around US\$ 800/t for grade but dropping to US\$ 250/t or less for stockfeed. This dichotomy in pricing makes cowpeas more risky for growers than mung bean, the summer pulse alternative. (Imrie, B. 2000)

1.6 Consumer Preferences

United States

Akara is an ethnic food that is very popular in West Africa. It is made from cowpea paste that is whipped into a batter, seasoned with fresh peppers (green or red, hot or mild), onions and salt, and deep fat fried. This product is relatively unknown in the United States but provides a novel form for the use of cowpeas.

A study to assess the acceptability of Akara by Americans who are regular consumers of fried foods was carried out. Varieties used were Blackeye, California Cream (white-eye), and a 2:1 mixture of California Cream: Kunde Giraffe (wild, short-season black-eyed type that is insect

and drought resistant). The seed coats were not removed as is done in the traditional West African process. Batter moisture content was adjusted to 64 percent to obtain optimum paste handling properties.

Sensory attributes were not significantly affected by variety. Hedonic ratings (1 = dislike extremely, 9 = like extremely) ranged from 7.2 to 7.6 for appearance, from 7.2 to 7.7 for colour, from 6.6 to 7.1 for texture, from 6.7 to 7.1 for aroma, from 6.4 to 6.8 for flavour, and from 6.5 to 6.9 for overall acceptability. These highly acceptable ratings indicate positive market potential for this product. (Patterson, S. P. *et al.*, 2000).

In the United States, later use included incorporating cowpeas into the traditional "good luck meal southern" traditionally prepared for New Year's Day. Among farmers who save seed, the seed is first dried and then frozen (Bean/Cowpea CRSP West Africa, Social Science Report April-Sept., 1998)

The Bean-Cowpea Collaborative Research Support Program funds UGA's akara project. The goal of this project is to broaden the way americans view and eat beans and cowpeas. UGA food scientists are working to introduce "Akara", to United States consumers through the frozen food and fast-food markets. Similar to cornmeal hush puppies, "Akara" is made from deep-fried cowpea (black-eyed pea) paste.



Fig. 15. An "Akara" low-fat fried food

Credit: Sharon Omahen

Most Southerners are accustomed to eating black-eyed peas typically used as a fresh or frozen vegetable for boiling. So eating black-eyed peas in the form of a fried food would be a new experience.

Akara's major drawback has been its high fat content, therefore UGA's newest formulations have solved that problem because the content fat has been significantly reduced. (Fig. 15) A consumer tests conducted by UGA food scientists have found that Americans like "Akara" because of its ethnic appeal. These surveys also show Americans would best accept "Akara" as a fast food or as a fully cooked, frozen, reheatable item. (Omahen, Sh., 2002)

West and Central Africa.

Consumers in the West and Central African countries generally prefer large grains and discount prices of grains that are damaged by insect pests. Their preferences for grain and eye colour vary from place to place.

Ghanaian consumers pay a premium for black-eye cowpeas whereas those in Cameroon discount black-eye ones. The most common preference for testa colour is white, but in some areas consumers prefer red, brown or mottled grains. (Langyintou, A.S., *et al.*, 2003)

Nigeria

Cowpeas are frequently consumed in West Africa as fried "Akara balls and steamed moin-moin", both of which are prepared from ground beans. In order to estimate this aspect of consumer acceptance, these dishes were made from local recipes, using flour of IITA cowpea cultivars. This work was done in cooperation with the test kitchen of the University of Ibadan.

Taste panels graded the product on the basis of taste, texture, and appearance. A high-quality cultivar was always included in the test as a standard, so that results were stated as preference or non-preference of the IITA cultivars compared with the standard.

In order to estimate the acceptance of new IITA cowpea cultivars by consumers in West Africa, several factors that determine acceptance were measured. These included cooking time and water uptake for whole beans, as well as taste, texture, and appearance of dishes prepared from ground beans. Cooking time and water uptake (or the ability to "fill the cooking pot") were measured by plotting increase of wet seed weight as a function of the time that beans were submerged in boiling water.

More than 100 cowpea lines were screened for these two factors. Cooking times ranged from 35 to 90 minutes and water uptake from 98 to 170 percent. Only those lines with short cooking time and high swelling capacity were acceptable to consumers. (Luse, R.A. 1980)

It also was determined that grain legumes are an important source of protein in the diets of people living in villages in Southern Nigeria, but that green leafy vegetables and other components of the soups and stews eaten daily also contribute more protein than is usually realized.

Other aspect to be considered is the daily food intake. A good proportion of daily food intake of Nigeria consists of food purchased from vendors in commercial eating-places. The principal food sources are:

- indigenous african food crops such as yam (*Dioscorea, sp.*), Cowpea (*Vigna unguiculata*), and locally reared animal;
- non-indigenous introduced crops such as cassava (*Mandioca sp.* And rice (*Oriza sativa*) and
- imported crop and animal products such as wheat (*Triticum vulgare*) and fish e.g. mackerel (*Scomberomorus tritor*)

Lately, there is a concern about the erosion of african genetic resources because of change in taste and urbanization, which has favoured the importation of food and the neglect of indigenous food crops.

Cowpea (probably the most important source of non-animal protein in the tropics) is under-utilised in commercial eating-houses in Nigeria. This could be due to the required long preparation and cooking time. Even in places where cowpea is found, it is served to accompany boiled or fried plantain. Other food preparation from cowpea such as "Akara" are not served routinely in the hotels but it can be prepared for customers on request. (Abiose, S., 1999)

On the other hand, consumption of cowpea flour has increased in Nigeria. A survey has shown that consumption of cowpea increased more than double in areas where villages mills were installed, despite of a price increase of 500 percent. (CANR, 2001)

Ghana

An exploratory market study of cowpea products in Ghana using data from case studies shows that cowpea flour, the main value added product, is typically sold in bulk or unbranded

small packages through retail and wholesale outlets and directly to consumers including individuals, institutions and the catering industry.

Cowpea flour is less prone to insect pest attack and consequently is a major source of food during the dry season and the period between harvests. However, the growth in the dietary share of cowpeas has been constrained by high preparation time and labour requirements, undesirable product characteristics including beanie flavour, low digestibility and abdominal upset as well as post-harvest grain losses to insect pests.

There are several dishes using cowpea flour produce in the household and these provide a varied nutritious diet and have added desirable attributes, which include easy cooking, availability and favourable taste. Although, a high proportion of processors are aware of the new cowpea utilization technologies, only a low percentage has capacity expansion for the next years.

The full impact of new utilization technologies will be realized over several years following substantial private capital investment in processing, marketing and strategic promotional activities. New formulations for utilization of cowpea flour are shown in Table 13.

Table 13. Some new formulations for utilization of cowpea flour in Ghana

Product	Description
Adunlei	Cowpea straw
Agonam	Cowpea pie
Akla	Fried cowpea paste
Apranpransa	Thick cowpea porridge
Atwomo	Cowpea twisted cake
Ayikaklo	Fried plantain mixtura
Ayitale	Fried cowpea/plantain
Ayiwonu	Cowpea egetable soup
Cornpea-pap	Mix
Cowpea cake	Cake
Cowpea stew	Stew
Cowpea fritter	Fritter
Cowpea pie	Pie
Danwake	Cowpea dumpling
Frido	Cowpea cutlet
Gbalegbale	Cowpea pancake
Kitikiti	Cowpea chips
Kpeblo	Cowpea rock buns
Mapele	Cowpea pudding
Majula	Cowpea doughnuts
Tseke	Steamed flour cowpea
Tsintsin	Cowpea sticks
Tuani	Steamed cowpea paste
Yikpono	Cowpea biscuits
Source: Randolph et al., 1981.	

The market study in Ghana also established Consumer Preference for selected product attributes measured in terms of responses to "agree/disagree" to declarative statements about selected product attributes include cooking quality, nutritiveness, availability, taste, keeping quality and comparison with soy flour. (Table 14). (Nyankory, J., 2001)

Table 14. Consumer preferences for cowpea flour attributes

Attribute	Favourable (%)
Cooking	92
Nutrition	90
Availability	80
Taste	68
Cost	29
Keeping quality	25
Prefer to soy flour	23
Source: Nyankory, J., 2001	

In many areas of Africa fresh leaves are regularly harvested and consumed often as a part of the typical "sauce" (Bean/Cowpea CRSP West Africa Mission).

Cameroon

One recent outcome of CRSP research in Cameroon is the discovery of a sweet-tasting cowpea. One particular line, 24-125B, has been accepted by cameroonian growers because of its taste. Chemical analysis of "sweet" line at Purdue University revealed that it contained at least twice as much as sucrose as ordinary non-sweet lines. (Murdock, L and Nielsen, S.S., 2000)

1.6.1 Some cowpea recipes

Akara (Black-Eyed Pea Fritters)

In Western Africa, a popular way to eat cowpea is to make a batter from which fritters are manufactured. These fritters (known as accra, akara, akla, binch akara, bean balls, kosai, koosé, and kwasi) are commonly prepared at home for breakfast, for snacks, or as an appetizer or side dish. They are also fast food, sold by vendors on the street, in marketplaces, and at bus stations. This same recipe, with a very similar name, is also known in the Caribbean. Akara however, take at least an entire day to prepare, in order to allow the black-eyed peas to soak and the batter to rest.

What it is needed:

- two to three cups dried cowpeas (black-eyed peas) or similar
- one onion, finely chopped;
- one-half teaspoon salt;
- hot chile pepper, and/or sweet green pepper or sweet red pepper, finely chopped (to taste);
- one-half teaspoon fresh ginger root, peeled and minced (or a few pinches of powdered ginger) (optional)
- peanut oil, palm oil, or vegetable oil for frying.

What to do

- clean the black-eyed peas in running water. Soak them in water for at least a few hours or overnight. After soaking them, rub them together between the hands to remove the skins. Rinse to wash away the skins and any other debris. Drain them in a colander;
 - crush, grind, or mash the black-eyed peas into a thick paste. Add enough water to form a smooth, thick paste of a batter that will cling to a spoon. Add all other ingredients (except oil). Some people allow the batter to stand for a few hours (overnight in the refrigerator); doing so improves the flavour;
 - heat oil in a deep skillet. Beat the batter with a wire whisk or wooden spoon for a few minutes. Make fritters by scooping up a spoon full of batter and using another spoon to quickly push it into the hot oil. Deep fry the fritters until they are golden brown. Turn them frequently while frying;
- Serve with an "african hot sauce" or salt, as a snack, an appetizer, or a side dish.

Moyin-Moyin

"Moyin-Moyin" (also called Moin-Moin, Moi-Moi), a sort of savoury bean pudding, is a unique and delicious way to prepare black-eyed peas or other beans. The traditional way to cook "Moyin-Moyin" is to wrap it in leaves (such as banana leaves) and steam it.

In modern Africa it is often cooked in empty tin cans, but it can also be made in muffin pans (muffin tins). There are many variations of "Moyin-Moyin". Skip all the optional ingredients to make a simple version; include one or more of the optional ingredients to make fancy Moyin-Moyin.

