Production, Processing and Marketing of Pulses in West Africa

— Considering Inter-Regional Markets and Improving the Living Standards of Local Residents through a Case Study of the Republic of Benin —

JAICAF ジェイカフ

Japan Association for
International Collaboration of
Agriculture and Forestry

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Cover Page: Painting of a water jar with holes supported by three hands. This was the symbol of a king who once ruled over the Republic of Benin (formerly Kingdom of Dahomey). The water jar represents the country or society, and it is hoped that all citizens will work together to prevent water (state resources) from seeping through their hands.

Preface

Many developing countries are located in tropical or subtropical zones and therefore face severe natural, social and economic conditions, so their crop production level is relatively low and unstable. Faced with such circumstances, developing countries must tackle the challenge of increasing food production and at the same time fight population problems and poverty. Techniques developed by advanced nations located in temperate zones are not often applied effectively. Accordingly, with regard to agricultural cooperation for developing countries, research and studies on locally applicable techniques should be carried out while taking into consideration of specific geographical and social conditions; and there are many such requests.

The Association has implemented studies on the techniques of tropical agriculture and has published a "Tropical Agriculture Series" (two versions: "Tropical Agriculture Handbook" and "Tropical Crops Handbook") as part of their research and study program.

On this occasion, with the assistance of the Ministry of Agriculture, Forestry and Fisheries, the Association collected and analyzed basic information on subsistence crops and information on improving production technology in developing countries. In addition to information on subsistence crops which are deeply rooted in local areas, research and a study were conducted in the Republic of Benin (hereinafter referred to as "Benin") in order to examine the potential of new subsistence crops which can lead to the One Village One Product (OVOP). Although tubers (such as cassava and yams), grains (such as millet, sorghum, maize and rice) and plantain bananas, etc. can be listed as major food crops in Africa, in the said area, approximately 40 million people appear to be on the verge of starvation, and if the number of malnourished is included, it is said that the number will reach 200 million. Despite this, agriculture in Africa continues to be sluggish, particularly in the area of food crop productivity, which has fallen dramatically behind developing countries, making improvement an urgent task. As mentioned, pulse (leguminous) crops appear to be extremely important since they are an excellent source of high-quality protein for people.

In the preparation of this Report, a study team was dispatched to Benin in order to obtain more accurate, up-to-date information. At the same time, the Japanese Technical Committee established within the Association (chaired by Professor Makoto KATSUMATA) examined the context from a technical point of view. Four particular types of leguminous crops (cowpea, groundnut, Bambara groundnut and soybean) were discussed by the members who participated in the said study. Once again, I would like to express my gratitude

to the members of the Technical Committee for their valuable contribution.

In closing, I sincerely hope that this Report will be useful at the actual sites of international cooperation in helping to reduce the number of starving and malnourished people, improve food self-sufficiency, ensure food security, and reduce poverty in Africa.

March 2007

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Photo 1:
Pastry "*Kluiklui*" made from groundnut paste. Some are spiced with red chili pepper.

Photo 2:
Freshly-made *Tofu* (bean curd) colored by liquid (bowl on the right) extracted from red sorghum stems.

Photo 3:
Typical bean dish "*Abobo*". Large beans on the left are Bambara groundnut. Small beans on top are cowpea. White powder on the bottom is "*Gari*" made from dried cassava, and the green topping is *Kren-kren* which is sticky like okra.

Photo 4:
Black balls in the center are solid *Miso-like ball*, a substitute of "*Afitin*" made from the seeds of the *Néré* leguminous tree.

Photo 5:
Néré tree, *Parkia biglobosa* (Jacq.) Benth. Photo of *Néré* seeds is at lower left.

Photo 6:
Market at Parakou. Agricultural products can be seen everywhere including various varieties of beans.

Photo 7:
Cowpea fields stretching as far as we can see (Azowlisse, Ouémé River flood plain)

Photo 8:
Meeting to report the findings of the study; chairperson (Dr. Louis K. GNAHO/Deputy Chief is seated in the center.) at Ministry of Agriculture, Livestock and Fisheries.

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Introduction

The actual state of food crops, which are presently cultivated, processed, distributed and consumed extensively in Africa, have not always been recognized in Japan. And even if we were aware of the situation, the approach of natural science is usually applied exclusively to the agricultural characteristics of crops. Therefore, from the viewpoint of social science, little research has been carried out to determine where a crop is actually positioned in society and its relevance in the economy or how it contributes to the lives of local residents. However, a comprehensive analysis of both fields is certainly indispensable to development research in developing countries.

This Report clarifies the fundamental realities of regional markets in Benin through a comprehensive study of legume crops from production to consumption in West Africa. The usefulness of the Report in the following three areas will be established from the viewpoint of developmental studies and administration of international cooperation.

Firstly, pulse (leguminous) crops, which are the main dietary source of local residents, will be discussed. The basis of conventional research conducted on food crops, and mainly in rice, has been expanded so that the actual eating habits of West Africans can be grasped in a more precise manner. In actual fact, even during the colonial period, food crops for local dairy consumption attracted little interest from the ruling authority, which gave top priority to the promotion of cash crops for exportation. In addition, although varieties such as rice or cassava have been improved, leguminous crops appear to have attracted little public attention.

Secondly, since the rate of urbanization (5% to 6%) in West Africa exceeds the population growth (2% to 3%), the ability to independently provide safe, inexpensive food in a stable manner to a rapidly increasing urban population through food exportation without stressing the balance of international payments has become an important political issue in the governments of each country. In other words, improving the ratio of food self-sufficiency has now become their primary goal. And although leguminous crops did not make it into the limelight, they have great potential, by improving productivity and quality, better distribution and new processed product development.

Thirdly, rural development by promoting the sale of specific items often typified in the One Village One Product (OVOP) Movement can be pointed out. In the future, pulses, the main dietary source of urban West Africans, have marketing potential not only in one's own country, but in neighboring countries

as well. So it appears that, through careful marketing practices, pulses can break fresh ground.

Although the usefulness of pulse research described above was pointed out, this simply entailed the collection of basic data. In the future, in a more specific approach to examining the potential for improving the living standards of local residents through the development of leguminous crops, I would like to emphasize that further studies and research, including a survey of bean producers, distribution financing and inter-regional tariffs, are still necessary.

Chapter I　Agriculture in West Africa

1. Natural Environment of West Africa

1-1 Topography

Between 600 and 200 million years ago the continent of Africa was located at the center of the super continent called Pangaea, and it is believed that other continents such as South America became separated from Africa and moved to their present locations by the upward power of the plume (hot mantle material) thrusting the ground surface starting approximately 200 million years ago (Paleozoic Permian period of the Paleozoic Era to Mesozoic Triassic period of the Mesozoic Era). Despite erosion due to external forces, the average elevation of Africa today is still higher than that of any other continent. Especially, the average elevation of the southeast Africa is higher than the northwest Africa. Consequently, the southeast is referred to as “Upper Africa”; whereas, the northwest is often called “Lower Africa”.

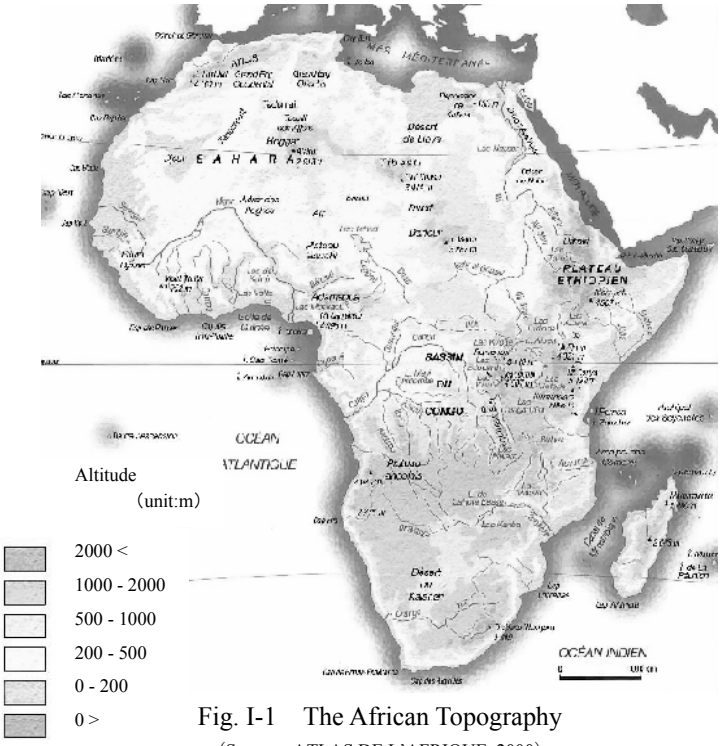

Fig. I-1　The African Topography

（Source : ATLAS DE L’AFRIQUE, 2000）

One reason of the difference in altitude between northern and southern part of Africa is the underground volcanic activity in the south which continues to raise the earth's crust even today. The earth rose when huge amounts of magma accumulated in the great cracks that were formed during the separation of the continents. As a result, the peripheral areas of Africa consist of highlands, and inland areas are relatively low basins, forming a dish-shaped topography (Yamagata, 2005). In West Africa, south of the Sahara (hereinafter referred to as "Sub-Sahara"), peneplains lower than 600m above sea level and a basement complex (West African craton) that is 1 to 3.5 billion years old dominate the terrain. The mountainous areas above 600m elevation in West Africa are the Mambila Plateau of eastern Nigeria near the Cameroon border, the Jos Plateau in central Nigeria, and the Guinea Plateau where the headstream of the Niger River (Wakatsuki, 1997). As mentioned above and shown in Figure I-1, Africa continent can be classified into two zones, 1) lowlands in the northwest Africa around the Sahara Desert, and 2) highlands stretching from Ethiopia to South Africa where volcanic activity continues even today.

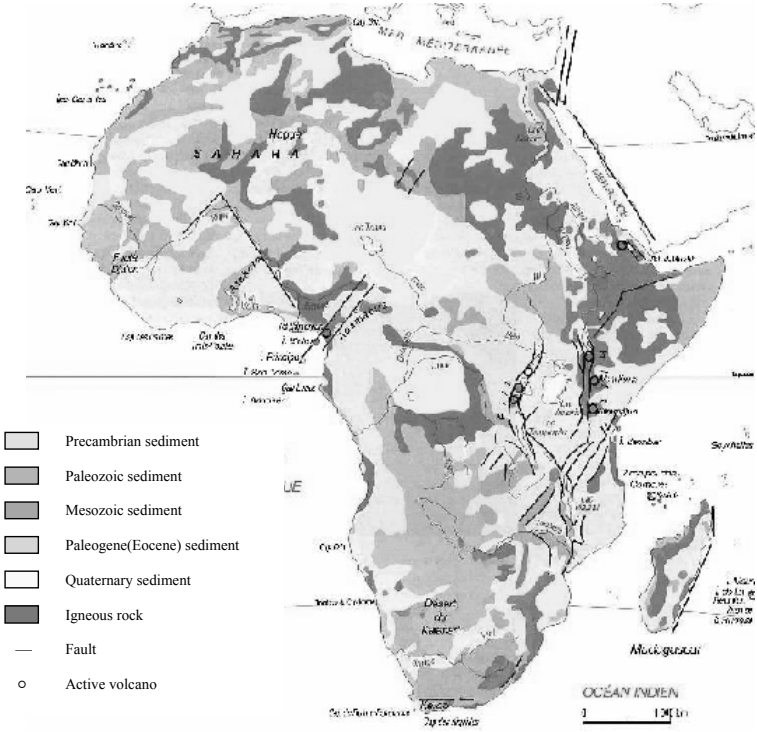

Fig. I-2 The African Geology

(Source : ATLAS DE L'AFRIQUE, 2000)

Furthermore, as illustrated in Figure I-2, Africa is an extremely old continent geologically. Therefore, soil fertility in the Guinea Savanna zone in central Africa is very low.

1-2 Climate

Both the Tropic of Cancer (35°N) in the Sahara Desert and the Tropic of Capricorn (35°S) in the Namib and the Kalahari Deserts traverse the continent of Africa. In addition, the African Continent faces the Indian Ocean to the east, the Atlantic Ocean to the west, the Antarctic Ocean to the south and the Mediterranean Sea to the north. Seasonal air masses that form over these waters greatly affect the climate in each region of Africa. The weather conditions in January and July are shown in Figure I-3. The rainy and dry seasons in the northern and southern hemispheres differ, and wind direction and rain patterns are influenced by air masses generated over the waters described earlier.

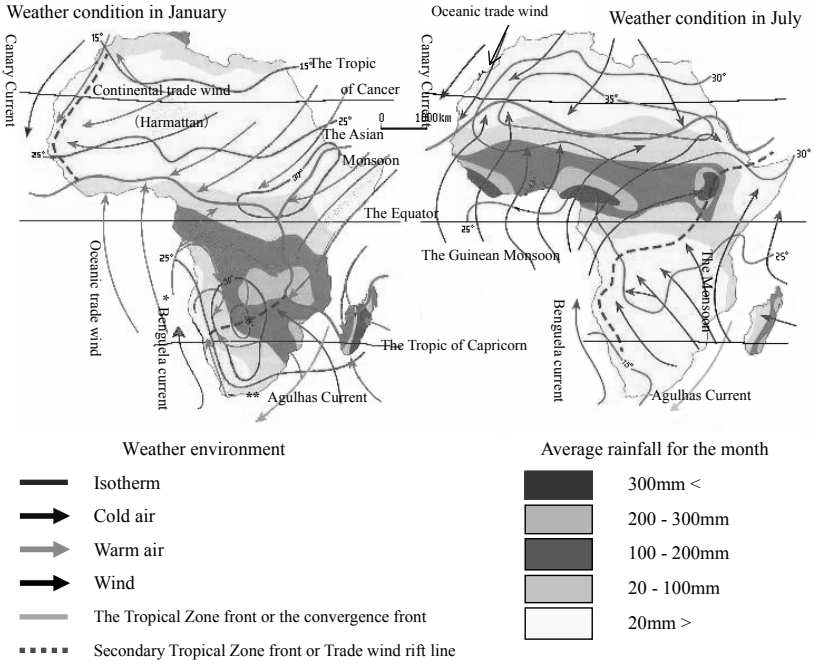

Fig. I-3 Climate condition in Africa

(Source : ATLAS DE L'AFRIQUE, 2000)

* Cold current moving north in the South Atlantic Ocean over open seas off Africa diverted by the Antarctic Circumpolar Current

** Warm current flowing from the India

A climate zone map of Africa is shown in Figure I-4. In West Africa, “Guinea Savanna” climatic zone spread from the coast of the Gulf of Guinea in West Africa to Central Africa. A desert climatic zone spreads to the north of Guinea Savanna zone across the extensive desert called the Sahara. Sandwiched by these climatic zones (despite more than 1,000 km between the north and south), the climatic zone of the steppe (hereinafter referred to as “Sahel”) and dry tropical climate (hereinafter referred to as “Sudan Savanna”) stretch from Senegal to Sudan. In addition, the yearly fluctuation in rainfall is extremely high in areas where annual rainfall is less than 600mm, resulting in severe drought in some years.