What it needed:

- two to three cups dried cowpeas (black-eyed peas) or similar
- one tablespoon dried shrimp powder
- one or two tomatoes, (peeled if desired), chopped -- *or* -- a similar amount of canned tomatoes -- *or* -- two tablespoons of canned tomato paste
- one or two onions, chopped
- salt and black pepper to taste
- chile pepper, chopped, to taste
- cayenne pepper or red pepper, to taste
- oil to grease muffin tin
- Optional Ingredients (a cup of one or more of the following):
 - ✓ cooked shrimp, chopped
 - ✓ cooked carrots, finely chopped
 - ✓ sweet green or red pepper (bell pepper)
 - ✓ hard-boiled egg
 - ✓ dried, salted, or smoked fish; washed, cleaned and torn into small pieces
 - ✓ canned sardines
 - ✓ leftover cooked meat, cut into small pieces
 - ✓ dried or smoked meat, torn into small pieces

What to do:

- clean the black-eyed peas in water in a large pot. Soak them in water for at least an hour or overnight. After soaking them, rub them together between the hands to remove the skins. Rinse to wash away the skins and any other debris. Drain them in a colander. If the beans have soaked only a short time, they may be cooked in water over a low heat until they are partially tender;
- crush, grind, or mash the black-eyed peas into a thick paste. Slowly add enough water to form a smooth, thick paste. Beat with a wire whisk or wooden spoon for a few minutes. A tablespoon of oil may be added. In a separate container combine all other ingredients and

crush and stir them together until they are thoroughly mixed. Add the other ingredients to the black-eyed pea paste and stir to make a smooth mixture;

- grease the muffin pans (or tin cans). Scoop the "Moyin-Moyin" mixture into your pans (or cans), allowing some room for it to rise while cooking. Place the pans (or cans) in a baking dish partially filled with water. Bake in a medium-hot oven for about a half-hour. "Moyin-Moyin" in tin cans can also be steamed in a large covered pot on a stove. Check for doneness with a toothpick or sharp knife, as one would for a cake;

Un alternate cooking method is the following: Wrap the Moyin-Moyin mixture in banana leaves or aluminium foil to make small packets. Cook the packets by steaming them in a large pot, using a rack to keep them out of the water.

It may be served hot or at room temperature.

Koki

Koki (or Ekoki, Haricots Koki, Koki de Niébé, Gâteau de haricots, or Bean Cake) is popular all over Cameroon. It is made from cowpeas (niébé or black-eyed peas) or other beans (haricots). It is similar to the Moyin-Moyin of western Africa in that the beans are mashed into a paste, which is wrapped in banana leaves and steamed.

What is needed:

- two to four cups (one to two pounds) dry cowpeas (black-eyed peas), kidney beans, white beans, or similar
- one or two sweet peppers (red, green, or in between) and/or chile pepper, cleaned and finely chopped
- one cup palm oil
- salt
- banana leaves (or aluminium foil) and string

What to do:

- soak the beans in cold water overnight. Then clean and rinse them. If using cowpeas (black-eyed peas), it may be necessary to remove the skins, depending on the variety. Do so by rubbing the beans between the hands. Make sure the beans are clean, and then drain.
- crush, grind, or mash the black-eyed peas into a thick paste. Put the crushed beans in a large bowl. Slowly stir in enough water to make the paste smooth. Beat with a wire whisk or wooden spoon for a few minutes or more. It is important to incorporate small air bubbles into the paste.
- heat the oil in a skillet for a few minutes. When warmed, add half the oil to the bean paste.
- fry the chopped pepper in the remaining oil for a few minutes, then add pepper and oil to the bean paste. Add salt to taste and mix well.
- warm the banana leaves for a half-minute in a hot oven, or on a grill, or in a pot of boiling water. This makes them easier to fold. Remove the centre rib of each leaf by cutting across it with a knife and pulling it off. Fold the banana leaves to completely enclose the ingredients in a packet two or three layers thick.
- place sticks or a wire basket on the bottom of a large pot. (A stovetop steamer can be used.) Carefully stack the packets on the sticks, add enough water to steam-cook them. Cover tightly and boil for one to three hours. Cooking time depends on the size of the packet. The finished Koki should be cooked to the centre, like a cake.

Koki can be eaten hot or cold and is often served with boiled yam or sweet potato. To make the most authentic Koki, red palm oil is essential as it gives the beans the right flavour and colour. In rural areas of Africa fresh palm nut sauce (similar to Moambé/Nyembwe sauce) is often used instead of the refined red palm oil, which is available in cities.

Outside of Africa canned palm soup base, also called "sauce graine or noix de palme" can be found in speciality grocery stores and can be used in place of the red palm oil.

Koki can also be made from "cocoyam" (taro) tubers, which are cleaned, peeled and grated and substituted for the beans. Crushed dried fish or shrimp are often added along with the red palm oil.

Red-Red

"Red-Red", a popular dish in Ghana made from cowpeas (black-eyed peas), might be named for the combination of red pepper and red palm oil. The Red-Red cowpeas stew is usually served with fried plantains.

What is needed:

- two to three cups dried cowpeas (black-eyed peas) or similar
- one cup red palm oil (or vegetable oil)
- one or two onions, thinly sliced
- two or three ripe tomatoes, quartered
- one or two bouillon cubes or Maggi cubes (optional) or small piece of smoked or dried fish and/or one spoonful shrimp powder
- salt, cayenne pepper or red pepper
- several ripe or near-ripe plantains (but not overly ripe)

What to do:

- clean the black-eyed peas in water in a large pot. Soak them in water for at least an hour or overnight. After soaking them, rub them together between your hands to remove the skins. Rinse to wash away the skins and any other debris. Drain them in a colander. If using smoked or dried fish, remove bones and skin, rinse and soak in water, then dry. If using dried shrimp, grind the shrimp (or obtain already ground or powdered shrimp).
 - place the black-eyed peas in a large pot, fill with water to just cover the peas. Bring to a slow boil, reduce heat, cover, and simmer until the peas are tender, thirty minutes to an hour. When cooked, the peas should be moist, but not standing in water;
 - while peas are cooking, heat oil in a skillet. Fry the onions until slightly browned, then add tomatoes, and fish and dried shrimp (if desired). Mash and stir the mixture to form a sauce;
 - stir the onion-tomato mixture into the black-eyed peas. Add Maggi cubes (if not using fish or shrimp). Simmer for ten minutes. Add salt, black pepper, and cayenne or red pepper to taste.
 - While peas and sauce is simmering, prepare fried plantains.
- Serve peas and plantains side by side on a plate.

Adalu

"Adalu" is cowpeas and maize. It is also called "Niébé et Maïs" or, in English, "black-eyed peas and corn". In Africa, it is usually made with dried cowpeas and either fresh or dried maize. It can also be adapted to use canned or frozen black-eyed peas and corn.

What is needed

- two to three cups (one to one-and-one-half pounds) dried cowpeas (black-eyed peas), or kidney beans, or similar
- one to two cups maize (corn), fresh, canned, frozen or dried
- a few small pieces of dried or smoked fish or ground dried shrimp (optional)
- one-half cup palm oil (or any oil)
- cayenne pepper or red pepper
- black pepper
- small piece of potash, or dash of baking soda, or salt (to taste)

What to do

- if using dried cowpeas (or beans) or dried corn. Clean and soak in water for a few hours or overnight, as needed. Rinse and drain;

- cook cowpeas in water in a large part until nearly tender (about an hour);
- add corn and other ingredients. Cook until cowpeas and maize begin to disintegrate and form a paste;
- season to taste.

Serve as a main dish or side dish. Without the fish or shrimp, "Adalu" can be served as a side dish with a West African soup such as pepper soup.

1.7 Others

Particularly in Africa continent and in developing countries cowpea post-harvest constraint are part of a broad chain of problems and limitants occurring in three following broad areas:

- abiotic: erratic rainfall, high soil temperatures, low soil fertility and degraded fragile soils;
- biotic: insect pests, parasitic weed, diseases induced by fungi, viruses and nematodes;
- socio-economic: resource-poor farmers are extremely risk-averse, farmer capacity to produce inputs is limited and input delivery systems function poorly.

To meet this situation enormous efforts have been made mainly in research activities. To date, cowpea research has been carried out by the West and Central Africa Cowpea Research Network (RENACO) in coordination with IITA. Funding was provided by the United States Agency for International development (USAID) through the Semi-Arid Foodgrain Research and Development in Africa Project.

There is also a cowpea research project that places priority on the development and dissemination of IPM technologies for cowpea. This project is being implemented by IITA and NARS and is funded by the Swiss Development Cooperation.

2 Post-Production Operations

2.1 Pre-harvest Operations

Losses between maturity and harvest of beans and cowpeas are caused by:

- pod shattering: spillage of seeds from drying pods that split can be a problem, but losses are not usually serious unless harvest is delayed;
- bruchid weevils: these insects are not only serious storage pests of pulse crops but also they can fly to the fields to infest cowpeas by laying eggs in cracks or cuts in the pods;
- seed deterioration: this can be a serious problem in cowpeas and can occur soon after maturity if rainfall continues. Studies by IITA have found that cowpea seed quality and germination decline rapidly when harvest is delayed. In tests under wet conditions, seed germination fell to 50 percent or lower within three weeks after maturity, and pre-harvest fungicide sprays were of little benefit in preventing this. (****)

If the leaves are still green at the time pods mature, Gramaxone may be applied as a harvest aid.

2.2 Harvesting

In the United States, cowpea can be harvested at three different stages of maturity: a) green snaps, b) green-mature, and c) dry. Depending on temperature and fresh-market demand, peas are ready for harvest 16 to 17 days after bloom (60 to 90 days after planting). Harvest date for green snap pods is normally specified by the processor. Most domestic cowpea production is mechanically harvested, however, hand harvested cowpeas suffer less damage and the harvest season may continue over a 1 to 3 week period. (Davis, W. *et al.*, 1991)

Determining Maturity

The pods begin to turn yellow during the final stages of growth, become brown and rather brittle once maturity is reached. Determinate bush varieties and some indeterminate types

have fairly even pod maturity, and the plants have usually lost most of their leaves by the time the pods have ripened. (****)



Fig. 16. Cowpea and maturing pods

Most indeterminate vining types mature much less uniformly, and a good number of pods may ripen while most of the leaves are still green. Seed moisture content is around 30-40 percent physiologic maturity. Pods are ready to be harvested as they turn light straw in colour and the seeds within turn brown or mottled in colour. At this stage the moisture content of seeds will be about 18 percent. (Fig. 16).

After the air dry pods during 1-2 sunny days, pods become brittle and easily to break with pliable bamboo sticks. At threshing, the seed moisture content should be about 12 percent (*)

When to Harvest

Indeterminate varieties with an uneven maturity are usually harvested in several pickings, while determinate bush types are harvested all at once when most of the pods are dry.

In Australia the ideal time to cut a cowpea crop for hay is at peak flowering, which occurs 70-90 days after sowing. Quality of hay declines as the crop matures; hay yields are generally 3 000-5 000m kg/ha. As a cover crop, cowpea can be incorporated at any time when sufficient green material is available, but is best done at the time of peak flowering. Grain or seed crops should be ready to harvest 120-150 days after sowing. (Cameron, A.G., 1999) If the crop is grown for seed, harvest would be when 75-80 percent of pod is dry. When it is grown for hay, cutting has to be when 25 percent of pods are coloured. (Rij, N.V., 1999). Harvesting should be carried out before the crop is too dry to avoid damaging the seed. In mechanized harvest, drum speed must be low (250-300 rpm) to avoid seed damages. (Cameron, A.G., 1999)

Method of Harvesting

The harvesting process will be determined by cultivar choice. Ranking types are harvest in windrows and threshed; determined types are harvested by pulling and threshing the same day. Hand harvesting is recommended for small areas. (Rij, N.V., 1999). If the harvest is mechanized and combine is used, a low drum speed is required to avoid splitting and cracking of seeds or grains.

The following methods apply to bush or semi-vine varieties with uniform maturity:

- **by hand:** the mature plants are pulled from the ground and placed in piles for drying. Pulling is best done in the early morning when the pods are moist to prevent shattering;
- **mechanized:** two basic methods are used. The plants are cut or "glided" out of the ground using a tractor with front-mounted horizontal blades with blunt cutting edges or rotating disks operated slightly below the soil surface. Several rows are combined into one windrow using a side-delivery rake, which can be rear-mounted behind the cutters. The windrows are dried for 5-10 days before threshing with tractor-drawn or self-propelled threshers;
- **direct harvesting:** it is popular in the United States and Canada using grain combines with modifications. (****)

For the whole seed market in the United States, quality of seed is important, so care in harvest and post-harvest handling may be important to avoid cracked or split seed. Handling the product at higher moisture reduces splitting of the seeds. If the leaves are still green at the time pods mature, Gramoxone may be applied as a harvest aid.

Cowpea grown as a dried pea product can be direct combined using a platform head or a row crop head. Adjustments to combine settings, and possibly screen/sieve sizes, should be made for the cowpea seed. (Quinn, J., 1999).

Grading

Seed must be graded at 10 percent moisture content using 4.8 mm diameter round perforated sieve and 4.0 mm diameter for small seeded varieties. (*)

2.3 Transport

The unit of shipping grains differs by the nature of the road and whether the truck is rented or shipment is by transport operator.

In Burkina Faso for example, the cost of shipping a tonne of cowpea on a rented truck on an unpaved road is $\$0.12 \text{ km}^{-1}$ and about 25 percent more if transported by transportation agents. In Ghana, Togo and Benin the unit cost of shipping a tonne on unpaved road are $\$0.11$, $\$0.15$ and 0.32 km^{-1} respectively (Langyintou, A.S. *et al.*, 2003).



Fig. 17. Farmers transporting cowpea forage in African Savannah

In developing countries, draught animals like horses, donkeys, oxen or even camels in desert areas as is shown in Fig. 17 are still a viable alternative suitable to small-scale farmers because of its low costs and local use transporting inputs and produces from field to farm and vice versa.

2.4 Threshing

Cowpea can be threshed manually by beating the plants or bagged pods with sticks once they are dry enough. Whatever the method used, cowpea seed can be easily injured if threshed too roughly or when too dry. Injured seed when planted will produce weak, stunted plants and other abnormalities. (****)

There are different threshing machines developed by african research institutions. Many of them are used to thresh various commodities such as maize, cowpea, sorghum, millet and other grains. (Fig. 18)



Fig. 18. Cereal thresher/threshing machine (URPATA/SAHEL)

2.5 Drying, cleaning and packaging

In Africa, different multipurpose machines have been developed to cleaning, drying and milling of food commodities. Fig. 19 gives an idea about a design multi-crop thresher machine.

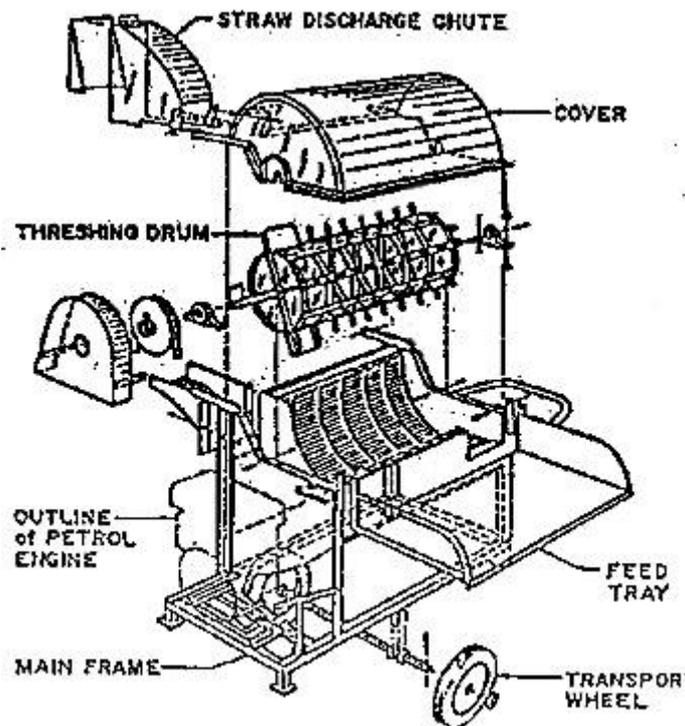


Fig. 19. Multi-crop thresher (GRATIS - Tamale ITTU)



Fig. 20. Transport of cowpea bags in an african local market.

In the United States, cowpea pods are packed, 25 pounds net in mesh bags (not burlap sacks) and dry cowpea seed is cleaned, graded, fumigated and packed in small plastic bags for sale to users. (Davis, W. *et al.*, 1991.)

The graded seeds after the removal of the broken and immature seeds should be dried to 7 to 8 percent of moisture content. Gada cloth bags or gunny bags are suitable for short-term storage and gauge thick polythene bags are appropriate for long-term storage. (*).

Fig. 20 shows labor force transporting 100 kg bags containing dried and cleaned cowpea grain to be sold in an african local market

In industrialized countries, when sold for the processing market, cowpeas are frequently sold at harvest by the truckload; at around 17 percent moisture is accepted for delivery. The product may benefit from a coarse cleaning process after harvesting to remove foreign material.

It should then be delivered quickly (one day or less) to

prevent quality degradation. Cowpeas are checked for discoloured seeds, as well as foreign material and the payment adjusted accordingly. Product may be rejected if there are too many discoloured, broken or cracked seeds. (Quinn, J., 1999).

2.6 Storage

Harvested green cowpeas will "heat" resulting in spoilage unless kept cool. Post-harvest facilities have to provide shade and adequate ventilation on the way to the cooler. Cowpeas cooled below 45° F may show chilling injury. (Davis, W *et al.*, 1991)

In the United States is recommended the grain be stored short term at around 12 percent moisture or less, with 8 to 9 percent recommended for long-term storage. Some buyers will want the seed cleaned and bagged, while others will take the grain in bulk form and clean it themselves. For some markets, the cowpeas must be harvested at a higher moisture, such as 18 percent and trucked directly from the field to the processor (Quinn, J., 1999)

An ISRA survey conducted in June 1996 indicates that the metal drum storage technology is used by most of the farm households (over 80 percent) and that it is used for the quasi-totality of the cowpea stored (95 percent).

As with almost every agricultural technology, farmers have introduced their own modifications of the drum storage method. In particular, many of them put insecticide in the drum. The insecticide may be a form of insurance that protects stored cowpeas even if the drum has unknown air leaks and/or it may limit reinfestation if the drum is opened regularly to obtain cowpea for family use. (Bean/Cowpea CRSP West Africa, Fy 96 Annual report October, 1995-April, 1997)

In Africa, cowpea storage is done in a variety of traditional structures. Figs. 21 through 24 shows some of them:



Photo	
Geografic Datas	Countries Burkina Faso - Etnic group Gourmantché / Mossi - Geographic Area West Sahelian Africa - Socio-cultural Area Gourmantche area - Agro-climatic Area guinean
Building Datas	Single structure. Framework : Branches - Body : Rammed earth, pisé (new evolution) - Platform : Wood - Supports : Stone/Wood - Roof : Palm
Location	Within the concession Storage Tradition Suspended storage
Preserving Technique	Ventilated storage Life Time none selected
Commodities	cereals and grains - cowpeas - grains - maize - millet - sorghum
Reference	Le stockage non étatique des grains dans les pays sahéliens -R. Audette et M.Grolleaud - Paris - Avril 1984 Rapport terminal de mission CEAO, CILSS et FAO - Rome, 1987
Author	R. Audette , M.Grolleaud, A. Diop
	Rec. ID 28 - Inputer unknown - Input Date 27/2/2000 - Last Updated

Fig. 21. Bwa - Bwa traditional storage



Geografic Datas	Countries Mali - Etnic group Dogon - Geographic Area West Sahelian Africa - Socio-cultural Area Dogon area, Bandiagara - Agro-climatic Area guinean		
Building Datas	Single structure. Body : Rammed earth, pisé (building is long and not easy) - Platform : Wood/Rammed earth, pisé - Supports : Stone/Rammed earth, pisé - Roof : Rammed earth, pisé		
Location	Within the concession	Storage Tradition	Suspended storage
Preserving Technique	Confined storage	Life Time	12 year
Commodities	cereals - cereals and grains - cowpeas - grains - millet - rice		
Product Conditioning	threshed or trodden grain	Preserving Quality	Good
[contenance]	Stored Weight (grains) 5 - 10 tonnes	Storage Duration	none selected
Reference	Dossier Technique traditionnel de conservation des céréales locales, Projet de Recensement des Technologies Nouvelles au Mali, January 1985		
Author	CINAM, ZOLAD , Montpellier		
Rec. ID 8 - Inputer unknown - Input Date 27/2/2000 - Last Updated			

Fig. 22. Dogon - Dogon traditional storage



Photo Gallery	
Geografic Datas	Countries Niger - Ethnic group Haoussa - Geographic Area West Sahelian Africa - Socio-cultural Area Tahoua region - Agro-climatic Area guinean
Building Datas	Body : Rammed earth, pisé (also used as roof)
Commodities	cereals - cereals and grains - cowpeas - millet - rice
Reference	Le stockage non étatique des grains dans les pays sahéliens -R. Audette et M.Grolleaud - Paris - Avril 1984 Rapport terminal de mission CEAO, CILSS et FAO - Rome, 1987
Author	R. Audette, M.Grolleaud, A. Diop
	Rec. ID 16 - Inputer unknown - Input Date 27/2/2000 - Last Updated

Fig. 23. Haoussa - Storage from ethnic group Haoussa



Geografic Datas	Countries Niger - Ethnic group Djerma - Geographic Area West Moist Africa - Agro-climatic Area guinean
Building Datas	Single structure. Framework : Wood - Body : Straw - Platform : Wood - Supports : Wood
Location	Within the concession Storage Tradition Suspended storage
Preserving Technique	Ventilated storage Life Time none selected
Commodities	cereals - cereals and grains - cowpeas - grains - maize - millet - sorghum
Damage	Fires Natural Ingredients none selected used
Reference	Le stockage non étatique des grains dans les pays sahéliens -R. Audette et M.Grolleaud - Paris - Avril 1984 Rapport terminal de mission CEAO, CILSS et FAO - Rome, 1987
Author	R. Audette, M.Grolleaud, A. Diop
	Rec. ID 6 - Inputer unknown - Input Date 27/2/2000 - Last Updated

Fig 24. Traditional Djerma storage called Barma

2.7 Processing

In Africa, particularly in Ghana, traditional milling and other processing practices are time and labour intensive, cumbersome and expose the product to losses and adulteration. Innovative technologies include decortication fermentation, extrusion and improved domestic processing. New cowpea-based product includes weaning mixes and blending, new formulation and fortification. (Nyankori, J., 2002)

No industrial processing entities currently exist in Niger for processing of dried peas to meal or flour. The only processing activities based on cowpea are artisanal operations, and are small in scale, producing cowpea fritters using cowpea semolina, which are generally eaten with rice. Modern commercial cowpea operations utilise adequate techniques for storage, based on drying followed by insecticide treatment where storage is for over 6 months. (European Union, 2002)

Summarising, Table 15 establishes a comparison between traditional and mechanized cowpea post-harvest operations.

Table 15. Comparison of traditional and mechanized cowpea post-harvest operations

Operation	Traditional Operation		Mechanized Operation	
	Equipments	Duration	Equipment	Throughput
Haresting	Hand, knife	80-100 labour/hour/ha	Harester	1 ha/hour
Field-drying	Sun drying	15-40 kg/hour	Sun drying	
Threshing	Hand		Thresher	
Cleaning, treatment	Hand, wood ash		Cleaner, Chemical	
Transport	On head, By car		Truck	
Storage	Earthenware Jars, Clay pots		Hermetically sealed container	
Source: INPhO (FAO)				

3 Overall Losses

Cowpea suffers terribly from its natural enemies. Insects are the worst of these enemies, but nematodes, bacterial diseases and viruses also cause losses. There are published data providing evidence that insects cause devastating losses in cowpea yields. Weevils - post-harvest pest - can destroy a granary full of cowpeas within two or three months. But people need to have the grain to eat for 12 months a year. (A BIOTECH, 2002).