Annual rainfall in equatorial climatic zones is usually high. However, whereas rainfall in Abidjan (Côte d'Ivoire) between May to July is very concentrated, Yaoundé (Cameroon), which belongs to the same climatic zone, has two rainy seasons, from March to June, and September to October due to its higher elevation of more than 600m.

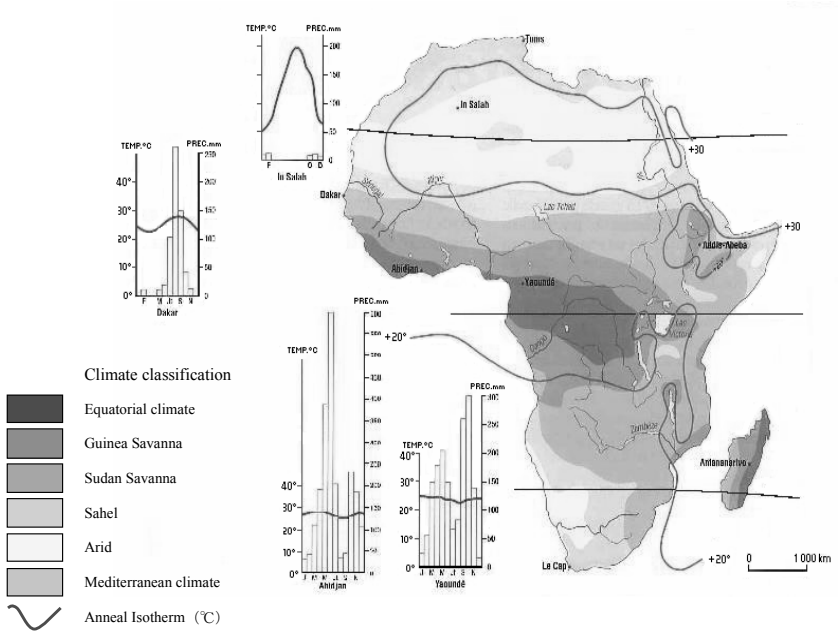

Fig. I -4 Climate Classifications in Africa

(Source : ATLAS DE L’AFRIQUE, 2000)

1-3 Vegetation

Due to the climatic divisions mentioned above, vegetation on the continent of Africa is characteristically different from the distribution of vegetation on other continents (Okitsu, 2005). The vegetation of entire Africa is shown in Figure I-5. Forest area is approximately 160 million ha (According to FAO statistics, it is less due to the absence of forest renewal since 1994), and tropical rainforest cover where the tree crowns are completely closed is estimated to be only 1.4 million ha at the end of 1985. At present, most tropical rainforest zone is used for farmland or has become savanna as a result of farmland being abandoned.

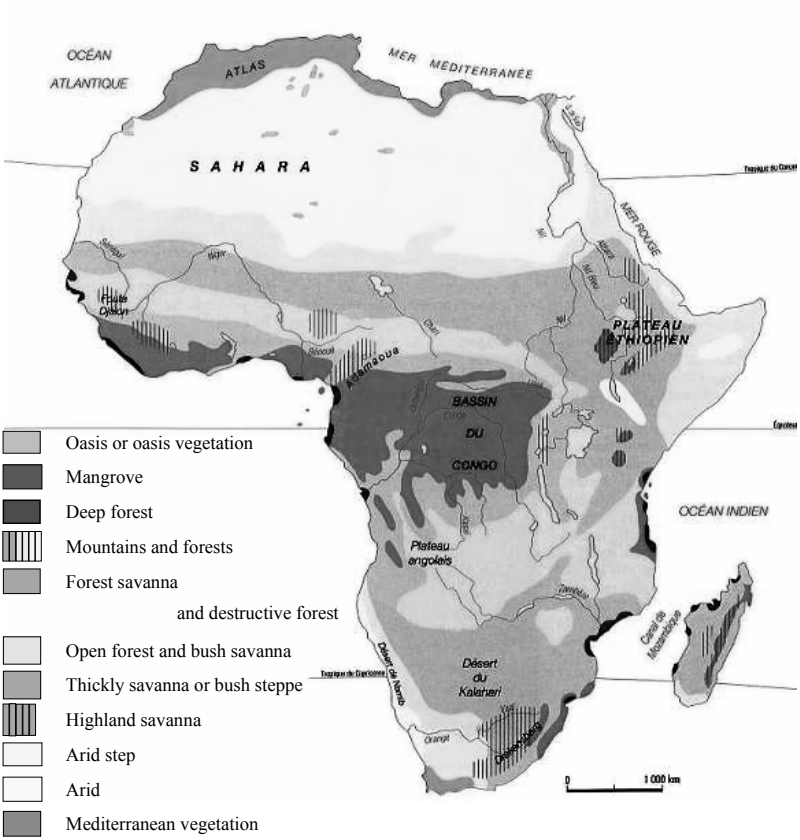

Fig. I -5 Vegetation in Africa

(Source : ATLAS DE L'AFRIQUE, 2000)

In West Africa, there appear to be approximately 3 million ha of mangrove and swamp forests, which are mainly distributed at the Niger Delta in Nigeria and from Senegal to Sierra Leone (Wakatsuki, 1997).

Although mountain forests are scattered throughout the Guinea Plateau and Mambila Plateau connecting the Cameroon Highlands, topsoil has been lost due to excessive upland rice shifting (slash and burn) cultivation, so there are many areas where no trees and grasses grow. Although forests were once cleared and the tea plantation was developed in the Mambila Plateau, it has been devastated and now consists of grassland or vegetation destroyed by excessive grazing by *Fulbe* nomads. As a result, grassland and soil erosion has become a serious problem. Consequently, most (over 80%) of the vegetation in West Africa is now sparse woodland or grassland (steppe) savanna.

2. Agriculture and Pulse Crops in West Africa

2-1 Historical Background

The fifteen (15) countries of Benin, Burkina Faso, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo are classified as West Africa. However, in some literatures, Chad and Cameroon are also included, and since the West Africa Rice Development Association (WARDA) includes seventeen (17) countries tobe member countries, these 17 countries are regarded as West Africa in this report.

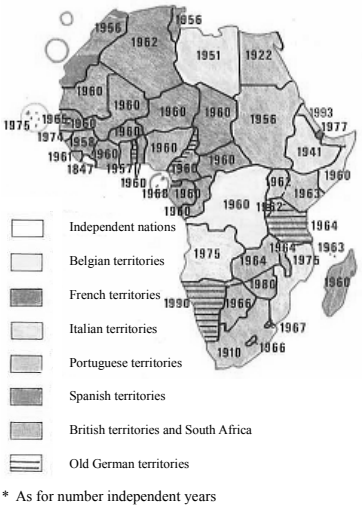

Fig. I -6 End of the colonization
(Source : ATLAS. J. A. DU CONTINENT AFRICAIN, 1993)

Although most of the countries have been independent of colonial rule since 1960, there are countries whose official language is English (Gambia, Ghana, Liberia, Nigeria, Sierra Leone and part of Cameroon), French (Benin, Burkina Faso, Côte d'Ivoire, Guinea, Mali, Mauritania, Niger, Senegal, Togo, Chad and Cameroon), and Portuguese (Guinea-Bissau). (Although there is an island nation in the Atlantic called the Republic of Cape Verde which is a former Portuguese territory located off the coast of Senegal, it has been omitted in this report for convenience sake.) However, since these countries were divided without the consent of

concerned parties based on the Berlin Conference (held at the end of the Russo-Turkish War) in 1878, the spheres of tribal language groups do not coincide with the current national borders.

For example, *Fulani* nomads* who are widely distributed across West Africa and live on a traditional lifestyle, travel south during the dry season to search for drinking water and feeding grounds for their livestock and north during the rainy season; whereas, some *Fulbe* have settled into cultivation for their livelihood (occupation). In addition, tribes such as the *Jula* and *Hausa* who have engage in trade since ancient times are spread over several countries. The *Jula* tribe can be found in Burkina Faso, Côte d'Ivoire, Guinea and Mali; whereas, the *Hausa* tribe live in Nigeria and Niger. In some sense, such languages could be considered as an international language in West Africa.

It is generally believed that development in West Africa was based on a "savanna farming culture" which originated in the higher reaches of the Niger River. Since ancient times, cowpeas, millet, moonflowers, sesame seeds and African rice (*Oryza glaberrima* Steud.) have been cultivated (Yoneyama, 1998). In addition, the Meroe civilization which flourished in Sudan from the 6th to the 4th Century B.C. had the technique to melt iron. Internal farming culture could not have been disseminated so quickly without this iron manufacturing technology. This technology began to penetrate into inland Africa, together with the Sudanese agriculturalists. Furthermore, as cattle, sheep, goats and donkeys are the main livestock in the region, some tribes like the *Fulbe* nomads described earlier have become more specialized as nomads.

Around the 8th Century, the Kingdom of Ghana flourished from the Senegal River to the inland delta** of the Niger River, and between the 11th and 15th Centuries the Kingdom of Mali flourished occupying the Kingdom of Ghana. In addition, the Kingdom of Songhaï flourished mainly in the former capital of Tombouctou between 15th and 16th Centuries. Various kingdoms appeared to have flourished due to the trading of halite (rock salt) and gold found across the Sahara (Wakatsuki, 1997). However, after the 15th Century, Europeans such as the Portuguese, followed by the Spanish, the Dutch and the British started to swarm to the region—the Great Age of Navigation. I would also like to mention that when the Portuguese first arrived at a fishing community in Senegal, they asked a local fisherman what the land was called.

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* A mainly nomadic tribe whose occupation is grazing distributed from Mauritania in the northwest to Cameroon in the east and in many countries in West Africa. In Nigeria and other countries they are called *Fulani*; but they call themselves *Fulbhe*. In addition, various titles such as *Foulah*, *Fulfulde*, *Peulh*, *Peul* and *Fulbe* are used (http://ja.wikipedia.org/wiki/).

** This is low flatland (below 350m above sea level) from Ségou downstream of Tombouctou with low water conduction capability, so river water floods and pools on the flood plain, forming an inland delta.

The fisherman misunderstood the question and answered "*Sunu* (our) *Gal* (boat)", which became the name of the country (Senegal). The Kingdom of Songhaï which boasted about its vast territory was destroyed by the attack of Moroccan armed forces in 1591. Europeans began to buy African slaves (or exchange with guns) from the heads of those kingdom or city states and sell them in the new continent (America). This is the beginning of a long sad period in history which lasted for more than 400 years. This caused lack of man power and slash-and-burn cultivation method increased. During the period of colonial rule which followed the slave trade period, a monoculture based on cash crops associated with the destruction of forests and agricultural resources became a major cause for internal agricultural stagnation which continues to this day.

2-2 Export Crops and Monoculture

Since the colonial period, exportation of agricultural products and mineral resources has replaced the slave trade mentioned earlier. The recent ratio of agricultural products in West Africa to the total exportation is shown in Table I-1.

Table I-1 Ratio of Agricultural Products in Total Exportation (1997)

Country Name & Region	%
Togo	57.3
Chad	57.1
Côte d'Ivoire	52.8
Gambia	51.4
Benin	48.6
Mali	48.3
Guinea-Bissau	44.4
Burkina Faso	36.4
Ghana	33.3
Cameroon	25.6
Niger	19.0
Sierra Leone	13.8
Liberia	9.0
Mauritania	9.0
Senegal	7.1
Guinea	6.6
Nigeria	3.5
West Africa	30.8
Africa	14.1
(Excluding South Africa 16.1)	
North & Central America	9.3
South America	27.7
Asia	4.4
Europe	8.3
Oceania	32.3
World	8.2

(Source: Illustrated African Economy, Katsumi HIRANO, based on FY2002)

Although the ratio is 14.1% of entire Africa (16.1% if South Africa is excluded), which is higher than the world average, it is still not as high as the figures for South America or Oceania. However, if we limit it to the region of West Africa, not only does the ratio (30.8%) greatly surpass the African average, it surpasses even large South American agricultural nations such as Argentina and Brazil. This shows that export crops are the central economic pillars of many West African nations.

However, few crops are able to earn more than 100 million US dollars annually. As shown in Table I-2, major cash crops in West Africa include cacao (Côte d'Ivoire, Ghana, Nigeria and Cameroon), coffee (Côte d'Ivoire) and cotton (Benin and Mali) (Hirano, 2002), Senegal being a special case, where groundnuts are cultivated. Since the World War II such crops have been introduced by French colonial governments, and the oil refining industry has also developed and become a motivating force for the agricultural industry. Although 200 million US dollars of foreign revenue was obtained from cash crops in 1994, the production remained relatively unstable depending on the weather, and rainfall in particular (Katsumata, 1997).