3.1 Field losses

If any broad spectrum insecticide is used on the growing crop, grain yields range from 1 400 to 1 700 kg per hectares. The insect pressure on cowpeas is an important weight that reduces yields to almost nothing. Yield losses in the field are only half the problem. Even when the crop has been harvested, the grain has still not escaped its insect enemies. (Murdock, L., 2002).

Murdock, L. states that traditional method and chemical insecticides have failed to control the insects. Despite millions of dollars spent and despite a great deal of research, average cowpea yields in Africa are still far below the yield potential. Insecticides are not the answer. They are widely available, they require expensive equipment and training for their use, and they are themselves expensive, polluting and potentially dangerous to users.

Murdock, L. continues to affirm "If we decided to solve the problem of insect control in cowpea solely by using insecticides, we would have to spray insecticides at probably a minimum of 250g of insecticide per hectare on the 8.8 million hectares of cowpea grown in Africa, that is, spreading 2.2 million kg of insecticide into the african environment every year, not only onto the plants of course, but also on the soil, the air and the water".

Field losses in West Africa are very high, because insecticide use is not frequent. Even when insecticides are available, farmers rarely have the money to buy them. In contrast, field losses in the United States (and probably in Australia) are quite low because of heavy use of insecticides.

Annual losses caused by Bacterial blight (*Xanthomonas vignicola*) and Aphid borne mosaic virus (CabMV) in Senegal have been estimated at 40 percent and 20 percent respectively (Gaikwad cited by Cissé, N. et al., 2000).

The parasitic weed *Striga gesnerioides* attack cowpeas particularly in the semiarid regions of West and Central Africa a mean yield loss of 30 percent (Aggarwal *et al.*, 1989 cited by Cissé, N. *et al.*, 2000). In Nigeria, the largest producer and consumer country in the world, the low yield is attributed to farmers' use of local land races that have low yield potential and high susceptibility to diseases, insect pests and parasitic flowering plants like *Striga* and *Alectra*. (NAQAS, 2001)

3.2 Storage losses

On the other hand, storage losses in West Africa are substantial in spite of the use of storage insecticides by merchants. Except in Senegal most West African farmers sell cowpea shortly after harvest, in part because they do not want to deal with the storage problems. A related problem is the lack of capital to invest in storing cowpea. In Senegal, farmers have slightly more resources than elsewhere in West Africa region and there is widespread use of hermetic storage methods developed by the Bean/Cowpea CRSP and the Senegalese Institute for Agricultural Research (ISRA).

The Fig. 25 represents the average damage recorded on stored cowpea in the Ghana northern region during the storage season 96-97. The number of farmers decreased over the storage season as they sold or consumed their cowpea. Few farmers keep their cowpea in store over the entire storage season.

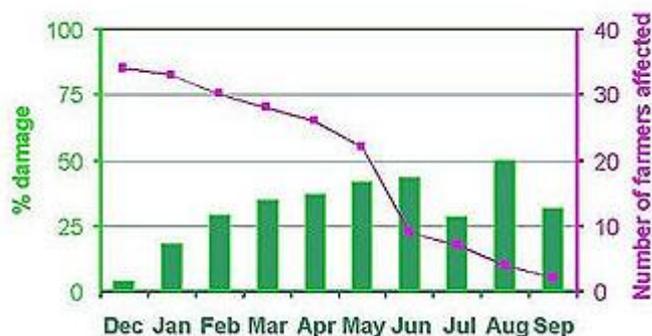


Fig. 25. Percentage damage of cowpea grain with at least 1 bruchid hole

These levels of damage were recorded on farmers' cowpea, under normal storage conditions and management. The weight loss remains lower than expected but observed levels of damage cause significant losses, hence price reduction.

Cowpea that are not stored with either chemical or the CRSP non-chemical methods are often completely consumed by bruchids in the first 10 to 12 months of storage. Even if the cowpeas are not completely consumed, West African consumers demand a substantial price discount before they will buy bruchid damaged cowpea. (J. Lowenberg-DeBoer, personal communication, 2003)

Grain legumes, such as cowpeas, are sold soon after harvest in many semi-arid areas of Africa, either because producers need cash to meet debts or because they cannot prevent losses due to storage insect pest damage.

Selling early in the storage season results in a loss of income because prices rise as grain legumes become increasingly scarce. However, deterioration in grain quality is not just a problem faced by farmers. [Traders](#) at all levels within the system also suffer storage losses as a result of insect pest damage and it is also a major problem for food aid agencies. (New Agriculturist on line.)

4 Pest Control

4.1 Pest Species

Most cowpea farmers in sub-Saharan Africa are confronted with low yields, caused by insect pests and diseases. Over the past few years, however, this picture has been gradually changing due to the establishment of a regional pest management project.

Cowpeas are susceptible to a wide range of pests and pathogens that attack the crop at all stages of growth. These include insects, bacteria, viruses, fungi and weed. Some 40 species of fungi are cowpea pathogens. (Dutcher and Todd cited by UC SAREP).

Insects

The main pests during the growing season are the **aphids**, the main storage pests are the **bruchids**. Both of these pests can severely reduce the yield of cowpea or the stored grain. (Farming Systems Research and Extension Unit, 1999d).

The primary insect pest causing losses to stored cowpeas in West Africa is the cowpea weevil, *Callosobruchus maculatus*. Infestation begins in the field at low levels. After the crop is placed in storage, the insect population continues to grow until there is an obvious, severe infestation. Another bruchid pest of cowpea is *Bruchidus atrolineatus*. This insect causes losses primarily around harvest time, and does not reproduce in storage. (Ntoukam, G. *et al.*, 2000)

The IPM CRSP Uganda through a fully participatory research program by engaging farmers in each stage of the research process including farmer field pests monitoring and on-farm trials established that the most likely field crop in Eastern Uganda to be sprayed with chemical pesticides is cowpea. Farmers could not identify the names of pests and diseases; however, the descriptions they provided showed that **aphids and pod borers** are the most important problems for farmers in this district.

Over 70 percent of farmers growing cowpea apply pesticides as often as 8 times per season. The mayor insect pests are **pod sucking bugs** (*Riptortus spp.*, *Nezara viridula* and *Acantomia sp.*), **aphis** (*Aphis fabae*), **blister beetle** (*Mylabris spp*) and **pod borer**, *Maruca vitrata*). (IPM CRSP, 2000)

In the North Ghana *Maruca vitrata* damage is most significant in areas where maize is a major component of the farming system. In areas where sorghum and millet are cropped extensively, pod-sucking bugs occur much earlier in cowpea pod development. (Salifu *et al.*, 2000)

Pod borer (*Maruca vitrata* and *Heliotis ssp*) caterpillars feed on tender foliage and young pods. They make holes in the pods and feed on developing seeds by inserting anterior half portion of their body inside the pods. (IITA Research, 2001). Failure to control insect pests could result in grain being downgraded from food quality to stockfeed and make production uneconomic. (Imrie, B., 2000)

In southern production areas of the United States, the major insect pest is cowpea curculio and the major disease is root knot, a severe root disease incited by several rootknot nematodes (*Meloidogyne spp.*). (Quinn, J. 1999). Fig. 26 illustrates some specimens of major and minor cowpea pest insects.

a. Major insect pests



Damages of cowpea aphids



Cowpea bruchid

b. Minor insect pests



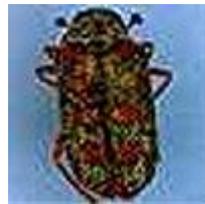
Clavigralla



Bean fly



Green stinkbug



Actenodia jucunda



Mylabris tinctoria



Ceroctis phalerata

Source: Farming Systems Research & Extension Unit. Namibia

Fig. 26. Major and minor pest insects of cowpea

Thrips (*Megalurothrip sjostedti*) are another pest affecting during growing season. (IITA Research, 2001) The adults and nymphs feed on leaves. They scrape the epidermis and suck the oozing sap. As a result, light brown patches appear on infested leaves. The affected leaves curl and become dry.

Clavigralla and **bean fly** are also considered important pests although they are not so widespread yet. More information is needed on these two pests to evaluate the extent of damage in farmers' fields.

Weed

Striga gesnerioides and *Alectra spp* are the principal parasitic weeds attacking cowpeas particularly in the semiarid regions of West and Central Africa. (Aggarwal *et al* cited by Cissé, N. *et al.*, 2000)

Diseases

The most important diseases in the Sahelian zone are **bacterial blight and viruses**. Bacterial blight (*Xanthomonas vignicola*) causes severe damage to cowpeas, while the most frequent virus disease encountered is Aphid borne mosaic virus (CabMV). (Gaikwad, 1988 cited by Cissé, N. *et al.*, 2000). Viruses cause mosaic diseases and mottle symptoms in cowpea. (IITA Research, 2001).

Cowpeas have not experienced any serious disease problems in the Northern Territory of Australia. Diseases such as powdery mildew, cercospora leaf spot and cowpea aphid borne mosaic virus have been recorded on cowpea grown in the Northern Territory. Control for them is normally not necessary or practicable. (Cameron, A.G., 1999)

Another most important disease has been found to be cowpea mosaic virus (*Sphaceloma sp.*), however, yellow blister disease (*Synchytrium dolichi*) is periodically devastating. Apart from these pests, cowpea flowers are visited by a large number of beetles. Under normal circumstances these beetles do limited damage to the flowers and are at present not considered so important.

Different diseases reported are fusarium wilt, bacterial canker, southern stem blight, cowpea mosaic virus (and several other less prominent viruses), cercospora leaf spot, rust and powdery mildew. Table 16 is a summary of fungal pathogens and the diseases they cause.

Nematodes

Cowpea is susceptible to nematodes and thus should not be planted consecutively on the same land. (Van Rij, N., 1999)

Birds

Birds of the parrot family, including corellas, galahs and red wing parrots can pull-up emerging seedling and also feed on developing green pods. They have been a major problem on cowpea crops grown under irrigation during the dry season in the Northern Territory of Australia. (Cameron, A.G., 1999)

Table 16. Fungal pathogens and associated diseases

Disease	Causal fungi	Distribution	Distribution
1. Seed and seedling diseases			
Seed decay and seedling mortality	Pythium aphanidermatum Rhizoctonia solani Phytophthora spp. Pythium ultimum	Widespread. South Africa.	Locally and seasonally damaging and up to 75% incidence in Nigeria. Locally important.
2. Stem, collar and root diseases			
Anthracnose	Colletotrichum lindemuthianum Colletotrichum dematium	Widespread. Recorded from east and west Africa and Brazil.	Locally important and losses up to 50% in Nigeria.
3. Foliar diseases			
Cercospora leaf spot	Cercospora cruenta	Widespread.	Major. Yield losses of 20-40%.
Septoria leaf spot	Septoria ignae Septoria ignicola	Widespread. Reported from east and west Africa, Brazil and India.	Probably important in saannahs of Africa.
Ascochyta blight leaf spot	Ascochyta phaseolorum Ascochyta boltshauseri	Widespread in Africa and Central America. Reported recently from India.	Major. Causes severe losses under cooler conditions.
Web blight	Rhizoctonia solani	Worldwide.	Major. Destructive under hot, wet conditions.
4. Pod diseases			
Scab (also a foliar and stem disease)	Sphaceloma sp.	Widespread in tropical Africa.	Major. Very damaging pathogen in saannah areas.
Brown blotch	Colletotrichum capsici Colletotrichum truncatum	Recognised only from Nigeria, Upper Volta, Cameroon, Kenya and Zambia.	Locally important in the African saannahs.
Source: Avelling, T., 1999			

4.2 Relative Status of major pest species

4.2.1 Cowpea weevil

- Common Name: Cowpea weevils, Onhuko yomakunde (Oshikwanyama); Ontuko yomakunde
- Scientific Name: *Callosobruchus maculatus* (Fabricius)
- Order: Coleoptera
- Family: Bruchidae

It has been identified at Mtwapa bruchid species infesting cowpea in the field, namely, *Callosobruchus rhodesianus*, *Callosobruchus phaseoli*, *Callosobruchus chinensis*, *Bruchidius atrilineatus* and *Callosobruchus analis*.

Pest status

Bruchid weevil is a cosmopolitan pest of stored legume seeds (Credland, P.) They are widespread throughout the temperate and tropical world. Several species are agricultural pests that have the potential to destroy stores of legumes. One species in particular, the cowpea weevil, *Callosobruchus maculatus*, is a cosmopolitan pest that causes considerable economic damage. (Profit, M., 1997)

Bruchids are major pests on cowpea in Africa. Attacks dried cowpeas and other related stored seeds. They are mainly found on cowpea grains in storage and may be the main constraint to increased cowpea production.

Description

Cowpea bruchid adults are small beetles (2-3 mm long), reddish-brown slightly elongate compared with the typical rounded appearance of other members of the bruchid family. Although weevil-like, they are not true weevils (Curculionidae) and do not have heads prolonged into a long "snout." Wing covers (elytra) are marked with black and grey and there are two black spots near the middle. The larva is whitish and somewhat C-shaped with a small head. Fig. 27 is a photograph showing the differences between female and male bruchid.



Fig. 27. Female and male adults cowpea bruchids

Source: A. P. Ouedraogo's Doctorate thesis, University of Tours

Damages

Damage is restricted to eating quality only. It is not possible to eat (or sell) the cowpea grains when they are riddled with bruchid holes. Germination of cowpea is not affected, however, and even seeds that are full of holes will germinate very well during the next season. (Farming Systems Research and Extension Unit. 1999d.)

Damaged grains are full of small holes and dead beetles may be found inside the grains. The white eggs are glued to the outside of cowpea grains and are clearly visible as small white dots on the grain. (Fig. 28). Damage and weight loss in stored seeds is caused by larvae, which develop within the grain, consuming the seed (New Agriculturist on line)



Fig. 28 Cowpeas attacked by bruchids

Life cycle

Adults may be found outdoors in flowers in early spring and colonize the cowpea cultures at the end of the rainy season carrying the bruchid populations into the stores where they continue to develop. (Van Huis, A., 1996)

Eggs laid by females hatch in 5 to 20 days. Larvae typically feed inside the

cowpea, taking from 2 weeks to 6 months to develop before pupating there. Six or seven generations may occur per year. Larvae chew near the surface and leave a thin covering uneaten which appears as a "window". Later the adult emerges from the "window". The typical period for each stage at 25 °C is as follows:

Table 17. Bruchid development stages

Stage	Duration
Egg hatch	4 days
First 4 instars	22 days
Pupal	3-4 days
Total development period approximately 30 days	
Source: Profit, M. 1997	

Habitat and food source

Mouthparts are for chewing. They prefer dried cowpeas but will attack other beans and peas in storage. Adults move about readily and can infest seeds in the field, but can also breed continuously in stored dry cowpeas. Larvae typically develop inside the dried peas.

Control

Farmers often mix cowpea grains with ash. This method is still recommended as a cheap and safe control method. To be efficient, it should be used at least 5 percent of ash. It is recommended to avoid using chemicals in stored food. If chemical control is still considered necessary, technical assistance is needed for precise advice on chemical control. (Farming Systems Research and Extension Unit. 1999d.)

A larval parasitoid wasp, (*Dinarmus basalis* and an egg parasitoid wasps *Uscana lariophaga* have shown to be promising candidates for biological control of the bruchids in Niger. (Van Huis, A., 1996). The wasps exist already in the agricultural regions of West Africa and it is through a process of nurturing those endemic populations that it is hoped to have a biological control programme in place before the end of 1996. (Profit, M., 1997)

Predators

In Namibia, a tiny flying insect is often hatched from cowpea grains that are infested with bruchids. It may be a parasite on bruchids, but has not yet been identified.

4.2.2 Aphids

- Common Name: Aphids (English); omudjenene (Oshikanyama); oshikagadhi (Oshindonga); omule (Oshingandjera, Oshikolonkadhi, Oshikwaluudhi); oshizenene (Oshimbalantu); plantluis (Afrikaans)
- Scientific Name: *Aphis cracivora*
- Order: Hemiptera
- Family: Aphididae

Pest status

The main pests during the growing season are the aphids which nymphs and adults suck the sap.

(***). The black aphids found on cowpeas are presently considered the most important aphids on field crops. The actual aphid damage by sucking may be limited in most cases, but aphids are also capable of transmitting a large number of virus diseases. (Farming Systems Research and Extension Unit. 1999f.)

Description

It is a relatively small aphid, shiny black with legs and antennae white to pale yellow with black tips. Cowpea aphids are usually black. (Godfrey, L. D., 2002). Adult aphids are wingless unless there is overcrowding on the plant, then some of the aphids develop wings for dispersal. Aphids infestations may be located through the presence of ants on the plants. (Farming Systems Research and Extension Unit. 1999f.) Fig. 29 shows winged adult and wingless nymph of cowpea aphid.

Damages

They are often found on the cowpea pods or the underside of leaves. Attacks of aphids early in the growth may completely smother the plants and pods and lead to reduce seed setting. Attacks late in the growing season do not seem to damage the production.



Winged adult
cowpea aphid



Wingless adults and
nymphs of cowpea aphid

Fig. 29. Adults and nymphs of cowpea aphids

The affected leaves turn yellow, get wrinkled and distorted. The insect also exudes honeydew on which fungus develops, rapidly covering the plant with sooty mould that interferes with the photosynthetic activity of the plant. A black fungal growth (called soot) often occurs on the honeydew secreted by aphids.

In short, aphids damage plants by: 1) sucking plant sap which causes heavily infested leaves to curl and stunt plants; 2) excreting honeydew which causes [sticky, shiny leaves](#) to ultimately turn black because of a sooty-mold fungus growth and 3) spreading plant diseases (a large number of viruses are vectored by aphids). Infestations frequently are localized with heavily infested leaves curled downward. (Godfrey, L. D., 2002)

Life cycle

Male aphids are rare in Africa, most aphids are females that produce nymphs without fertilization. A female aphid can give birth to two to three young aphids per day, which may

rapidly result in populations of several hundred aphids. (Farming Systems Research & Extension Unit. 1999f.)

Control

In most cases, it is not recommended to control aphids. There is a tendency among farmers and extension staff to overreact to aphid infestation. Control should only be considered where large infestations are threatening the crop or when viral infections have been observed.

Several commercial pesticides are available to control aphids, of which the most effective are systemic pesticides.

In some cases heavy rain may reduce the number of aphids, for example the black cowpea aphid, which is very exposed on the pods. If a few plants are seriously affected they can be pulled up and burnt or fed to livestock. Old plants that have been harvested are best removed from the field, as they often host the aphids. (Farming Systems Research & Extension Unit. 1999f.)

Aphid control in cowpea and beans is not always necessary. The decision to treat for aphids is based mainly on visual counts and the stage of crop development. Measurable thresholds are not available. Frequently, parasites and predators prevent the infestation from becoming established throughout a field. Hot temperatures (greater than 30 °C) frequently inhibit build-up of large densities of aphids. (Godfrey, L. D., 2002)

Predators

Predators - mainly larvae of hover fly or ladybird - are often found feeding on the well-established aphid colonies. (Fig. 30). These predators may give some degree of control, when aphids are developing slowly, but in most cases they cannot control the rapid build up of aphid infestation. (Farming Systems Research and Extension Unit. 1999f.)



Fig. 30. Aphid predator, hover fly larvae

4.2.3 Pod sucking bugs

The mayor insect pests in the field are pod-sucking bugs (*Nezara viridula*, *Riptortus spp* and *Acantomia sp*),

- Common Name: Green vegetable bug (English); groenstinkbesie (Afrikaans)
- Scientific Name: *Aphis cracivora*
- Order: Hemiptera

- Family: Pentatomidae

Pest status

Green stinkbug is widespread in north central Namibia, but it is only a minor pest. The host range is large. Green stinkbugs have been observed on maize, pearl millet (*Pennisetum glaucum*), cowpea (*Vigna unguiculata*) and many vegetable crops. There are seldom many stinkbugs on a crop and they do not reach such high population levels as the melon bugs for instance.

Description

The young stages (nymphs) of stinkbugs look very different from the adults and are often mistaken for another species. The nymphs are round and flat, rather like a coin, with a green and black pattern on the shield. (Fig. 31) The adult stinkbug is green and 15 mm long. It is often found on heads of pearl millet and hiding in green vegetation (Farming Systems Research and Extension Unit, 1999)

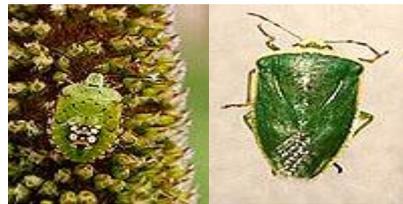


Fig. 31. On the left side young nymph, on the right side adult green bug.

Damages

Severe damage has not yet been recorded in Namibia.

Control

Control is not recommended due to the small number of green stinkbugs to be found on local crops.

4.2.4 Blister beetle

- Common Name: Blister beetle (English), no local name
- Scientific Name: *Mylabris tinctoria*
- Order: Coleoptera
- Family: Meloidae

Pest status

Host plants are legumes and many weeds. It is often found on flowers of "Ombidi or Omboga" (*Cleome gynandra*). This plant is used as local spinach and therefore not removed from the field during weeding.

Description

Beetle blister is 16 mm long and has a pattern of black and yellow bands across the back. The back end is often dark red.

Blister beetles can give severe burns and blisters when handled. They exude a chemical that causes itching shortly after the chemical has touched human skin. A few hours later, large blisters begin to form and they stay for a day or two. Hence the common name.

Control of blister beetles

Local farmers do not consider most beetles important pests, and they may not even be mentioned. Farmers get worried, however, in the rare cases when large numbers of beetles are found on flowering crops.

Handpicking of beetles is not common, but at Onaanda in the Omusati region, an old farmer collected buckets full of beetles while working in the field. She mainly collected *Mylabris oculata* and did not use gloves, although most species are known to give blisters. To speed up hand picking, a simple homemade net could be used for catching the flying beetles. (Farming Systems Research & Extension Unit. 1999b)

4.2.5 Bean fly

- Common Name: Bean fly (English); Boontjiemaaiër; Boontjievlieg (Afrikaans). No local names are recorded.
- Scientific Name: *Ophiyomyia phaseoli*
- Order: Diptera
- Family: Agromizyidae

Pest status

Bean fly is known to attack all beans and many other legumes. In Namibia it has especially been noticed on phaseolus, cowpea and lablab. It is found on nearly all cowpea plants in the fields and it is believed to be widespread and common in many regions. (Farming Systems Research and Extension Unit, 1999c) Bean fly is normally in areas north of Adelaide River, Australia. It can cause seedling mortality. (Cameron, A.G. 1999)

Damages

The bean fly is a very small inconspicuous fly. Damage symptoms are the most reliable method to detect bean fly attacks: Bean flies cause a characteristic swelling of the stem at ground level where the maggots (fly larvae) burrow into the stem. The maggots pupate at the base of the plant and as the stem grows it often cracks open. Pupae can be found in the cracks and on the outside of the stem.