Table I-2 Major Export Crops and Amount of Exports

Crop Name	Country Name	Export Amount (1 million US$)	Ratio in Total Export (%)	Ratio in Agricultural Production (%)
Cacao	Africa in Total	1,919	2.6	2.4
	Côte d'Ivoire	1,200	28.5	43.4
	Ghana	367	23.7	11.5
	Nigeria	172	1.1	1.0
	Cameroon	142	7.7	3.8
Coffee	Africa in Total	1,784	1.7	2.2
	Côte d'Ivoire	264	6.3	9.5
Cotton	Africa in Total	1,307	1.3	1.6
	Benin	168	41.3	20.7
	Mali	156	27.8	12.6

(Source: Illustrated African Economy, Katsumi HIRANO, based on FY2002)

On the other hand, although the export crops account for high percentage in total export, the ratio of cash crops to the total agricultural production is surprisingly low. Percentage of export crops to the total agricultural product for cacao in Côte d'Ivoire is 43.4%, and for cotton in Benin is 20.7%, and for cacao

in Ghana is maintaining a level of 10%. In order to clarify the relationship between export crops and subsistence crops (grains and tubers), the percentage of planted area of each crop to the total arable land area is shown in Table I-3 (Hirano, 2002). As is shown in the table, the planted area of export crops is less than subsistence crops. Agriculture in West Africa is generally considered to be a monoculture of cash crops, production of the subsistence crops is more important in this region.

Table I-3 Ratio of Planted Land in Cultivated Areas (1997)

(%)

Country Name	Cotton	Cacao	Coffee	Sugar Cane	Tobacco	Grains	Tubers
Benin	23.5	-	-	0.1	-	41.0	15.8
Burkina Faso	8.1	-	-	0.1	-	86.3	0.3
Cameroon	2.7	5.0	4.2	1.9	-	13.4	6.1
Chad	9.5	-	-	0.1	-	46.4	4.6
Côte d'Ivoire	3.2	27.2	22.4	0.3	0.3	20.5	11.9
Gambia	1.5	-	-	-	-	47.0	1.0
Ghana	1.1	23.6	0.2	0.1	0.1	28.0	22.7
Guinea	1.3	0.4	3.4	0.3	0.1	46.3	10.6
Guinea-Bissau	0.9	-	-	-	-	36.0	3.1
Liberia	-	1.5	4.6	7.6	-	23.2	15.3
Mali	9.1	-	-	0.1	-	57.4	0.2
Mauritania	-	-	-	-	-	54.8	0.6
Nigeria	1.4	1.5	-	0.1	0.1	57.7	17.6
Niger	-	-	-	-	-	-	-
Senegal	2.4	-	-	0.4	-	56.8	0.9
Sierra Leone	-	6.4	2.6	-	-	64.7	14.8
Togo	6.0	0.9	0.6	-	0.2	34.8	7.0
West Africa Total	4.6	3.9	2.2	0.7	0.1	42.0	7.8
Africa Total	2.3	2.2	1.9	0.7	0.2	45.1	9.4

(Source: Illustrated African Economy, Katsumi HIRANO, based on FY2002)

2-3 Food Production

The dietary habits in West Africa differ according to nation, region and tribe. Agro-ecological map is shown in Figure I-7. Maize is the staple food of East African nations. Whereas in Sub-Saharan region of West Africa, staple food differs depending on weather conditions, in particular, with the amount of rainfall. Consequently, nations with less rainfall depend on grains such as pearl

millet and sorghum. As rainfall increases, corn, cassava, yam and plantain bananas increase.

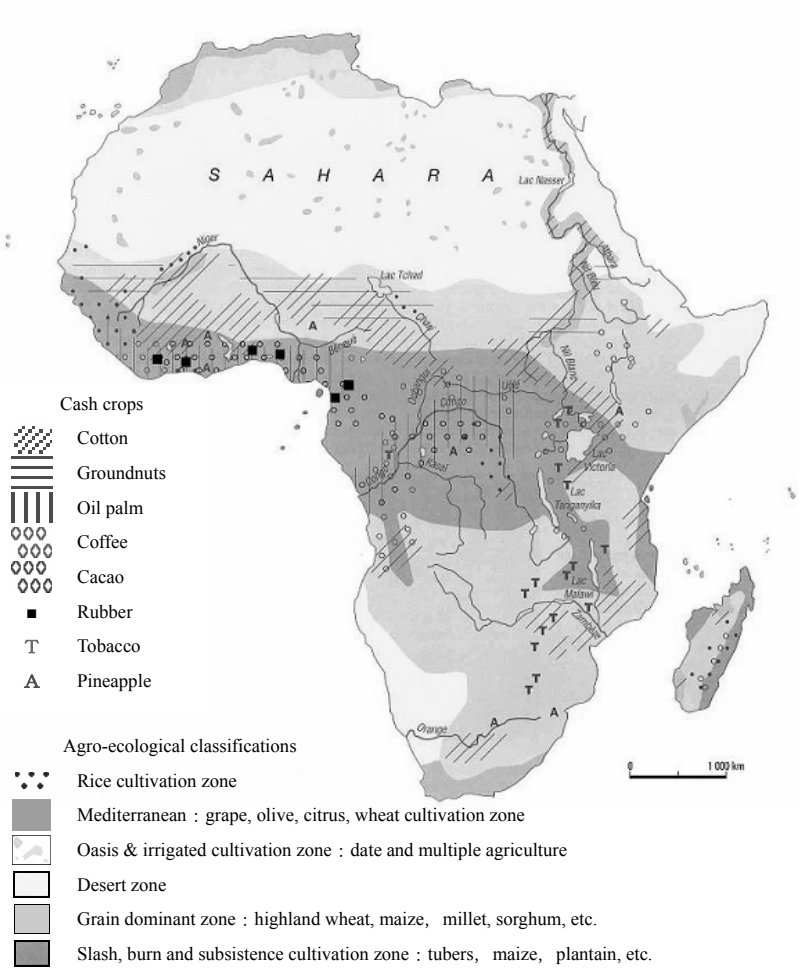

Fig. I -7 Agro-ecological classifications in Africa

(Source : ATLAS DE L'AFRIQUE, 2000)

The Niger River basin is the origin of African rice, *Oryza glaberrima* Steud, and has been cultivated since as early as 3,500 years ago (Jones, M. P. et al.). About 500 years ago, Asian rice (*Oryza* sativa) was introduced from Asia

via the Portuguese. *Oryza sativa* L. has been mainly cultivated as upland rice (Tsuboi, 2005). In addition to the population increase at an annual rate of 3%, a change in dietary habits toward consuming more rice in both urban and rural areas, rice consumption has increased at the rate of 5% annually since 1970 (Futakuchi, 2005). Custom of eating bread was widely established in many countries due to the influence of former ruling nations, no nations except for Nigeria are able to cultivate wheat, so it is necessary to import wheat from advanced nations.

2-4 Soil in West Africa

Geological features in Africa as mentioned in the preceding paragraph (1-1) have an influence on soil distribution and determine the level of agricultural productivity in West African region where soil fertility is extremely low. A soil type distribution map of West Africa is shown in Figure I-8 (soil classification based on the FAO/UNESCO system).

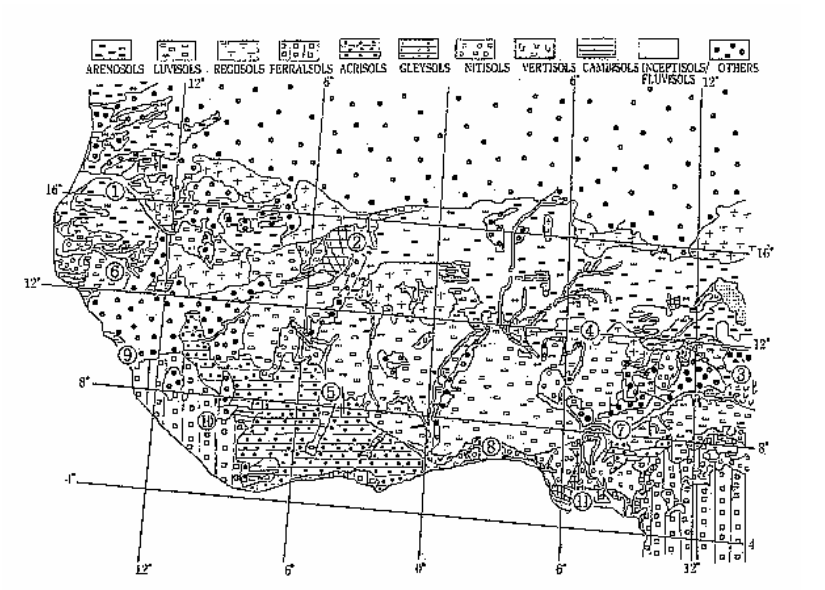

Fig. I -8 Soil map in West Africa

（Source：FAO Soil Map of West Africa, FAO/Unesco, 1974, 1990）

Furthermore, the upper figure "Restoration of ecological environment of the west African savanna and regeneration of the farm village", by Shohei HIROSE and Toshiyuki WAKATSUKI were compiling, from 1997 posting.

The following three characteristics can be observed from the soil map of West Africa. The first characteristic is that the soil type distribution is zonal. Major soils are distributed in a belt coincide with a gradual decrease in rainfall from the Gulf of Guinea to the Sahara Desert, which correspond with the distribution of vegetation zones. The second characteristic is that even in the same soil zone; the influence of base material is recognized. The third characteristic is that even in the same zonal classification and base material classification, different soil appears due to water conditions, sedimentation or erosion due to the influence of topography, in the area, (Wakatsuki, 1997). In Table I-4, major soil types distributed in West Africa were listed based on a report by Dr. Wakatsuki.

Table I-4 Soil Distribution by Climatic Zone

Soil Unit	Characteristics	Climatic Zone and Area
Arenosols	Soils of quartz sand; deep soil layer and weak development; coarse parent materials consisting of relic to alluvium sediments which are not affected by ground water.	・Sahel: Extensively distributed, less than 500mm rainfall; area with almost no possibility for agricultural utilization other than nomadic grazing. ・Sudan Savanna: Comprising largest area of northern half continuing from Sahel.
Regosols	Shallow layer soils on non-consolidated materials; shallow soil layer and weak or immature development; coarse parent materials consisting of colluvial deposits which are affected by ground water.	
Fluvisols	Fluvisols with almost no soil; deep to medium soil layer, weak to medium development, coarse to fine-textured parent materials consisting of alluvium sediments, weak to medium impact by ground water.	・Sahel: Flood plains along the banks of Senegal River, Niger River and Lake Chad or lowland along the river such as inland delta. ・Sudan Savanna: Branches of Senegal and Niger Rivers, lowland of various basins feeding Lake Chad. ・Guinea Savanna: Flood plains such as Niger, Volta and Benue Rivers ・Equatorial Zone: Mangrove zone, sulfide Thionic Fluvisol distributed along the coast from Senegal to Sierra Leone.

Soil Unit	Characteristics	Climatic Zone and Area
Gleysols	Gleysols with anaerobic layer; deep soil layer and medium development; fine-textured parent materials consisting of alluvium sediments, which are remarkably affected by ground water.	・Sahel: Flood plains along the banks of Senegal River, Niger River and Lake Chad or lowland along the river such as inland delta ・Sudan Savanna: Branches of Senegal and Niger Rivers, lowland of various basins feeding Lake Chad. ・Equatorial Zone: Major soil in Niger Delta.
Vertisols	Vertisols rich in montmorillonite-type clay; no salt accumulation; weak leaching fine-textured composition	・Sahel: Part of lowland around Lake Chad; inland delta in Mali, flood plains of Niger and Senegal rivers. ・Sudan Savanna: Mainly in the vicinity of Burkina Faso and Lake Chad. ・Guinea Savanna: Around upstream of Volta River in Ghana, upstream of the Benue River in Cameroon.
Planosols	Albeluvic soil; no salt accumulation; brown subsoil; some eluvial and albic horizon; some corroded and iron illuvial horizon	・Sudan Savanna: Distributed in Burkina Faso accompanying Vertisols.
Luvisols	Luvisols with argillic horizon; no oxide layer but reddish brown subsoil; high base saturation and great change in clay contamination in soil layer	・Sudan Savanna: South of the said zone, major soil in Mali; distribution of especially rich iron Ferric Luvisols and red clay-spotted Plinthic Luvisols. ・Guinea Savanna: South of Senegal, Mali, South of Burkina Faso, Ghana, Togo, Benin, Nigeria and north of Cameroon; same as above, due to high quantity of Ferric and Plinthic, southern limit conforms to 1,250mm annual isohyets. ・Equatorial Zone: South of Nigeria
Nitosols	Nitosols of low clay accumulation with low CEC argillic horizon; no oxide layer as well as Luvisols but red subsoil; low to high base saturation; small change in clay contamination in soil layer	・Sudan Savanna: The coast of south of Senegal, east of Nigeria, north of the Benue River. ・Equatorial Zone: Benin, south of Nigeria; especially fertile and rich nutritional Eutric Nitisols on the left bank of the Niger Delta and southeast of Nigeria.

Soil Unit	Characteristics	Climatic Zone and Area
Acrisols	Acrisols weathered with argillic horizon;, no oxide layer as well as Luvisols and Nitosols but red subsoil; low base saturation and great change in clay contamination	・Guinea Savanna: Acid Ferric in southern Guinea Savanna with a lot of rainfall such as Guinea and Côte d'Ivoire. ・ Equatorial Zone: South of Nigeria, Côte d'Ivoire, Guinea, Ghana
Ferralsols	Ferralsols; red to reddish yellow subsoil due to no clay accumulation with oxide layer; low base saturation and small change in clay contamination	・Guinea Savanna: Part of Guinea Savanna in Cameroon ・Equatorial Zone: Sierra Leone, Liberia

* For soil characteristics, with reference to "Identification of Soil Units based on FAO/UNESCO System", Takayuki YOSHIZAWA, Expert Bulletin for International Cooperation of Agriculture and Forestry Vol.13, No. 1, AICAF, 1992.