Leaf symptoms are more difficult to spot in field crops. One or two leaves on the plant turn yellow while the other leaves remain green. The petiole often shows dark streaks where the maggots have moved through and damaged tissue.

Description

The adult bean fly is 2 mm long and black. It is difficult to see, but in still weather one may see the small black flies move around and lay eggs on the cowpea leaves.

Life cycle

The tiny white eggs are laid individually in small holes in the leaf surface. The egg hatches on the leaf and the small white maggot bores down through the stem and feeds just above ground level. Here the stem will swell and crack. The small brown pupae can sometimes be found in the stem.

Control

For a rain-fed crop such as cowpea there is little to do apart from keeping the field free from legumes debris. Little is known about the bean fly during the various seasons, but it has been noted that some plantings of host legumes get through without any attack at all.

At present, chemical control is not recommended on communal farms. Spraying of the few scattered or intercropped cowpea plants will be difficult, and it is not yet certain that the damage from bean fly justifies chemical control. (Farming Systems Research & Extension Unit. 1999c)

In the Northern Territory of Australia, cowpea crop should be sprayed 3-4 days after seeding emergence for Bean fly control. A further spray 7-10 days after emergence may occasionally be necessary. (Cameron, A.G. 1999)

4.2.6 Parasitid weed (Striga)

- Common Name: Witchweed (English); onime (Oshiwambo); oludhigo (Oshindonga)
- Scientific Name: *Striga spp.*
- Order: Scrophulariales
- Family: Scrophulariaceae

A total of five *Striga* species are recorded for Namibia but the following three are the most common pests: *S. hermonthica*, *S. asiatica* and *S. gesnerioides*.

Pest status

There are not sufficient data to evaluate the pest status of parasitic weeds in northern Namibia. At present there is only evidence, that all three *Striga* species are widespread but not common. The existence of local names for parasitic weeds, however, indicates that it may be important to some farmers.

The pest status is complex because the forms of parasitic weeds that are found on one species cannot germinate on another host plant. Careful observations and records are therefore necessary to clarify which crops are parasitised by which species.

Biology

The tiny brown seeds of *Striga* can stay dormant in the soil for many years, but they cannot germinate until the right host plant is grown in the field. In order to germinate, the seed must be in close contact with roots of young host plants, such as for instance sorghum, millet or cowpea.

The roots of the host plant release chemical substances that trigger the germination of *Striga* seed. This parasitic weed then develops a specialised structure (haustoria) that links the *Striga* to the host plant. More haustoria develop, until the *Striga* is closely anchored to the host plant and can suck nutrients and energy from the host.

Germination of *Striga* typically happens 10 days after the first rains, while host plants are developing. The attack is underground, and the main damage has already occurred, before the *Striga* can be seen above ground. Later on, it develops its own leaves and is less dependent on the host plant.



Fig. 32. Witchweed (*Striga gesnerioides*)

Striga flowers a few weeks after germination and each plant may produce as many as 20 000 seeds. These seeds need about six months to break their dormancy and then stay viable in the soil, waiting for the next host crop to be planted.

Control

Control of *Striga* is difficult and time consuming. At present, chemical control is not recommended, as the chemicals are expensive, handling of them is very difficult and no research results are available to support chemical treatment..

Farmers are advised to improve soil fertility where this weed is a problem. Soil fertility has an effect on *Striga* infestation; the more fertile soils are less infested with *Striga*. Use of manure and/or small amounts of fertilizer may reduce the infestation, when combined with weeding of

plants before seed setting.

Hand weeding of the infested areas before it set seeds is the most important control method at present. *Striga* should be weeded out as soon as any flowering is observed, as the

development of seeds takes only a few weeks. It may be necessary to weed the area twice in a season. (Farming Systems Research & Extension Unit. 1999e)

4.3 Stored grain pest control

Low Temperature

A serious post-harvest of cowpea stored grain is cowpea weevil *Callosobruchus maculatus*, (Coleoptera: *Bruchidae*). Loss of methyl bromide and possible restriction of phosphine in addition to rising popularity of organic produce lines has created interest in non-chemical disinfestations treatments.

In developed countries, one alternative is the use of cold storage. Johnson, J.A. and Valero, K.A., 2000 found that exposures to -18 °C during 6 to 24 hours reduced pest numbers by more than 99 percent (Table 18.)

Table 18. Survival of adult cowpea weevil after exposure to -18°C

Exposure (minutes)	Active	Moribund	Dead	% Reduction
0	30	0	0	-
10	28	0	2	6.7
20	25	0	5	16.7
30	5	4	21	83.3
40	5	4	21	83.3
50	0	2	28	100.0
60	0	6	24	100.0

Source: (Johnson, J.A. and Valero, K.A., 2000)

Good Hygiene and chemicals.

Good hygiene is an essential part of insect control in stored grain. Other options for pest control include:

- cooling grain with aeration,
- drying,
- treating grain by mixing Dryacide or residual chemicals,
- treating infested grain with dichlorvos,
- fumigation (bombing) with phosphine, or
- controlled atmosphere treatment (e.g. carbon dioxide),
- treating storages and equipment with Dryacide or residual chemicals.

A combination of good hygiene, aeration, drying, treating storages and equipment, and mixing chemicals or Dryacide with the grain is effective to prevent or reduce the chance of infestations developing. If insects are found, grain could be treated with dichlorvos, fumigate with phosphine, or apply a controlled atmosphere treatment.

Insecticides, especially the dust form and the gas form are recommended for short-term storage. The product Actellic (2%) or Actellic Super and Phostoxin gas are very helpful to the farmer punctually. However, insecticides are expensive and may not be available in all areas. Phostoxin is a fumigant that can kill humans and animals. (Ntoukam, G. *et al.*, 2000)

Table 19 gives general guidelines for the pest control options that can be used for various grain types and markets.

Table 19. Pest control options for various grain types and markets

Treatment		Cereal grains* for:			Pulses*or Oil-seeds*	Any grain for organic markets
		On-farm use	Markets accepting residual treatments	Markets not accepting residual treatments		
• Hygiene		a	a	a	a	a
• Aeration		a	a	a	a	a
• Drying		a	a	a	a	a
• Controlled atmosphere		a	a	a	a	a
• Phosphine fumigation		a	a	a	a	r
• Dichlorvos		a	a	r	r	r
Treatment of storages and equipment	Dryacide	a	a	a	a	r?
	Residual chemicals	a	a	r	r	r
Mixture with grain	Dryacide	a	r	r	r	r?
	Residual chemicals	a	a	r	r	r

Cereals include: barley, maize, millets, oats, rice, sorghum, triticale, wheat
 *Pulses include: **cowpea**, faba beans, chickpea, , field pea, mung bean, navy bean, soybean, pigeon pea
 *Oilseeds include: canola, linseed, safflower, sunflower
 a: (accepted) can be used
 r: (restricted) cannot be used
 r ?: some organic markets are reported to accept this treatment, others do not

Timely delivering

Delivering the grain to a bulk handling company or a buyer within six weeks of harvest usually avoids pest problems, and should be regarded as a pest control option if equipment for other options is not available.

Integrated Pest Management

Given that 70 percent of farmers growing cowpea apply pesticides as often as 8 times per season in Uganda, IITA has provided, introduced and tested new varieties resistant to insect attack, and simultaneously IPM-CRSP has assembled two IPM packages for cowpea that integrate well timed insecticide spray application (once each at budding, flowering and podding) with cultural practices including early planting, manipulated plant densities and cowpea/sorghum intercrop. The results have been found to be effective in reducing insect pest on cowpea and increasing grain yield by over 90 percent (IPM CRSP, 2000)

Neem oil

In Togo, Benin and other African countries in the eighties, GTZ extended a stored cowpea protection method based on the use of neem oil (SPV/GTZ, 1988). This method offered the following advantages in small-scale farming:

- it was easy to apply;
- it required locally available resources;
- Raw materials were free and
- it posed no risks to users and consumers.

In practice, harvesting and oil extraction and application go through the stages described in Fig. 33. Given the considerable losses caused by bruchids and the advantages mentioned, there is no doubt that the recommendations responded to a real and serious problem, and that the proposed technology had all that was required to attract the interest of the rural target groups.

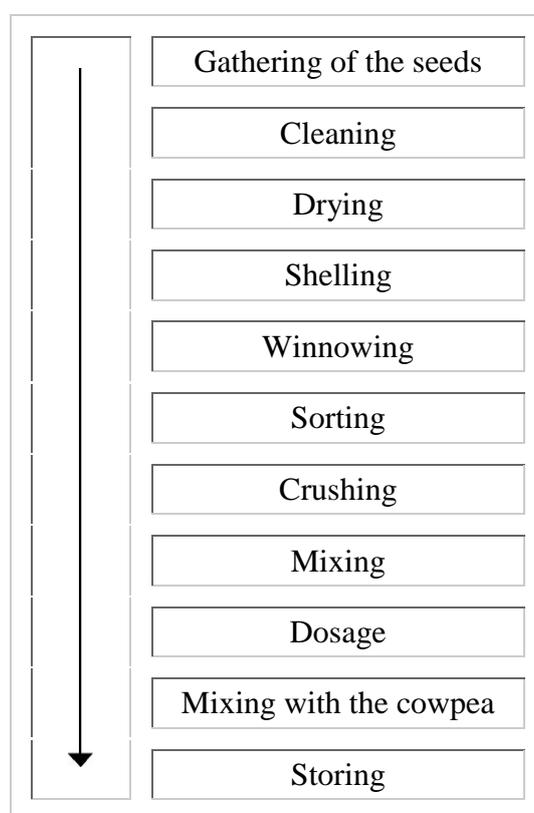


Fig. 33. Protection stages of stored cowpea with neem oil.

In fact, farmers found that neem oil was very difficult to extract and also it was very bitter. In spite of all the effort at extending it, the adoption rate for the preservation of cowpea with neem oil remained generally low. Informal investigations carried out in the framework of the extension programme in Benin revealed that the collection of grains, and most especially the cottage industry production of oil were considered too energy and time consuming. Furthermore, the bitter taste of neem oil discourages many farmers from applying it on beans meant for consumption, even though the taste is completely removed when soaked for a long time in water.

A lesson to be drawn from these experiences is that "generally, all technical innovations in the post-harvest sector posed socio-cultural or socio-economic problems", for example:

- Low profit margin;
- Additional workload;
- Contradict traditional practices.

The divergence between technical recommendations and the realities of rural life translates in most cases into a low adoption rate and unsustainable innovations.

It also appears that in Togo, the state is not in a position to resolve all the problems associated with the development of post-harvest systems. This is why non-governmental organization, private organization such as traders were addressed more and more in interventions. (Bell, A. and Muck, O., 2000). This situation is true for many developing countries.

Solarisation and biorational products

The efficacy of using biorational products, solarisation, and synthetic insecticides to control bruchid damage (*Acanthoscelides obtectus* and *Callosobruchus spp*) in stored beans and cowpea was compared by IMP-CRSP in Uganda. The most effective treatments for cowpea were solarisation, tephrosia and tobacco.

An economic assessment of these same treatments indicated that wood ash, solarisation, tephrosia, and tobacco provided economically viable post-harvest protection of beans and cowpeas for up to 3 months.