Fertile soils are generally distributed in the river basins and flood plains of West Africa. However, the soil fertility of the Sudan savanna which receives little rainfall is higher than that of the Guinea savanna which receives more rain than the said zone. The reason for this is that, 1) parent materials of the Sudan savanna consist of relatively young sediments in geological time (Tertiary, Quaternary) (Figure I-2), 2) the Sudan savanna is located on the leeward side of seasonal wind called Harmattan* and Aeolian dust (Harmattan dust) accumulates as Loess (yellow ocher), in contrast the Sahel (Guinea savanna) is located on the windward side of Harmattan causing a heavy soil erosion during the dry season.

Furthermore, in the Guinea savanna forests have been lost and soil erosion is severe in many areas, so much of the soil is unproductive due to its coarseness and the thinness of the topsoil. Hence its population density is low and agriculture is not considered to be important although it is receives more rainfall than the Sudan savanna.

Of the soils in the equatorial belt, Ferralsols are distributed extensively throughout Sierra Leone, and Liberia. This area has become the primary plantation zone for crops such as rubber and oil palm. Acrisols are distributed throughout in Côte d'Ivoire, Guinea and Ghana in the equatorial belt, while Nitosols, acid but relatively fertile, are distributed extensively in Benin and Nigeria. Consequently, these zones are used for growing cash crops such as cacao, coffee, coconuts and oil palm, etc. (Wakatsuki, 1997).

* Dry, high-temperature seasonal winds blow from the Sahara Desert (November to March).

2-5 West African Pulses: Their Importance and Future

Pulse crops are often mixed with other grains in the statistics, not only in West Africa but in other regions as well. In addition, even if some pulse crops are indicated as pulses, it is often difficult to identify the species. However, this does not mean that pulse crops are not important for the people in the area, but it is because the importance as cash crops is merely low.

Except groundnut, pulse crops in West Africa (such as cowpeas, kidney beans, bambara groundnuts*, etc.) do not have cash earning ability and usually planted as mixed crops with staple grain crops (pearl millet, sorghum and corn). The yielding ability pulses have not been considered as important characters. However, it is clear that pulse crops are firmly established as components in the local diet culture. It is believed that pulse crops help to maintain and preserve soil fertility in addition to the improvement of major grain crops productivity.

The staple foods (such as yam, cassava, rice and maize) mainly supply the carbohydrates, and pulse crops served as an important source of vital vegetable protein (Table I-5). Especially, cowpea which is originated in West Africa is important as grain food. In addition, its stalks and leaves are effectively used as forage (animal feeds). So people in the countries in the Sahel zone such as Mali and Burkina Faso where a livestock industry is common prefer prostrate type of cowpea, which is considered as a "non-waste" crop.

Soybean was introduced recently to West Africa for the purpose of improving nutritional status of the poor and infants. They were disseminated by UNICEF and NGOs as foodstuffs for processing soybean milk and soybean flour (*kinako*) etc., and become firmly established in some countries and regions. For example, since soybean milk was used in school lunch in some countries, the dietary habits of the young have changed. Soybeans are also considered to be a promising substitute of néré** (*Parkia biglobosa*), an ingredient of traditional seasoning.

Figure I-9 shows the trend in production of four major pulse crops (cowpea, groundnut with shell, bambara groundnut and soybean) in West Africa. (Source: FAOSTAT)

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* *Vigna sbterranea* (L.) Verdc. Pulse crop originated in the Niger River basin in West Africa; Japanese name is *Futago-mame*.

** Néré, seasoning made from the seeds of *Parkia biglobosa* (Jacq.) benth and fermented and is called *Soumbara* in Mali and Burkina Faso, *Dawdawa* in Ghana and *Afitin* in Benin.

Table I-5 Nutritional Value of Major Food Crops in West Africa (per dried food)

Variety		Calories (per 100g)	Crude Protein (%)	Carbohydrates (%)	Fat (%)
Grains:	Maize	409.7	10.16	82.6	4.09
	Rice (polished rice)	397.1	9.10	89.9	0.14
	Sorghum	394.1	15.03	76.2	3.25
	Millets	413.8	9.02	83.2	4.99
Tubers:	Yam	385.9	3.75	90.1	0.34
	Cassava	390.9	2.58	94.1	0.43
	Yautia (New Cocoyam)*	382.6	4.93	88.5	0.59
	Sweet Potatoes	391.1	5.24	91.5	0.46
Pulse:	African locust bean**	444.7	30.38	35.1	20.30
	Bambara groundnut	357.6	21.14	53.5	6.54
	Cowpea	389.9	24.67	67.3	2.46
	Mungbean	363.6	28.46	60.2	0.99
	Groundnut	579	27.0	17.0	45.0
	Soybean	452.4	44.08	26.1	19.10
	Pigeon pea	354.6	23.27	62.4	1.11
	Common bean	341	22.1	61.4	1.7
	Lentils	346	24.2	60.8	1.9
	Chickpea	358	20.1	61.5	4.5
	Fenugreek ***	335	29.0	57.2	5.2
	Broad beans	343	23.4	60.2	2.0

(Source: Kazumi MAEDA, Agriculture and Pulse Crops in Africa, Various Agricultural Problems in Africa, 1998)

* Taro, *Colocasia esculenta* Schott. and New Cocoyam, *Xanthosoma sagittifolium* Schott.,

** *Perkia filicoidea* Welw. ex Oliv., similarly to néré, *Parkia biglobosa* (J. utilized as a fermented seasoning.

*** Fenugreek, *Trigonella foenum-graecum* L. is originally from India. Young foliage and pea pods are eaten as a vegetable and the seeds are utilized as a spice and in medicines. (Source of photo on the right: Asahi Hyakka, World Plant 5, pp.1142, Seed Plant V, Asahi Shinbun Newspaper Publishing Company, 1980)

Photo I -1: Fenugreek

1) Cowpea

Although the production (Figure I-9-1a) and planted area (Figure I-9-2a) of cowpea in Nigeria are clearly outstanding, the yield in Nigeria and other West African countries remains relatively low (Figure I-9-3), with the exception of Cameroon. Generally speaking, the increase of planted area of cowpea account for the increase of total production in Nigeria. However, in Cameroon where the climate is more favorable for cowpea production, the yield of cowpea is stable and high. Although Niger has the second largest planted area of cowpea among West Asia, a shortage of rainfall gives a low yield.

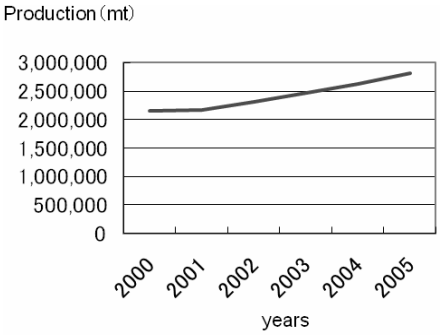

Fig. I-9-1a Production of cowpea in Nigeria

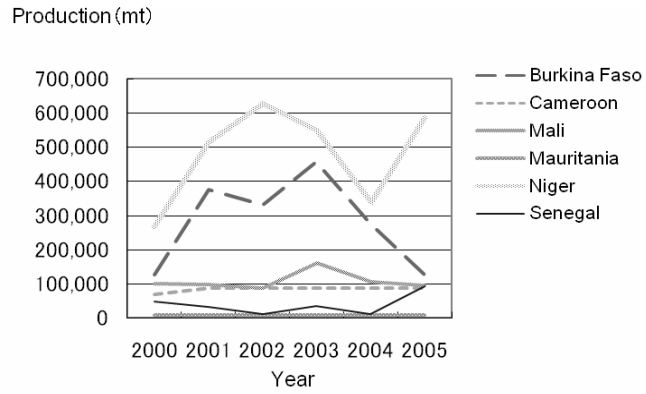

Fig. I-9-1b Production of cowpea in West Africa, Nigeria excepted

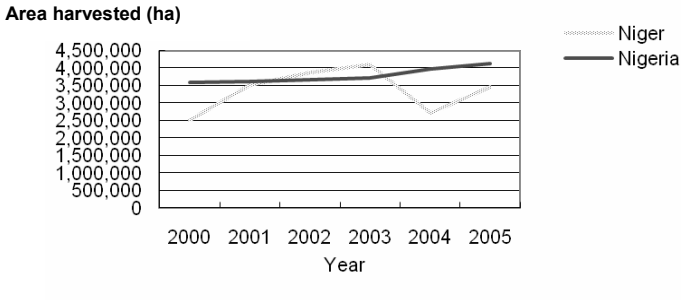

Fig. I-9-2a Area harvested of cowpea in Niger and Nigeria

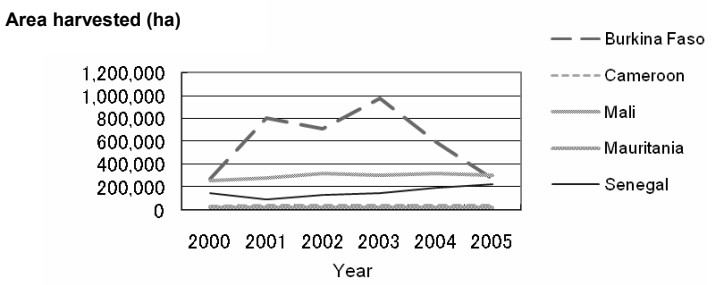

Fig. I-9-2b Area harvested of cowpea in West Africa, Niger and Nigeria excepted

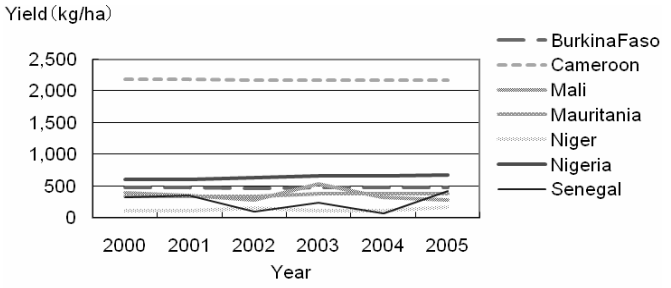

Fig. I-9-3 Yield of Cowpea in West Africa

2) Groundnut

In addition to the direct use as food, the demand for groundnut oil is large among vegetable oils. Since groundnut is generally planted as a cash crop in West African countries, the production and planted area are the largest among the pulse crops. The yield of groundnut is particularly outstanding in Nigeria (Figures I-9-4a, I-9-5 and I-9-6). Both the production and yield in Senegal, which economically highly depends on peanuts among West Africa, are unstable due to climatic conditions in the Sahel zone. For example, in 2002 the nation faced an economic slump due to severe drought which went hand in hand with delays in the distribution of groundnut seeds (Figures I-9-4a and I-9-6).

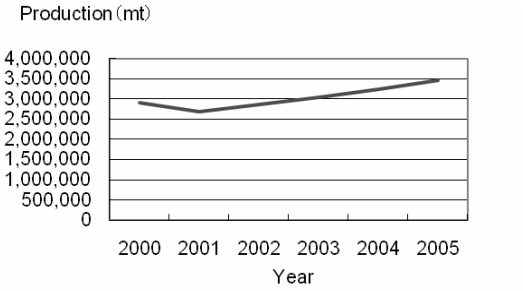

Fig. I-9-4a Production of Groundnut seeds in Nigeria

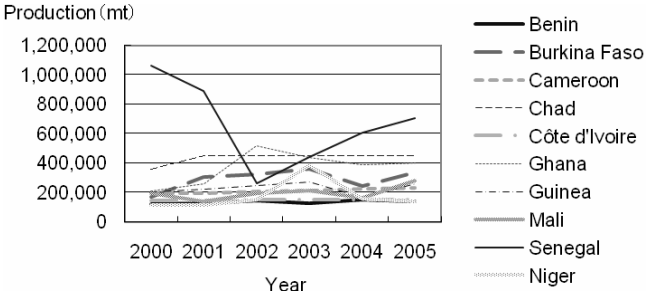

Fig. I-9-4b Production of Groundnut seeds in West Africa, the higher rank 10 Nigeria excepted

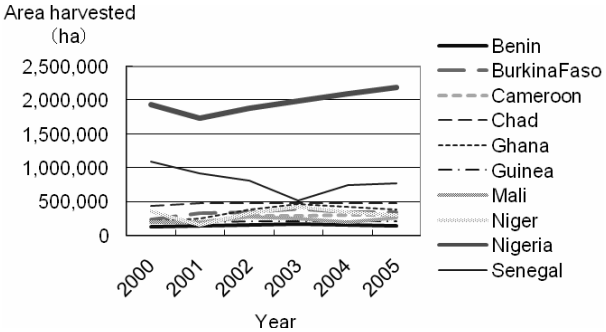

Fig. I-9-5 Area harvested of Groundnut seeds in West Africa higher rank 10

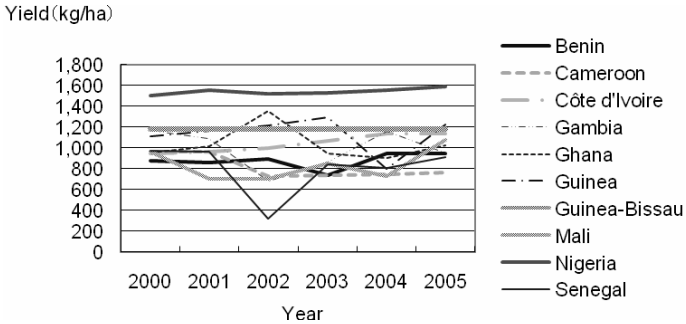

Fig. I-9-6 Yield of Groundnut seeds in West Africa higher rank 10

3) Bambara groundnut

Although bambara groundnut originated in West Africa, only three countries are listed in the data, so bambara groundnut has a negative image that this bean is a minor crop. Although their production is limited to West Africa, certain demand can be observed. This shows that the said item is a precious genetic resource and important protein source.

Since the production (Fig. I-9-7) and the planted area (Fig. I-9-8) in two countries other than Cameroon are not stable and the yield is also low (Fig. I-9-9), it is not considered as a stable cultivated item. Recent consumer need is

thought to have a considerable effect on this. In similar manner as groundnut, bambara groundnut bears fruit under the ground. The seed coat covering the grains is hard so it takes a time to cook. Consequently, the nut is not a very popular ingredient among households recently. As the planted area is not expected to increase dramatically, the crop is considered as a “traditional crop to be protected”.

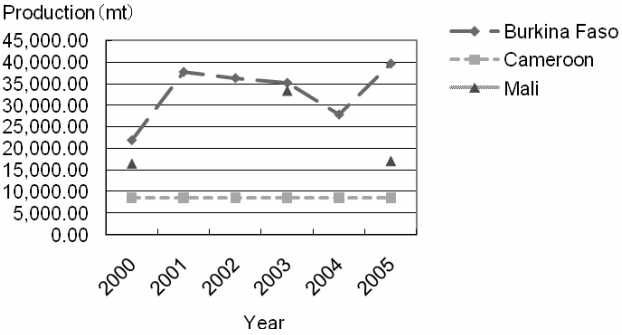

Fig. I-9-7 Production of Bambara groundnut in West Africa

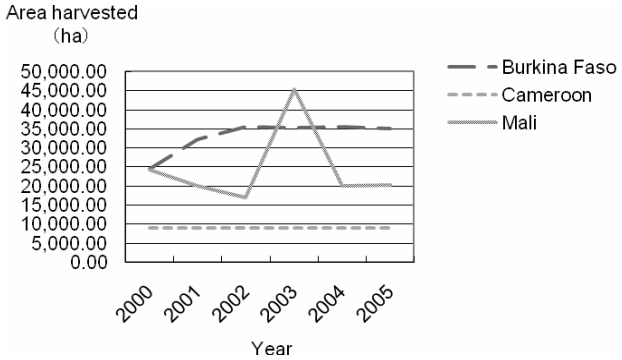

Fig. I-9-8 Area harvested of Bambara groundnut in West Africa

Note: Due to the omission of 2001, 2002 and 2004, the figures do not form a line graph. Therefore, statistics on production in Mali are indicated with the marker (▲).

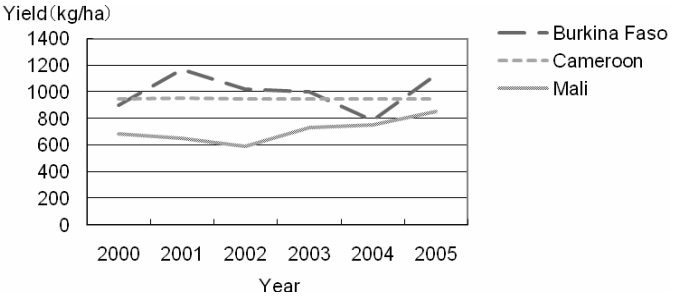

Fig. I-9-9 Yield of Bambara groundnut in West Africa

4) Soybean

The soybean market has shown remarkable growth in recent years in West Africa, and Nigeria has particularly outstanding production (Figures I-9-10a and I-9-11a). Although the yield is low as a whole, the planted area has definitely been increasing (Figures I-9-11a and b).

Although not as large as Nigeria, the production and planted area in Benin have grown remarkably. One reason for this is that many pulse producing districts in Benin introduced soybean as a substitute crop following a slump in cotton prices. So districts that conventionally cultivated cotton from the central to northern regions of Benin have increased their planted area of soybean. Soybean is mainly used after processing, and will contribute extensively to nutrition and diet improvement in the region. Accordingly, UNICEF and NGOs are endeavoring to increase soybean cultivation for producing processed foods such as soybean milk and power (*kinako*) or *tofu* (bean curd).

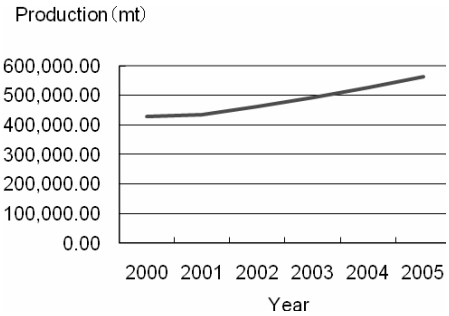

Fig. I-9-10a Production of Soybean in Nigeria

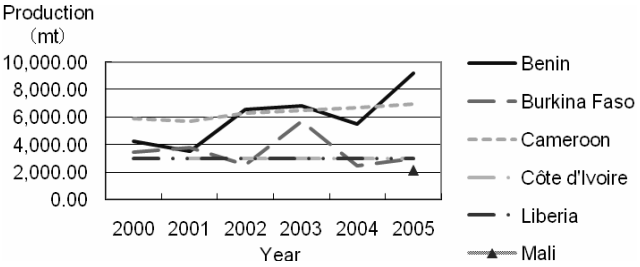

Fig. I-9-10b Production of Soybean in West Africa, Nigeria excepted

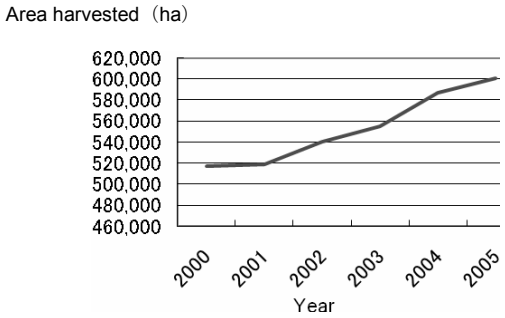

Fig. I-9-11a Area harvested of Soybean in Nigeria

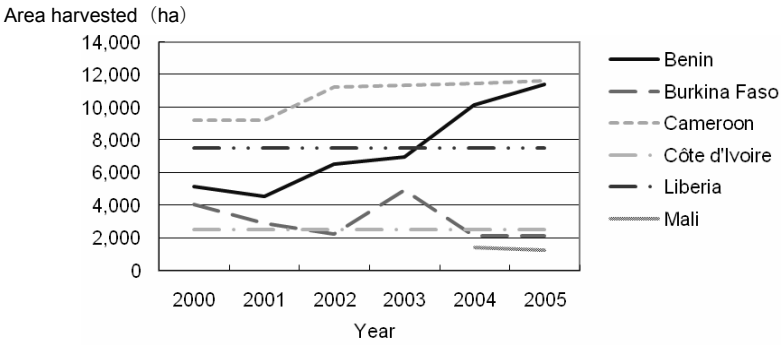

Fig. I-9-11b Area harvested of Soybean in West Africa, Nigeria excepted

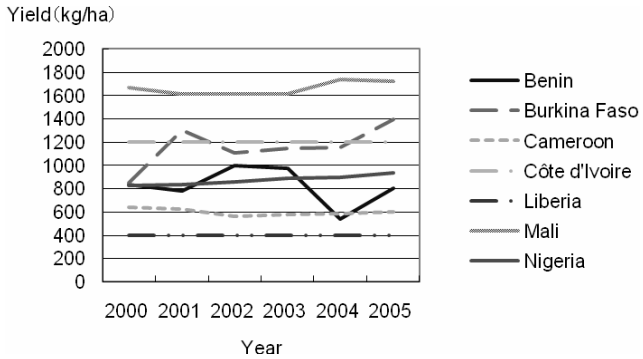

Fig. I-9-12　Yield of Soybean in West Africa

3. Agriculture in Benin

3-1　Land Use and Irrigated Area

Arable land area in Benin, which was 2.3 million ha in 1990, has increased 1.5 times in 2006 (3.467 million ha). Considering the lack of change in the forest area, this is not a result of an expansion of farmland due to forest clearing, but a result of an expansion in the arable land in the lowlands of the river basins. The present irrigated land is 12,000 ha and that was just 10,000 ha in 1990, irrigated area does not increase rapidly. Consequently, rice still appears to be cultivated mainly in rain-fed rice paddy fields.

Table I-7　Land Utilization

Form	Area	Form	Area
Total Land	11.262 million ha	Land Area	11.062 million ha
Forest Area	3.4 million ha	Arable Land	3.467 million ha
Permanent Grassland	550,000 ha	Perennial Crops	267,000 ha
Irrigated Area	12,000 ha	Other	3.566 million ha

Source: FAOSTAT, 2006 (However, due to a lack of renewal data since 2003, the latest data on forest areas is 1994.)

3-2 Administrative Divisions

As shown in the following figure, the administrative divisions in Benin include 12 departments and 77 communes.

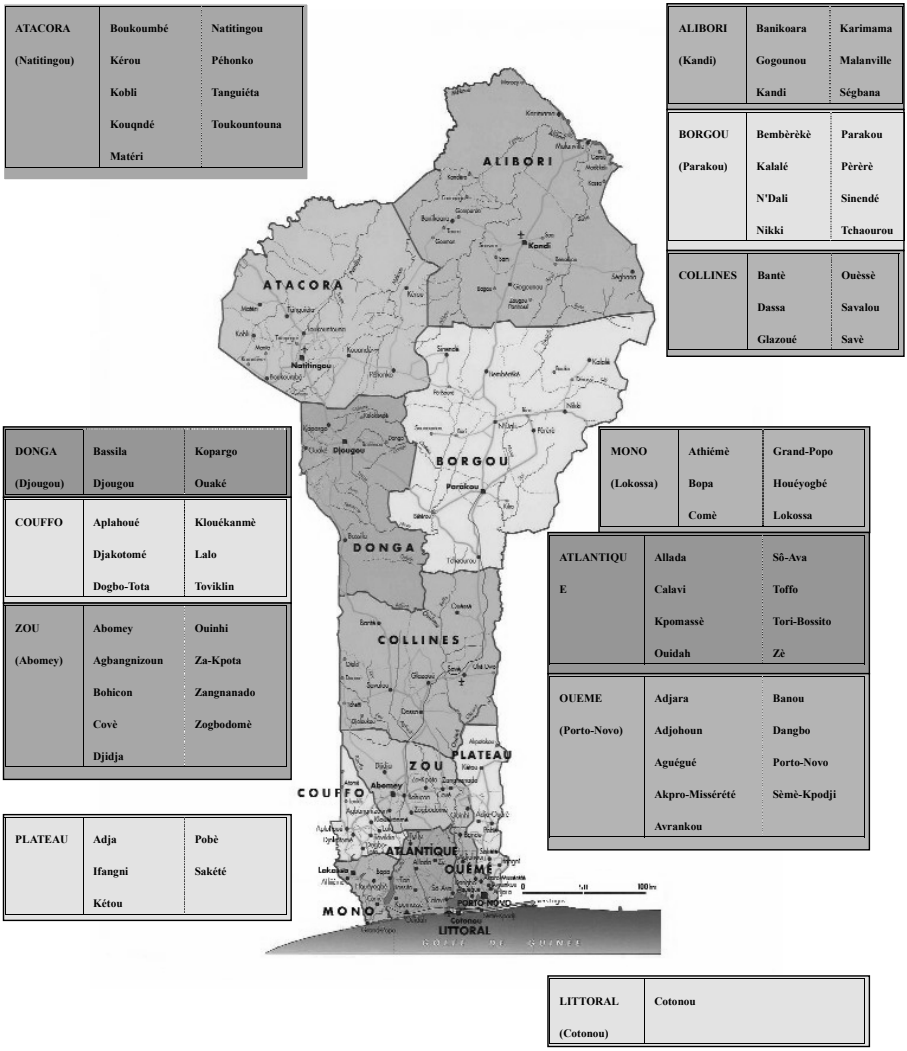

Fig. I-10 Administrative Divisions

(Source : République de Bénin, les classiques africains, 1999)

3-3 Topography

The republic of Benin (hereinafter referred to as “Benin”) is located on the Gulf of Guinea and borders Nigeria to the east, Niger and Burkina Faso to the north and Togo to the west, which is located in the equatorial region in West Africa between 0° to 4° of east longitude and 6° to 13° of north latitude. The southern part of the country is partially forested and the tropical northern part is characterized by the Sudan Savanna. Except for a few mountains in the northwest, the topography is generally flat and can be divided as follows (Figure I-11).

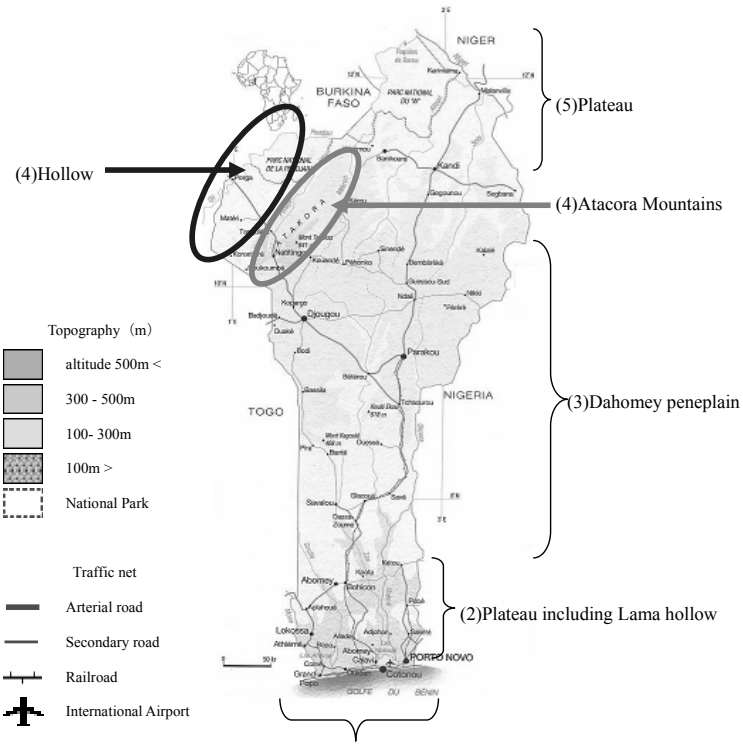

Fig. I-11 The Topography of Benin

（Source：ATLAS DE L’AFRIQUE, 2000）

(1) Coastal plains: lowland less than 10m above sea level with sandy soil. Lakes or lagoons are often scattered to make swampy areas. This plain

average width 4km covers length 125km.