On the other hand, the economic analysis determined two important differences on the results of the biological analysis. Firstly, mixing cowpeas with tobacco powder was viewed favourably from a biological perspective though this option was not found as economically viable. Secondly, treatment with wood ash did not appear to be very efficacious from a biological perspective but profitable because ash was valued at zero opportunity cost. (IPM CRSP, 2000)

It is convenient to point out that storage of cowpea grain in ash will arrest an initiated infestation, although it does not immediately kill insects already living within the cowpeas. However, the insect do fail to reproduce and will eventually die. (Ntoukam, G *et al*, 2000)

Solar disinfestations technology is an effective, low cost, non-toxic pest control process, which does not alter the physical, cooking, nutritive, and other desirable properties of the cowpea grain (Nyankori, J., 2002). Exposing threshed cowpea to solar radiation on a simple solar heater developed at Purdue and tested/improved in Cameroon can kill within minutes, resident infestation of cowpea weevils in grain. Fig. 34 shows women and men exposing to solar radiation cowpea grains by using a plastic sheet.



Fig. 34. Solarisation to disinfect cowpeas

This technique has already undergone testing and extension in Cameroon in many african countries, namely, Burkina Faso, Mali, Nigeria, Chad, Benin, Ghana and Zimbabwe in West Africa region. Storage bulletins written in English, French and Fulfulde as well as training film have been developed. (Ntoukam, G *et al*, 2000)

Metal drums plastic sheets and plastic bags

In 1998 CRSP carried out studies on feasibility of metal drum storage, especially with botanicals, steam treatment and other storage technologies for rural and urban use. Results have indicated that like the solar heater and triple bagging, drum storage has the greatest economic advantage for long storage periods (e.g. > 3 months).

Metal drum storage has a lower labour requirement than solar treatment or insecticides because the grain is handled only to fill and empty the drum. For solar or insecticide treatment the grain must be handled an additional time. Use of botanicals would add mainly to the labour cost of drum storage. This is because of the time required to find and prepare the appropriate plant materials.

In Senegal, drum storage is economical because of the large supply and hence modest cost of steel drums. In other regions, drums are often sold at higher prices and drum storage may be less economical than triple bagging, solar treatment or other storage technologies. The economics of steam treatment for storage was not attempted because it is too early in the development process of the region for an economic feasibility study like this.

The permanent placement solar heater being developed in Cameroon appears to have about the same cost per kilogram of grain treated as the plastic sheet solar heater.

The principal economic advantage of the permanent placement solar heater is that it has a long useful life. It has been estimated a useful life of 10 years for the corrugated aluminium that forms the bottom of the heater. The plastic sheets deteriorate with exposure to the sun. They eventually shred along the edges and tear. Their useful life with heavy use is about 2 seasons.

For a 3-month storage period the permanent placement solar heater costs almost the same on a per kilogram basis as the plastic sheet solar heater (Table 20). The insecticide treatment cost for 3-month storage is slightly lower than the per kilogram cost of the lower volume solar heater and slightly higher than that of the higher volume solar heater.

For a 6-month storage period the solar heater shows a greater advantage over insecticide treatment than in the 3-month storage case. This occurs because insecticide treatment must be repeated in 3 months involving an additional outlay for more insecticide. (Bean/Cowpea CRSP West Africa, Social Science Report April-Sept., 1998)

Table 20. Comparison of Costs of Cowpea Storage Using Two Types of Solar Heaters or Insecticide, 1997.

Item	Plastic Sheets Low Volume	Plastic Sheets High Volume	Permanent Placement Low Volume	Permanent Placement High Volume	Insecticide
Volume Treated, (kg)	2 000	4 000	600	1 200	80
Annualised Materials Cost, FCFA*					
Woven Bags, 80 kg	7 500	5 000	2 400	4 500	300
Solar Heater*	5 400	5 400	938	938	0
Actellique	0	0	0	0	260
Labour	?	?	?	?	?
Cost for 3 Months Storage					
Opportunity Cost of Capital, FCFA**	6 338	7 275	2 739	3 001	70
Materials Cost per kg stored, FCFA***	10	7	10	7	8
Cost for 6 Months Storage****					
Opportunity Cost of Capital, FCFA**	7 275	9 150	3 039	3 654	173
Materials Cost Per kg stored, FCFA***	10	7	11	8	11
*Cost in this line is straight-line depreciation. The useful lives assumed are: plastic sheets, 2 years; aluminium sheets, 10 years. The plastic sheet solar heater is assumed to be 3m x 3m.					
** Opportunity Cost of Capital is 50%.					
*** Storage cost per kilogram includes opportunity cost of capital invested in materials.					
**** Calculations assume that insecticide and solar heater treatments must be repeated every three months (if grain is not triple plastic bagged). Insecticides must be purchased for the repeat treatment.					

Three 50 kg capacity plastic bags placed one inside the other can provide affective airtight conditions. This storage method is widely used in Cameroon and many countries in West Africa. (Ntoukam, G., *et al*, 2000)

Plastic bucket, solarisation and kim-kim solution

On-farm trials in farmers' stores, to test the most promising treatments for protecting grain pulses identified in station trials, revealed that hermetic storage in plastic buckets is very effective. Unfortunately it was also the most expensive form of protection tested and is therefore unlikely to be adopted by farmers.

Thermal disinfestation (seeds laid out in the midday sun for 3hrs) proved to be very valuable followed by treatment with "kim-kim" (*Synedrella nodiflora*) solution or admixture with

"shea" nut butter. Farmers have more recently commented that it discolours cowpea grain, which deters consumers and reduces the market value. (New Agriculturist on line)

Treatment for traders: cotton or plastic sheet with inert dust

In northern Ghana, other than bruchids, a major pest is Khapra, *Trogoderma granarium* beetle that causes high damages of cowpeas, local maize and groundnut because pest control is usually ineffective, if not hazardous, particularly in the case of indiscriminate use of aluminium phosphide fumigation tablets and the incorrect mixture of synthetic insecticides. Additionally, the conditions in stores have been observed to lack the most basic storage hygiene, which makes cross-infestation (from neighbouring stores) and re-infestation from one season to the next, unavoidable.

A Communal Fumigation Centre has been provided in Tamale, Ghana where trained personnel carry out management of the site and fumigation work. Traders pay a small fee per bag for treatment of stored grain.

Although fumigation allows the disinfection of large quantities of stored grain, it does not provide long-term protection. To provide long lasting protection, alternative procedures have been tested such as cotton or plastic sheeting placed over stacks of fumigated bags (to act as a physical barrier to insects) and dusting stack surfaces with the inert dust, Dryacide. With good hygiene in the store, re-infestation did not occur until after five months of storage. Traders were impressed with the effectiveness of these cheap and simple techniques, as they had been provided with the means to store and sell good quality produce and obtain premium prices. They are now anxious to have storage facilities improved and discussions are being held with the Tamale Municipal Council, which is keen to offer support. (New Agriculturist on line)

4.4 Field pest control

Chemical weed control

No specific information is available on tolerance to herbicides. According to (Duke, cited by UC SAREP), amines of 2,4-D and MCPA are used as preemergence sprays and Trifluralin before sowing gives good weed control.

Weed control options are less than soybeans, but more than many other crops. In the United States Labeled herbicides* are Dual, Poast, Pursuit, Treflan, and Sodium Chlorate. Pursuit and Treflan both provide some broadleaf control, while all the products control grass weeds. However, row crop cultivation may be more necessary than for soybeans, depending on the weed pressure, soil conditions, and rainfall. Preplant tillage can greatly help reduce early weed pressure. Trifluralin is the only herbicide register for use on cowpea. (Imrie, B. 2000)

Chemical diseases control

The following fungicides* are registered for cowpeas: Mefenoxam, Metalaxyl, Mycostop, Ridomil-Gold, and Thiram.

The following insecticides* are registered on cowpeas: Azadirachtin, Bacillus thuringiensis, Di-Syston, Gaucho, Guthion, Insecticidal soap, Lorsban, Mattch, Methaldehyde, Methomyl, Methoxychlor, Pyrellin, Pyrethrin, Sevin, Success, Telone, and Trilogy. (Quinn, J., 1999)

* Pesticides mentioned as being labeled are based on reference lists published in the Thomson Publications "Quick Guide" on crop pesticides, 1999 edition. These lists are believed to be accurate, but given the changing nature of herbicide registrations, labels and relevant government regulations should be checked before approving any pesticide.

Genetic

On the other hand, IITA has developed high-yielding varieties for both sole and intercropping, with resistance to major diseases, insect pests, nematodes, and parasitic weeds. Over 60 countries have released improved cowpea varieties from IITA.

Researchers are continuing to develop new varieties with high grain and fodder yields that can be used in traditional farming systems. Varieties with resistance to parasitic weeds such as *Striga*, are under testing in farmers' fields. Early maturing varieties with increased drought and shade tolerance are also being developed. (IITA Research, 2001)

The most important source of resistance to *Striga* in semiarid West Africa are B301 and IT82D-849 these two lines are resistant to 4 of the 5 races of the parasite found in these areas. Complete resistance to all five have been sought in recombinants of the race differential varieties.

The cowpea variety Moriede and Melakh developed by the ISRA/CRSP research, are largely diffused in Senegal. Mouride is a medium maturing cultivar adapted to the semiarid zones of the Zahel with resistance to CabMV, bacterial blight, *Striga* and Bruchid. Melakh is an indeterminate early variety, adapted to the short rainy season of the Zahel. It has resistance to CabMV bacterial blight and aphids. (Cissé, N. *et al*, 2000)

Breeding to combine seed and pod resistance is another tool to reduce losses. Screening for pod resistance to cowpea weevil has revealed several high-yielding IITA lines with high pod resistance; also, five local lines appear to be highly resistant. Two cowpea lines of that order (LORI NIEBE and CRSP NIEBE) were developed and tested in IITA Breeding Program. A sweet cowpea variety has also been identified: 24-125 B. (Ntoukam, G. *et al*, 2000)

Biotechnology

Molecular biologists at IITA are also working to develop improved cowpea varieties, through transfer of useful genes such as those encoding plant and bacterial proteins that kill insect pests of cowpea. This is still at the experimental stage, and rigorous field testing will be carried out before transgenic cowpeas are released. IITA holds the world's largest collection of cowpea germplasm in its genebank, more than 16 000 accessions, or plant samples. (IITA Research, 2001).

One promising avenue to introduce new sources of insect resistance into cowpea involves genetic transformation, using resistance genes taken from other plants that may not be easy to cross or that may even come from bacteria or fungi. The current state of the art is as follows:

- genes are available that would impart a high degree of resistance to at least two insect pests of cowpea, (*Bacillus thuringiensis* crystal toxic, effective against *Maruca testulalis* legume pod borer, and α -amylase inhibitor, effective against cowpea bruchid *Callosobrochus maculatus*. (Shade *et al.*, 1994 cited by Murdock, L and Nielsen, S.S., 2000);
- cowpeas cells have been transformed with foreign genes, but so far no one has successfully transformed germ-line cells, and
- methods have been developed that allow cowpea plant to be regenerated from cowpea tissue or cluster of cowpea cells. (Kononowicz *et al.*, 1993 cited by Murdock, L and Nielsen, S.S., 2000).

A new cowpea variety, California Blackeye No. 27 (CB27) has been developed. CB27 has resistance to a broader range of root-knot nematodes as well as it has resistance to 3 of 4 *Fusarium* wilt. (Hall, A. *et al*, 2000.)

4.5 Others

Biotechnology

Murdock, L, 2002 have proposed genetic engineering because he doesn't know other viable ways to circumvent the huge losses insects cause. He affirmed "We can put insect protection into the seeds the farmers plant through genetic engineering" thus offering a new weapon against insects.

Murdock considers that genetic modification is a powerful and efficient way to introduce new sources of resistance into cowpea by taking genes from one organism and putting them into cowpea cells. One gene it expected to use is that encoding "Bt", a powerful protein toxin that is highly specific to insects. "Bt" is the favourite insecticide of organic farmers, by the way. Another gene which may be used is that encoding "alpha amylase inhibitor", taken from common bean. In effect, we would be taking a gene from common bean - which people eat - and putting it in cowpea, which people eat in about the same way. Both of these genes would impart a high degree of protection against major insect pests of cowpea. Farmers could plant these seeds and never have to use insecticides. Insect protection would already be in the seed. In 2001, a Dakar meeting of the NGICA - the Network for the Genetic Improvement of Cowpea for Africa - recognized the need to use the tools of modern molecular biology to genetically transform cowpea. (A BIOTECH, 2000).