(2) Southern plateau including Lama hollow: a clay-textured plateau containing iron, elevation not exceeding 400m above sea level. The area consist of the river basins of the Couffo Zou and Ouémé Rivers stretching from north to south, of the clay-textured or peat-like textured Lama hollows spread from southwest to northeast.

(3) Dahomey peneplain: composed of crystalline rocks that make up a major part of the land of Benin. It is a peneplain mixed with many quartz, granite or gneiss hills. The elevation is from 250 to 350m above sea level.

(4) Northwest mountains: mountains are basically composed of quartz and crystalline rocks running from the northeast to the southwest. The mountains are located in Natitingou district, which is the highest in Benin at 650m above sea level. The Atacora Mountains are the source of many of Benin's rivers.

(5) Northern and Northeast plateau: The elevation is about 250m above sea level. The sand-textured plateau around Kandi contains conglomerate and clay from the Cretaceous period. Small hills are scattered throughout the area. The plateau with the basin of the Sota River is descending gradually to the Niger River.

3-4 Climate

Since Benin stretches latitudinally, different types of climates are distributed from north to south. Depending on its rainfall and latitude, it can be divided into the following four climatic zones (Prosper, 1995, Figure I-12).

1) Benin Climatic Zone (Sub- equatorial)

This is an area between 6° and 8° north latitude where two rainy seasons and a dry season occur in a year. The average annual rainfall is from 800 to 1,400mm, and there is a dry season (August) between two rainy seasons that reach maximum rainfall in June and in October. Although 40% of the total rainfall is concentrated in the four months between April and July in this area, rainfall exceeding 40mm per hour is rare. The number of rainy days per year is approximately 100 days. Since the area is close to the Atlantic Ocean, humidity is extremely high, the lowest humidity being more than 60% and the highest humidity nearly 100% in Cotonou, the center. In addition, the temperature difference is only 5°C and generally fluctuates between 25°C and 30°C.

2) Sub-Sudan Climatic Zone

This climatic zone is distributed in the peneplain in the central part of Benin, which can be roughly classified into a rainy season between April and October and a dry season between November and March. The annual rainfall is between 1,100 to 1,300mm, and 90 to 95% of that falls during the five months

of May to September. Moreover, rainfall of more than 40mm per hour is observed about three times annually. Humidity is lower than that of the Benin climate mentioned above. The average lowest humidity is 30% and highest is 80%, and the difference in daily temperature sometimes reaches 14°C.

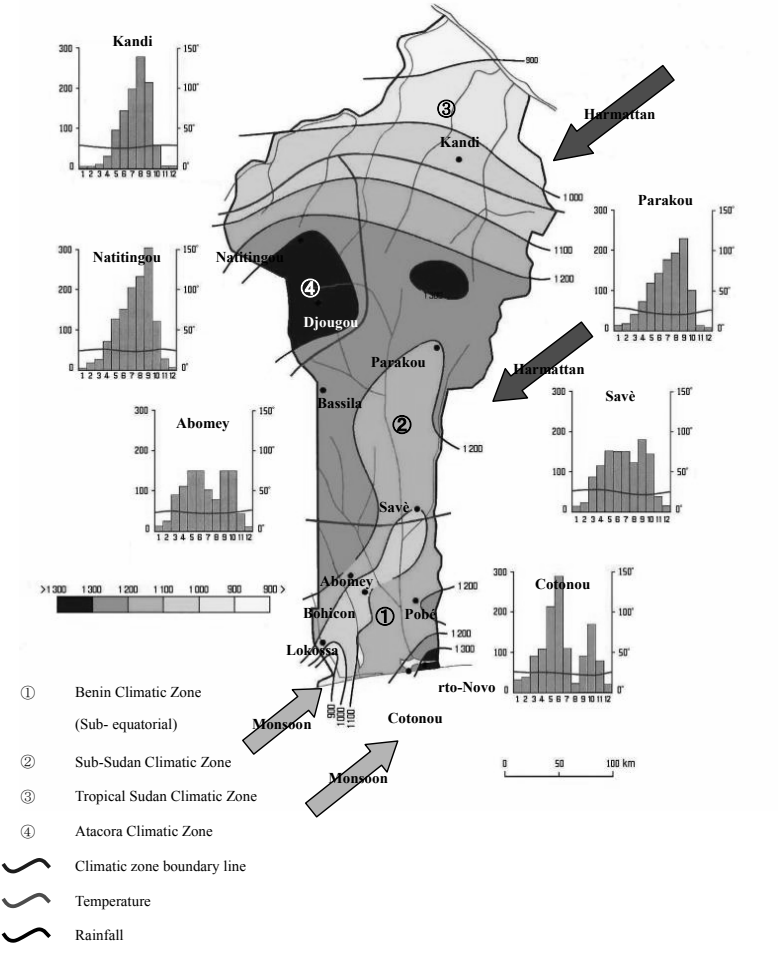

Fig. I-12　Climatic division in Benin
（Source：le Bénin, Kolawplé Sikirou ADAM / Michel BOKO,
Les Edition du Flamboyant/EDICEF, 1993）

3) Tropical Sudan Climatic Zone

This climatic zone is located in the northern area, and has a rainy season between May and September and a dry season between October and April. This region has different characteristics depending on the area. Since it is affected by seasonal winds (harmattan) from the Sahara Desert, dry hot winds blows from the northeast between December and March. The annual average rainfall is between 800 and 1,100 mm and the humidity is relatively low (less than 30% during the harmattan season and the annual highest humidity is approximately 75%).

4) Atacora Climatic Zone (Mountainous Sudan)

This region has almost the same climate as the previous region and is located in the mountainous zone in the northwest. This area is located at the highest altitude and there is a lot of rainfall (1,000 to 1,400mm). Although showers frequently occur and rainfall per hour reaches 100mm, the amount of rainfall decreases during the harmattan season. Due to excessive concentration of rainfall for three months between July and September, extremely large-scale soil erosion is a problem.

3-5 Farming Population

Forty two percent (3.463 million people) of a total population (approximately 8.2 million) is farmers, 21.9% of which are women.

3-6 Farm Size

Self-employed (independent) farming (including tenant farming) is dominant and the average scale of each farm is 7 laborers per single farm household and approximately 1.7ha of cultivation area. However, 5% of farmhouses in the south and 20% in the north have farming land (including plantation) exceeding 5ha, so large-scale management with agricultural machinery can be observed.

Although agricultural income per farm household is not very high at $100 to $300 US, this income is often obtained through cotton cultivation, and a considerable amount of income can be obtained in the northern districts.

In addition, income obtained from cotton cultivation includes large profits through the acquisition of foreign currency not only for producers but also for some public institutions and even the state. However, the amount of planted area has been decreasing due to the impact of the “cotton crisis” mentioned later; whereas, the planted area for soybeans as a substitute crop has been increasing.

3-7 Farm Management

Fig. I-13 demonstrates the distribution of major agriculture zone in Benin. Cotton which is a major agricultural product in Benin is planted on a nationwide

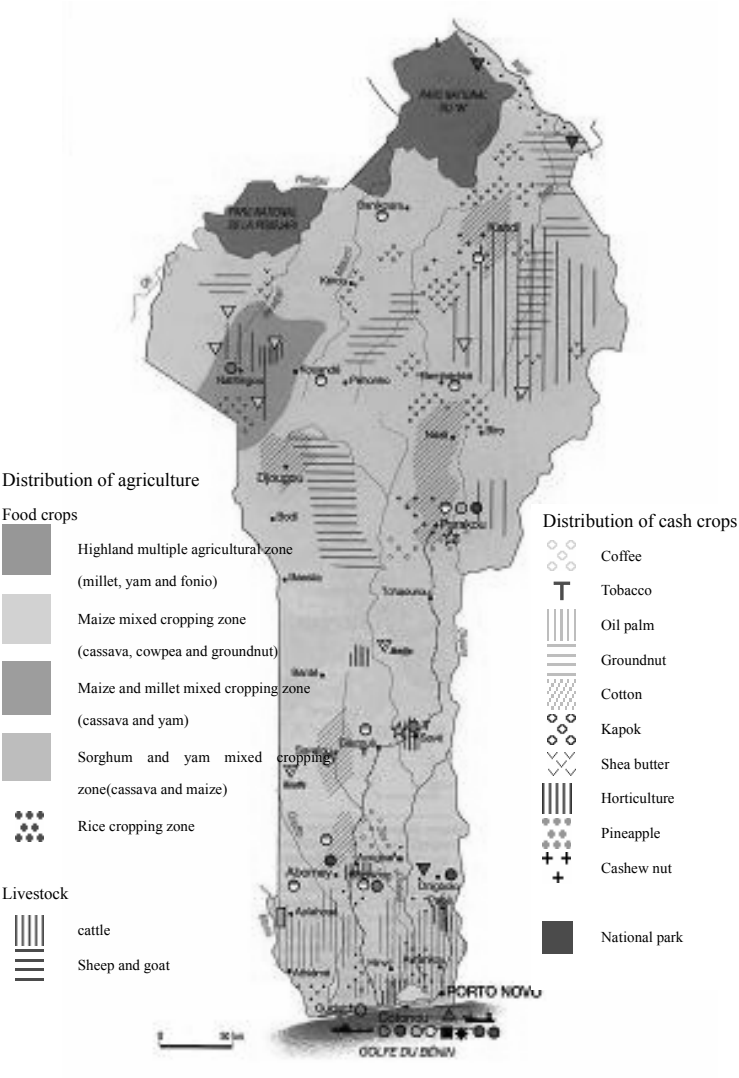

Fig. I-13 Main industrial distribution in Benin

(Source : ATLAS DE L'AFRIQUE, 2000)

scale, except in the south (Atlantique and Littoral departments) and groundnut is planted on almost on a nationwide scale mainly by small-scale farming. In the south, large-scale farm households are the primary cultivators of plantation crops such as oil palm or coffee, and horticultural crops such as fruit trees or vegetables for the purpose of obtaining foreign currency.

However, corn, cassava, sweet potato, cowpea, tomato, red paper and okra are cultivated on a nationwide scale and are indispensable food crops for the people. Grains such as sorghum and millet are planted in the North and the Midwest (Atacora and Donga), in the North and the Middle East (Borgou and Alibori) and from the Central to the South (Zou and Collines); whereas, rice and yam are cultivated on a nationwide scale except in the South (Atlantique and Littoral departments). In recent years, both the planted area and the production of soybean have increased (Tables I-8 and I-9).

Table I-8 Change in Planted Area for Major Cultivated Crops in Benin (1998 to 2005)

Unit: ha

Crops	1998	1999	2000	2001	2002	2003	2004	2005
Food Crops								
Maize	594,277	625,482	653,630	623,412	684,882	662,533	714,154	1,013,628
Sorghum	167,880	154,564	176,533	182,644	193,106	173,695	181,269	180,723
Millets	39,345	37,958	44,259	46,211	50,905	45,361	44,762	45,497
Rice	17,079	17,561	23,323	26,504	28,787	23,440	24,754	28,731
Cassava	189,400	202,117	219,404	240,048	261,750	237,894	226,434	207,299
Yam	144,650	145,368	156,831	155,733	173,624	166,921	172,739	98,411
Sweet Potatoes	8,253	10,885	12,474	10,716	13,123	10,523	11,163	12,793
Taro	919	1,020	925	745	814	767	851	834
Cowpeas	113,298	112,580	119,111	115,908	134,681	119,460	122,560	129,002
Bambara Groundnuts	13,297	12,911	15,306	16,496	20,573	17,755	18,576	17,232
Goussi[*]	14,460	15,029	16,032	15,511	17,296	16,746	16,124	10,850
Pigeon Peas	5,728	4,543	5,278	5,323	5,511	4,229	4,005	3,859
Vegetables								
Tomatoes	20,297	25,959	25,790	22,781	25,427	28,264	24,526	28,272

Photo I-2 Goussi Fruit

Photo I-3 Seeds

[*] *Citrullus lanatus* (Thumb.). Member of the gourd family, (*Cucurbitaceae*) like a water melon, seeds are called *Goussi*, or Sésame and is also called Egusi in Nigeria and is an ingredient in many dishes.

Fruit pulp can be used as a laxative (seeds in Photo I-3 on the right are extracted from gourds in Photo I-2 on the left.)

Red papers	19,636	19,817	23,682	21,430	23,716	22,863	19,961	23,738
Okra	18,870	17,595	19,509	18,887	21,413	19,977	20,754	27,804
Cash Crops								
Groundnuts	122,229	125,414	138,586	145,572	152,774	154,005	160,504	147,850
Cotton	380,311	370,445	319,318	356,786	306,890	314,097	313,011	187,360
Tobacco	930	707	1,007	1,010	1,195	1,005	874	1,116
Soybeans	2,830	4,210	5,140	4,533	6,591	6,954	10,175	11,133

Source: Planning and Forecast Bureau of the Ministry of Agriculture, Livestock and Fisheries in Benin, hereinafter the same applies.
Cash crops such as coffee and oil palm do not fall under the jurisdiction of the Ministry, and are not included in this table.

Table I-9 Change in Production Volume of Major Cultivated Crops in Benin (1998 to 2005)

Unit: t

Crops	1998	1999	2000	2001	2002	2003	2004	2005
Food Crops								
Maize	662,227	782,974	750,442	685,902	797,496	788,320	842,017	2,016,551
Sorghum	138,425	126,440	155,275	165,342	182,639	163,276	163,831	167,337
Millets	29,427	29,519	36,352	34,969	40,751	35,457	36,817	36,991
Rice	35,562	34,040	49,246	54,901	63,219	54,183	64,699	77,133
Cassava	1,989,022	2,112,965	2,350,208	2,703,456	3,154,910	3,054,781	2,955,015	2,804,733
Yam	1,583,713	1,647,009	1,742,004	1,700,982	2,151,452	2,010,699	2,257,254	2,093,354
Sweet Potatoes	40,854	68,847	65,592	56,996	83,800	51,098	49,999	60,771
Taro	3,756	4,551	3,518	3,080	3,207	3,003	2,981	2,117
Cowpeas	75,452	74,237	85,613	78,353	95,332	81,823	93,789	96,689
Bambara Beans	9,260	14,594	14,790	12,354	15,925	14,549	20,267	11,321
Goussi	9,554	8,031	10,291	10,152	13,662	10,951	10,207	6,985
Pigeon Peas	3,490	2,952	3,302	3,363	3,712	3,116	2,969	3,200
Vegetables								
Tomatoes	105,626	124,401	139,231	117,563	134,820	141,815	144,235	144,244
Red papers	20,070	24,562	33,293	29,309	36,624	25,222	41,865	48,084
Okra	53,170	54,579	58,956	58,099	74,824	64,626	68,519	65,667
Cash Crops								
Groundnuts	98,897	101,943	121,159	125,377	130,008	143,516	154,551	132,904
Cotton	359,331	375,586	339909	393,060	376,739	372,967	348,353	189,728
Tobacco	583	460	679	621	852	723	611	855
Soybeans	1,995	3,444	4,296	3,543	4,744	6,812	5,526	8,991

In the livestock industry, goat, sheep, pig and chicken are raised. Major livestock products include poultry, beef and milk, etc. Cow, sheep and goat are especially common in the Central region and in the Northern district, where approximately 40,000 cows are raised as working cattle, and play an important role in the plowing of upland fields.

In addition, the fisheries industry also plays a role in providing food and the annual catch is estimated to be 40,000t. Since modern fishing methods have been rapidly developed thanks to new investments, state-operated fishing companies now own deep-sea fishing vessels. However, traditional fishing has declined due to the pollution of lagoons as a result of the development of the Port of Cotonou, so a new direction for freshwater fish aquaculture is being studied.

Conventionally, ownership of farmland used a traditional possession system including inheritance (father → children → grandchildren). However, legislation has been introduced in recent years making it possible to carry out transactions and time-limited rental agreements. However, complicated procedures and taxes have been imposed. Nevertheless, farm households who have worked hard to improve the fertility of the land are reluctant to part with their land.

Irrigation is indispensable to rice and is controlled by the Irrigation Service Bureau located in Porto-Novo. In recent years irrigation system has been improved with the assistance from China. The feasible area of irrigation in Benin is approximately 100,000ha in the river basin (27,740ha in the Mono River basin, 30,000ha in the Niger River basin and 60,000ha in the Ouémé River basin) and 200,000ha in the inland lowland area (Data by the Planning and Forecast Bureau of the Ministry of Agriculture, Livestock and Fisheries). Although 8,000ha was irrigated until the 1990s, it has decreased to 1,800ha at present. This is an indication of how difficult it is to maintain irrigation facilities (for example, concrete work maintenance and headwater conservation).

3-8 Soil

The soil is composed of organic matter originated from plants and animals and mineral matter from rocks in general. Depending on its nature, the characteristics of soil constituent elements and geographical features, soil is mature and can be differentiated. In Benin soil is mainly classified as follows.

1) Little-evolution Mineral Soil

It can be observed in all areas (land covered by rock or coastal dunes) where rock is exposed.

2) Ferruginous Soil

This is the most extensively distributed soil, and can be roughly classified into the following two sub-types.

① Strong ferruginous congealed soil: soil that cannot be used to cultivate

crops due to its continuous layers like armors in the North.

② Weak ferruginous congealed soil: isolated gravel with a slight indication of fertile soil.

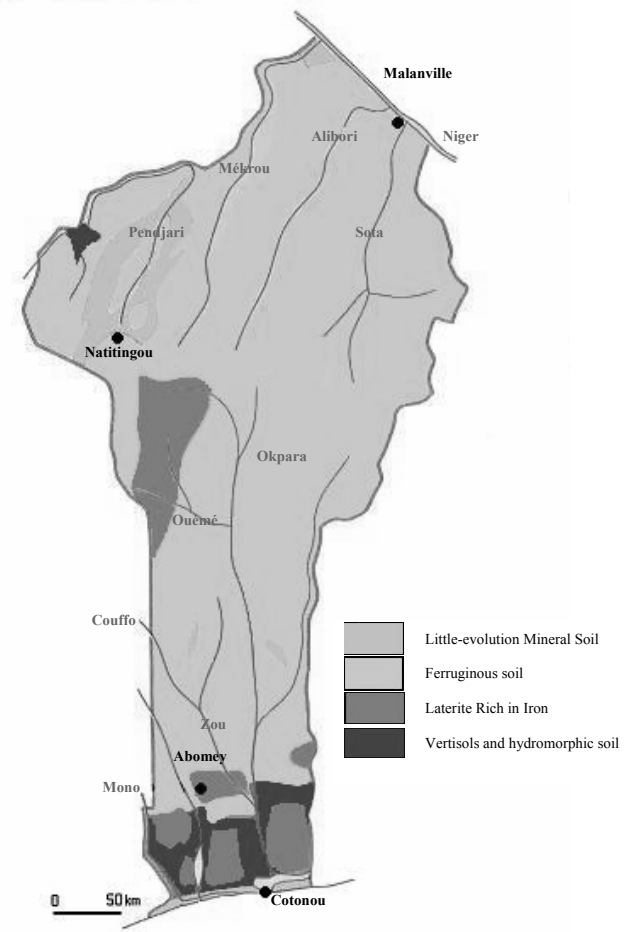

Fig. I-14 Soil map in Benin

(Source : le Bénin, Kolawplé Sikirou ADAM / Michel BOKO, Les Edition du Flamboyant/EDICEF, 1993)

3) Laterite Rich in Iron

This is red thick-layered soil which is formed on the Continental Terminal in the South, which is suitable for crop cultivation.

4) Vertisols and Hydromorphic Soil

Black thick-layered, fertile soil observed in hollows in the central region and in the large basins (such as the Niger, Ouémé, Couffo and Mono Rivers).

3-9 Cropping System

The National Agricultural Research Institute of Benin (INRAB [*]) mentioned later takes their initiatives from the development of new varieties and crop cultivation technologies. New varieties and technologies are transferred to the research institutes in each local department. After extension staff at the Regional Center of Agricultural Promotion (CeRPA[**]) and farming leaders receive pilot experience and the prospect for dissemination is ready, they are introduced at the actual sites. Hereinafter, recommended varieties and the characteristics of major crops and cultivation standards are shown.

1) Maize

(1) Variety: NH1(1971)[***], NH2 (1975), NCP 80 (1980), CIMMYT-IITA-BENIN POZA-RICA 7843 SR (1981), CIMMYT-IITA-BENIN Pirsaback 7930 SR (1981), DMR-ESR (1984), CIMMYT-GHANA- BENIN Oba Tampa (1988), IITA-BENIN EVDT 97 STR (2000)

(2) Variety Characteristics

① Recommended variety: IITA-BENIN EVDT 97 STR

② Growing period: 90 days

③ Average Yield: 2 to 3t/ha

④ Other: *Striga hermonthica* (parasitic plant) resistant

(3) Cultivation Standards

① Fertilization: TSP (triple super phosphate) 50kg/ha

② Planting density: 80×40cm 2 seedlings/stock

③ Preceding (rotation) cropping: Cotton, peanuts and cowpea

2) Rice

(1) Variety: Gambiaca (1977), IR 442 (1980), ADNY 11 (1982), ITA 212 (1983), 11365 (1987), NIARIS 85-12 (1987), IRAT 136 (1994), ITA 222 (1997), BERIS 21 (1999), NERICA (2002)

(2) Variety Characteristics

① Recommended variety: As for upland rice variety, IDSA 85, IR 47 701, NERICA 1and 2

As for paddy rice variety, ITA 222, SIK 131, BERIS 21 and

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[*] Institut National des Recherches Agricoles du Bénin.

[**] Centre Régional pour la Promotion Agricole.

[***] ( ) indicates the year introduced.

WITA 4

② Average yield: 2 to 3 t/ha in upland rice variety, 4 to 6 t/ha in paddy rice variety

③ Other: NERICA 2 which is resistant to damage by birds (which is not susceptible to feeding damage due to long arista)

(3) Cultivation Standards

① Fertilization: Compound fertilizer (N15-$P_2O_5$20-K_2O15-S5-MgO3.5-Zn0.5) 200kg/ha, urea 75kg/ha, if it does not exist, fertilizer for cotton can be used. After cropping cowpeas, TSP 50kg/ha

② Rotation cropping: In the case of rotation cropping with cowpea in the lowlands, 50% of the fertilizer can be saved.

③ Weeding: Topstar 0.7 ℓ/ha before weed grow, Garil 5 ℓ/ha after weeds grow

3) Cowpea

(1) Variety: IT 82 E-32 (1986), IT 81 D-1137 (1986), IT 95 K-193-12 (2002)

(2) Variety Characteristics

① IT 82 E-32: 60-day growing period, the average yield of 0.95t/ha, 2.2t/ha potential yield, reddish brown grain color, semi-upright form

② IT 81 D-1137: 70 to 80-day growing period, 1.0t/ha average yield, 2.2t/ha potential yield

③ IT 95 K-193-12: 65-day growing period, 1.0t/ha average yield, 2.0t/ha potential yield

(3) Cultivation Standards

① Fertilization: At seeding time, 100kg/ha TSP (triple super phosphate)＋50kg/ha potassium chloride

② Planting density: 50×15cm 1 seedling/stock (upright), 60×20cm 1 seedling/stock (semi-upright)

③ Pest control: Chemical spray 3 to 4 times

- 1^{st} (optional) if damaged 10 to 15 days later landfill
- 2^{nd} (recommended) when flowering sprouts appear
- 3^{rd} (recommended) when the first sheaths appear
- 4^{th} (optional) around 15^{th} day after implementing 3 times

④ Pesticide: mixed liquid of 400ml Decis＋800ml Malathion, 1000ml/ha Kinikini

4) Groundnuts

(1) Variety: MOTO, TE-3, TS-32-1

(2) Variety Characteristics
① Recommended variety: TS-32-1
② Growing period: 90days
③ Average yield: 1.2t/ha
④ Potential yield: 2.5t/ha
⑤ Oil content: 51%
(3) Cultivation Standards
① Growing density: 40×20cm 1 seedling/stock
② Fertilization: P40+S12

5) Cassava
(1) Variety: TMS 30572 (1988), BEN 86052 (1986), RB 89509 (1989)
(2) Variety Characteristics
① TMS 30572: 35 to 40t/ha yield
② BEN 86052: 12-month growing period, 17.5t/ha average yield, 25.0t/ha potential yield, pest and disease resistant (such as mosaic virus, *Pseudomonas cichorii* and *Cassava green mite*), *hypovirulence*, upright
③ RB 89509: 35 to 40t/ha yield
(3) Cultivation Standards
① Cuttage time: March to the early April
② Harvest time: 12 months after planting
③ Fertilization: N60kg-P16kg-K138kg/ha for22t/ha, N30kg-P30kg-K60kg/ha for 18t/ha
④ Propagation method: 3 types of basket method, piling up method by heaping, stop-gapping, cuttage seedlings 10 to 20 times.

3-10 Food and Farming Policies

1) Agro-politics

In Benin, agriculture is an important exporting industry for obtaining foreign currencies (in particular, cotton accounts for 30% of trading items). In the national development policy, agriculture is given a high priority. However, there are no special policies on the production enhancement of pulse crops, which is different from other major crops, especially cassava, rice and cotton. Although information on pulse crops is available at the INRAB as will be mentioned later, there are no projects or programs conducted by the Ministry of Agriculture, Livestock and Fisheries (MAEP*) or under the national policy. In

* Minietère de l'Agriculture, de l'Elevage et de la Pêche.

other words, the most important goal is to increase the production of staple foods such as corn, cassava, yam and rice, and to attain self-sustainability and a safe food supply system. Although self-support of staple foods has almost been accomplished, maintaining a stable food supply is expected to become difficult in the future due to the increasing food demand associated with sluggish agricultural productivity and high population growth (2.6%, 2000 to 2005, %/year). Consequently, national agricultural policies advocate ① substantiation of agricultural techniques and extension activities, ② support for farmer organizations, ③ introduction and diffusion of agricultural machinery and plant materials with superior seed quality, and ④ promoting agricultural research.