IPM

The fundamental aim of IPM is to prevent unacceptable losses to pests while minimizing the use of chemical insecticides. The IPM approach was developed, at least partly, because of a historical pattern of overuse of insecticides. Continued use of an insecticide eventually causes the targeted insect population to become resistant. There are several features of an IPM program:

- knowledge of the insect pest is essential, its life history and ecology;
- knowledge of the crop it lives on, in our case, cowpea;
- knowledge of the insect levels that cause significant damage, the economic injury threshold, allows appropriate action to be taken;
- monitoring of the pest insect populations is another requirement;
- knowledge of the pest population levels makes it possible for the grower to intervene when it is necessary and useful to do so, and not to intervene when it is unnecessary.

This saves labor, time and materials and reduces insecticide use. In short, when control measures are necessary, IMP offers a variety of options that may be used. These may be cultural actions such as picking insects from the plants, the use of natural enemies like predators or parasitoids of the pest insect, or the use of chemical or botanical insecticides. Other actions of the grower can reduce the insect problem below the economic threshold. The grower can plant cultivars that are genetically resistant to the insect, or plant in intercrop culture (which in some cases decreases insect pest levels), or plant later in the season or earlier in the season. (Bean/Cowpea CRSP West Africa Mission).

5 Economic and Social Considerations

5.1 Overview of costs and losses

Cowpea suffers heavily from insects, both in the field as well as when the grain is stored after harvest. Yield reductions caused by insects can reach as high as 95 percent, depending upon the location, year, and cultivar.

Although insecticides are widely available, they require expensive equipment and training for their use, they are expensive, polluting and potentially dangerous to users. Consequently, a

great many cowpea growers in Africa don't use insecticides, can't obtain them, or can't afford them, don't have the necessary equipment, or haven't been taught how to apply them properly. That is why conventional insecticides are not the answer to the insect problems. Insects continue to damage cowpeas after harvest. The major pest is the cowpea weevil. A single cowpea weevil female can reproduce herself 20-fold every 3-4 weeks. Harvested cowpea grain that has a very light infestation - which starts in the field before it is stored - will have a heavy infestation within two or three months. Foods prepared with this grain have an unpleasant flavour. If taken to market, the price of this grain is discounted. (Bean/Cowpea CRSP West Africa Mission)

5.2 Major problems

Small holders and medium scale farmers are facing five factors that constitute the mayor constraint on cropping, storage and consumption of cowpea. They are the following:

1. Abiotic: erratic rainfall, high soil temperatures, low soil fertility and degraded fragile soils;
2. Biotic: insect pests, parasitic weed, diseases induced by fungi, viruses and nematodes;
3. Socio-economic: farmer capacity to produce inputs is limited and input delivery systems function poorly. Seed of improved varieties (e.g. Melakh an Mouride) is not widely available. The difficulty is linked to the high value of cowpea green pods for family consumption and sale. Farmers are reluctant to leave any improved variety mature for seed.
4. Socio-cultural: low acceptability of cowpea new formulation as well as low adoption of some improved post-harvest technologies. Change in taste and urbanization, which has favoured the importation of food and the neglect of indigenous food crops;
5. Political: negative or neglected position of the developing countries governments to resolve the problems associated with the development of post-harvest systems.

Within biotic factor, insects in the field causes the most important losses; sometime cowpea field yield is reduced to zero in developing countries. But yield losses in the field are only half the problem. Once the crops has been harvested, the grains continue to be damaged by enemy insects, particularly weevil (bruchid post-harvest pest) can destroy or induce quality degradation a granary full of cowpeas within two or three month. But the people need to have grain to eat for 12 months a year. (A BIOTECH, 2000)

In general, all technical innovations in the post-harvest sector posed socio-cultural or socio-economic restrictions. The most common are:

- Low profit margin;
- Additional workload;
- Contradict traditional practices. (Bell, A. and Muck, O., 2000).

5.3 Proposed improvements

The Food and Agriculture Organization of the United Nations (FAO) reported that across Africa, a continent with 646 million people, protein energy malnutrition affects 40 percent of children under three years of age, with 5 percent of the children classified as severely malnourished. (FAO, 1974 cited by Osho, S.M and Dashiell, K. 1997).

Recent statistics show that for the past 30 years, food production rates in Africa have declined compared with population growth. The food deficit has been maintained by food importation. However, rising costs of grain worldwide will seriously threaten this strategy, leading to greater food insecurity. Dietary protein deficiency is particularly critical in Africa because many people cannot afford regular supplies of protein-rich foods

5.3.1 Increasing of cowpea utilization

Consequently, the first proposed improvements of this document are focused in increasing of cowpea utilization by poor people particularly in the African continent. According to Phillip, R.D. *et al.*, 2000, there are three mayor components in increasing cowpea utilization. They are basically the same in West Africa and the United States:

1. to discover and transfer to consumers information on the health and nutrition promoting qualities of cowpeas.

Chemical and nutrition properties of cowpea-based foods determine both sensory quality and efficacy in meeting nutritional needs. Processing may also affect the content of bioavailability of cowpea carbohydrates. While extrusion has been shown to greatly increase the digestibility of starch as well as protein, germination has less effect.

On the other hand, the research has shown that germination reduces both the aligosaccharide content and the flatulence. Cowpea is a significant source of vitamins, although fortification with others is necessary in products like weaning foods. The same is true of minerals. Germination actually results in modest increases in some of B vitamins. The availability of amino acids, starch and micronutrient depends on the content of antinutritional compounds, of which cowpeas contain several of them.

2. to develop specific cowpea-based foods and ingredients.

Many traditional african food that have been fortified with cowpea are customarily made of cereal or other starchy products and most are fermented with naturally occurring lactobacterias and other microorganisms.

The focus has been on where in the process, cowpea may be introduced, how much can be used and whether or not it can undergo fermentation. There are several dishes using cowpea flour produce in the household (Adunlei, Ayikaklo, Ayitale, Cowpea cake, Cowpea fritter, Kitikiti and many other) that provide a varied nutritious diet and have added desirable attributes, which include easy cooking, availability and favourable taste. (Nyankory, J., 2001). Cowpea flakes have been provided for use in treating acutely malnourished children in studies at Accra's hospitals have shown effective in reversing malnutrition.

3. to develop mechanisms for incorporating cowpeas and cowpea-based ingredients into foods and the diet.

Extrusion cooking is an extremely versatile process that, by subjecting raw cereal and legume flour to a unique combination of high temperature, shear and pressure for a few seconds is capable of completely cooling and sterilizing the resulting product, which range from precooked weaning food to expended snacks.

5.3.2 Abiotic, biotic and socio-economic constraints

Considering that constraints on cowpea development occur in three broad areas, namely, biotic, abiotic and socio-ecoomic, IFAD have proposed an interesting programme with main research areas that involve:

- using participatory methods, introducing and disseminating among farmers technologies such as improved cowpea varieties which show greater resistance to diseases, insects, drought, heat and parasitic weed and adaptable to poor fertility soils;
- developing and disseminating to farmers integrated production packages, including IPM technologies developed by PEDUNE.
- seed multiplication and the diffusion of improved cowpeas (IFAD, 2000). In agronomic terms, there is the need, therefore, of an effective seed multiplication and distribution systems to be improved upon so as to enhance farmers' access to improved varieties. (**)

- To achieve greater impact, improved varieties would need to be used for dry cowpea production, not only used for green pods. (Bean/Cowpea CRSP West Africa, Fy 96 Annual report October, 1995-April, 1997)

5.3.3 Consumer preferences

Concerning consumer preference, it is essential to know the developing cowpea market. Breeder needs to know what characteristic consumers want. Integrate management pest specialists need an estimate of the consumer-level cost of grain damage. Consumers are more sensitive to bruchid damage than it is thought.

5.3.4 Post-harvest systems analysis

The post-harvest system analysis is a very valuable strategy tool. It provides an integrated overview of the different levels, which are usually examined separately, such as the macro-economic and legal framework, the behaviour of the system, bottlenecks in the chain, as well as the potential for investments and development.

Generally, the production, stability and flexibility of a system serve as performance indicators. Here, it involves the ability to respond to future production and demand trends.

Indicators should be prepared especially for the following two areas:

1. the comparative evaluation of the effectiveness and transaction costs of the different goods, regions and countries (e.g., the share of original farm prices in wholesale prices, transportation costs, etc.);

2. the analysis of institutional failures and the need for government intervention:

- market failures (lack of markets, cost of excessive transaction, lack of information, external factors);
- institutional failures (policy failure, administrative failure, lack of intervention in the case of market failure). (Bell, A. and Muck, O., 2000)

It is possible to analyse each link in the post-harvest chain by focusing on the constraints and the subsequent need for intervention. Below is an example drawn from the study carried out in Kenya (Anonymous, 1997).

In the second place, the constraints identified can be classified according to their degree of priority and evaluated according to their influence on the other correlation within the system.

5.3.5 Political aspects

With regard to post-harvest systems development, it is the government's responsibility to define the policy framework for development and to establish public services, which the private sector does not provide. Such "public goods" include the creation of infrastructures, the assurance of a legal guarantee, fair market activities, etc. Governments should not try to intervene actively in the market, but rather intervene indirectly by encouraging the private sector through support services like extension. (Bell, A. and Muck, O., 2000).

5.4 Gender aspects

In Africa, cowpea provides a source of cash income for women farmers who make and sell snack foods from this nutritious legume. (Okike, I., 2000). In Cameroon most of the cowpea green pod marketing is handled by women; in many african countries, woman harvest and sell direct to consumer on roadsides, because pod prices are higher than dry grain prices. (Fig. 35)

In August 1998 informal interviews were conducted with Ghana Ministry of Food and Agriculture personnel at the Ejura CARS. A focus group interview was conducted with about 15 of the participating farmers (about half of whom were women).

The focus group participants indicated that they had joined CARS because they wanted to acquire the knowledge being imparted, they wanted to teach their husbands this knowledge, they thought IPM might help them make a better profit on their cowpea, and hoped that IPM can improve their farming so that they can more adequately provide for their families.



Fig. 35. African women harvesting cowpea

There did not appear to be any gender differences in relation to motivation to learn IPM in hopes of adopting it. Rather, the majority of these participants seemed keenly concerned about the economics of their current farming, and needed less costly alternatives. In addition, most also simply wanted the knowledge. (Bean/Cowpea CRSP West Africa, Social Science Report April-Sept., 1998)

Women in Cameroon appear to sell cowpea for a higher price than male vendors, probably because women sell in small quantities for immediate consumption. (Faye, M. *et al.*, 1999). In general, african woman are retailers who acquire the grains from wholesalers and commission agent to sell smaller quantities in local markets as it is shown in Fig 36.



Fig. 36. Cowpea on sale on Tamale market (Northern Ghana)

In Nigeria, men particularly value the income and food benefits, while women emphasize home cooking and consumption and the feeding of small ruminants.

(CGIAR SYSTEM-WIDE LIVESTOCK PROGRAMME, 2000).

Women use CRSP storage technologies, particularly solar heaters, because they often not have access to storage insecticides. (Bean/Cowpea CRSP West Africa, Fy 96 Annual report October,1995-April, 1997).

A rapid appraisal survey of adoption of cowpea varieties and storage techniques carried out in 1996 in the northern Peanut Basin of Senegal indicated that both men and women use the improved varieties and the metal drum for grain storage.

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