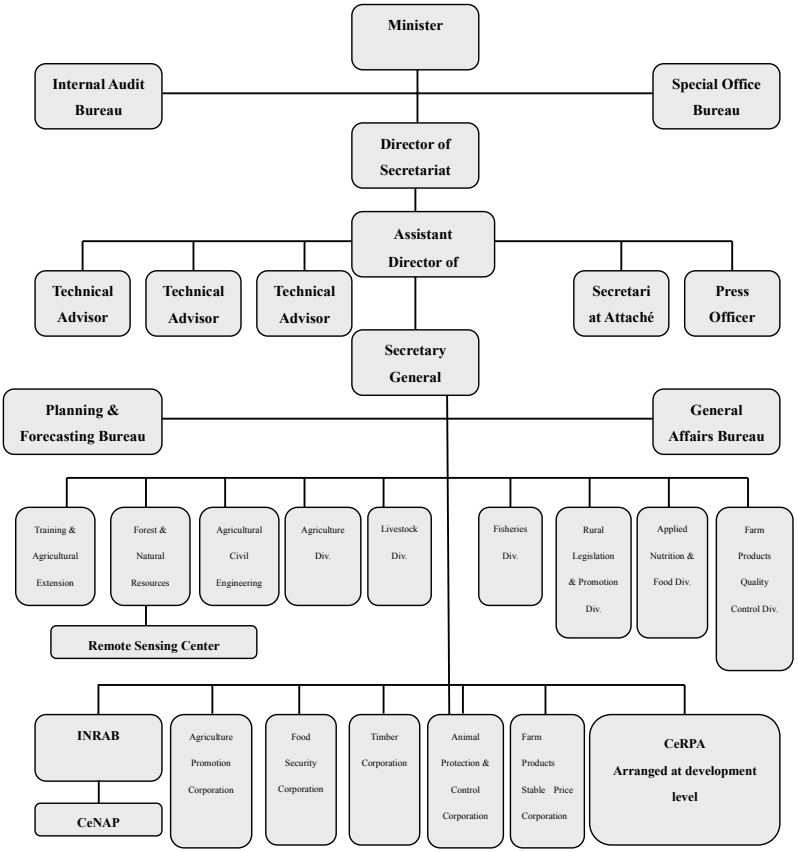

Fig. I-15 Organizational Chart of Ministry of Agriculture, Livestock and Fisheries

(Source: Ministry of Agriculture, Livestock and Fisheries)

2) Agricultural Administration

The Ministry of Agriculture, Livestock and Fisheries is the highest organization, and the following bureaus and departments are divided as shown in Figure I-15. The INRAB, which is the key organization for agricultural research, and the Regional Centers for Agricultural Promotion (CeRPA) for agricultural extension fall under the control of the Ministry.

3) Agricultural Experiment and Research

In Benin, the INRAB undertakes research initiatives in agricultural sciences in collaboration with the International Institute of Tropical Agriculture (IITA), whose head office is located in Nigeria, for the purpose of providing information on food crops (such as improved varieties and pest control technology). The Africa Rice Center (WARDA*) in Cotonou is responsible for the rice research. The IITA has a branch (Benin Station) in Cotonou and conducts experiments and research in the fields of African farm households mainly in integrated pest managements control (IPM) for their mandate food crops (such as cassava, yam, maize, cowpeas and vegetables).

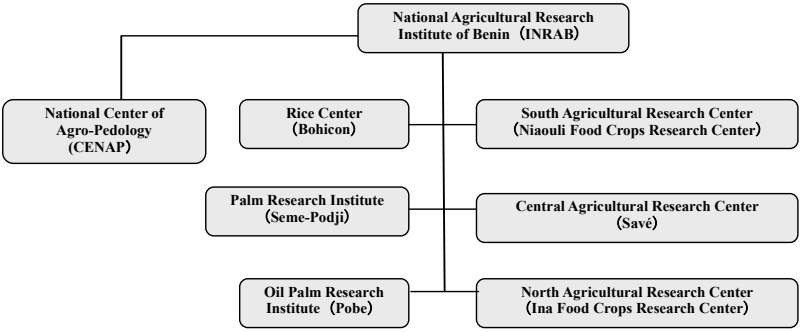

Fig. I-16 National Agricultural Research Institutions

(Source: Ministry of Agriculture, Livestock and Fisheries)

The INRAB was established in 1992 and ① contributes to the formulation of national policies on research in the field of agriculture. At the same time, it ② plans, formulates and implements research programs in the agricultural sector. In addition, the Institute ③ contributes to the transfer of technology to beneficiaries such as those involved in agriculture, ⑤ coordinates national activities on agricultural research, and ⑥ provides staff training for agricultural research and development. Moreover, the Institute ⑦ conducts

* In the past the Africa Rice Center was called the West Africa Rice Development Association or WARDA for short, and is still firmly established even at the present.

surveys and appraisals in the field, while at the same time, ⑧ dispatching information on the findings. During the 1990s, the Institute had 12 affiliated technical research institutions, 64 researchers and 100 engineers. However, during the 3rd structural adjustment program issued in February 1996 and a roundtable conference on the research program in the same year, the decision was made to reorganize and integrate personnel and research activities for coming 5 years. Consequently, only institutions listed in the following figure carry out research issued by the INRAB.

Hereinafter the group of institutions is outlined.

(1) National Centre of Agro-Pedology (CENAP)

The Center appears in the organizational chart of the Ministry of Agriculture, Livestock and Fisheries and carries out research in the following issues in order to fully understand natural resources for the purpose of soil utilization for sustainable development.

① Classification and evaluation of soil resources
② Preparation of soil maps
③ Analysis on soil, water conservancy and vegetation
④ Soil fertilization and rehabilitation
⑤ Soil and water conservation

(2) Rice Center (Bohicon)

This is the only laboratory specified for rice research and development in Benin. Improved varieties are obtained from the International Rice Research Institute (IRRI) in the Philippines, or WARDA carries out experiments on regional adaptabilities of each rice variety.

(3) Palm Research Institute (Seme-Podji)

This laboratory is specialized in coconut palm, and was established in 1949, located at 20km from Proto-Novo, the capital, near Cotonou. Major research themes are as follows.

① Development of superior varieties
② Development of a technical package necessary for disseminating hybrid palm trees
③ Regeneration of soil deteriorated by coconut palm

(4) Oil Palm Research Institute (Pobe)

This oil palm research institution was established in 1922 and is the oldest in the world. The research themes are as follows.

① Improvement of oil production per ha through hybrid research which is expected to obtain good results within the Benin ecology
② Research on physiological characteristics in order to understand different reactions demonstrated in dry fields
③ Agronomic research in order to develop cultivation techniques and fertilization methods suitable for the climatic conditions of Benin

④ Seed production
⑤ Seedling production
⑥ Support for oil company associations
⑦ Support for plantations

(5) South Agricultural Research Center (Niaouli Food Crops Research Center)

This center, the oldest center in Benin, was established in 1904 for the purpose of adapting European cultivation technology to tropical crops. The center has 220ha of experimental field, and the following researches are conducted for grains (corn, rice and cowpeas) and tubers (cassava):

① Survey, collection, evaluation and conservation of local plant genetic resources
② Introduction of improved varieties and their evaluation
③ Development of varieties adapted to the local agricultural environments and other conditions
④ Research on comprehensive pest control
⑤ Research on appropriate cultivation techniques
⑥ Research on traditional production system for sustainable agriculture
⑦ Diversification of cultivation technology

In addition, the following researches are conducted at present.

① Cowpeas: Many varieties that are resistant to Striga (parasitic plant) are selected through farmer participation.
② Soybeans: Studies on yield improvement, on varieties suitable for mixed cropping or rotation cropping system, on varieties for high oil content are included.
③ Cassava: Selection of high yielding varieties.
④ Groundnut: In a similar manner as soybeans, experimentation and research are carried out, and selection and soil fertility testing are conducted through farmers' participation. The first seeds materials were obtained from the IITA.
⑤ Other crops: As for a cropping system, mixed cropping with maize and pulses are recommended. Although a germplasm storage facility is developed at the Center, power blackouts frequently occur and generators are utilized during emergency situations.

(6) Central Agricultural Research Center (Savé)

At the Center, a wide range of food crops such as rice, yam, maize, sorghum cassava and groundnut are being studied.

(7) North Agricultural Research Center (Ina Food Crops Research Center)

The Center, established in 1930, has an area of 3,255ha. Although maize, yam sorghum and groundnut are the main crops studied by the Center, cowpea is also included. In recent years, soybeans are targeted. Major research themes are as follows.

① Adding extra values to the crop varieties desired by farmers and the development of new varieties
② Improvement of traditional production systems in collaboration with development institutions
③ Reduce pesticide by utilizing IPM against major pests and during post harvest treatment
④ Research on cultivation technology and natural resources conservation
⑤ Research on technology to add value to post harvest products
⑤ Diversification of cultivation (vegetables)

4) Agricultural Extension

As shown in Figure I-10, there are 12 administrative departments (ATACORA, DONGA, ATLANTIQUE, LITTORAL, BORGOU, ALIBORI, MONO, COUFFO, OUEME, PLATEAU, ZOU and COLLINES) and 6 regions (ATACORA-DONGA, ATLANTIQUE-LITTORAL, BORGOU-ALIBORI, MONO-COUFFO, OUEME-PLATEAU and ZOU-COLLINES). In each region, the Regional Center of Agricultural Promotion (CeRPA) is conducting the extension work. During the colonial period, many support groups in the agricultural sector were developed for political reasons. In 1975 the Government established the Rural Development Action Center (CARDER*) whose major role was food security and the promotion of cotton production. In the 1990s, products became diversified due to the liberalization of the economy and a drop in the international price for cotton. The Government was pressed to reform and began to focus its attention on improving the living standards of farmers under a new agricultural policy, and a draft for organizational reform known as the CeRPA was submitted in 2004 and a new organization, the CeRPA was inaugurated in 2005.

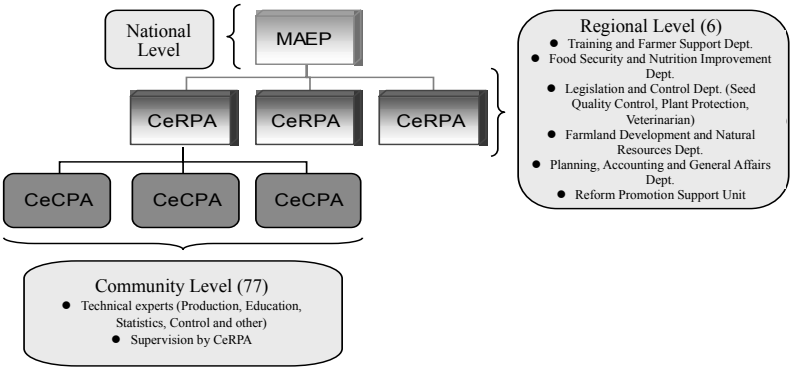

Fig. I-17 Organization chart of CeRPA

(Source : from the fact-finding at CeRPA Ouémé-Plateau)

* Centre d'Action Régional pour le Développement Rural.

The role of the CeRPA is ① to disseminate new technology, ② to dispatch information to rural areas, ③ to provide training and ④ to support farmers' organizations, at the development level. CeRPA is located in each administrative department, divisions smaller than department such as communes or communities are covered by the Local Centers for Agricultural Promotion (CeCPA*) which is located in 77 communes (communities) nationwide. The Responsible Communal for Agricultural Promotion (RCPA**) takes charge of their duties. The organization of the CeRPA is illustrated in the following figure.

The Local Promotion Team (EPZ***) is responsible for administrative divisions (departments) smaller than communities under the control of the CeCPA

In the days of CARDER, extension workers (APV****) were not evaluated because they just distributed technical manuals on agricultural production. At present, extension workers (technical experts) at the CeCPA have the expertise in terms of crops production, livestock and fishery production, farming, farmland development and natural resources management. However, due to the budget restraints, no new extension workers have been hired during the past 20 years, so aging of human resources has become a major concern. Although the cotton textile development corporation does recruiting new extension workers every year, this is a very special case. The extension workers are national civil servants. However, those who are hired in local areas work at their relevant site and are not transferred to other areas due to local language barriers (tribal languages). In some departments such as Mono, a governor hires extension workers at his own discretion. However, this is a rare case even under the general tendencies of decentralization. Although the numbers of civil servants including extension workers differ according to the population and size of each department, in the case of the Ouémé-Plateau region, there are 145 full-time employees and 94 temporary workers (239 persons in total). In the past, those who had graduated from agricultural college or senior high school could become extension workers. However, only those who have obtained their BAC (university candidate qualifications) or who graduated from a 4-year university are now hired. For positions higher than manager at the CeRPA, a master's degree or higher is required.

Main technologies of extension to farmers include ① improving soil fertility by the effective use of cover crops, ② biological pest control

* Centre Communal pour la Promotion Agricole.
** Responsible Communal pour la Promotion Agricole.
*** Equipe de la Promotion Zone.
**** Agent de Polyvalant Vulgarisation.

technology (e.g. effective use of Neem*), ③ promotion of sustainable agriculture, and ④ alley cropping. In addition, crop production technologies on acidic soils are of particular importance.

Agricultural implements such as power tillers (cultivators) have been introduced as a community program. Farmers themselves procure general farming tools such as hoes or axes at the market. Since introduction of the large-sized milling machines have not been successful, small-sized milling machines are now installed in the community.

In this chapter (Chapter I), agriculture in West Africa (natural environment, pulse crops and agriculture in Benin) is outlined. With respect to the pulse crops, cowpea, groundnut, bambara groundnut and soybean are the most important. The origins and diversification, production and harvest, cropping and cultivation systems and utilization, breeding and causes for production restraints and future prospects of these important pulse crops will be discussed in Chapter II.

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* *Azadirachta indica A.* Juss.

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Chapter II　Pulse Crops of West Africa

1. Cowpea (*Vigna uncuiculata* (L.) Walpers)

English name: Cowpea, Benin: Niébé

Photo II-1-1　Cowpea

Source：NIAS Genebank・Illustrated legume genetic resources database
http://www.gene.affrc.go.jp/plant/image/legume_j.html

1-1 Overview

Cowpea, which originated in West Africa, is an important pulse crop and is cultivated extensively throughout Africa. In the dry savanna zone of West Africa, many varieties have been developed for diversified cropping systems. From a nutritional aspect, cowpea has played an important role in protein supplementation of staple grains (maize, sorghum and millets). However, present yields are low and they are not very resistant to drought or pests and diseases. Despite this, cowpea is popular in Africa and production is increasing. The International Institute of Tropical Agriculture (IITA), whose head office is in Nigeria, has taken an active role in improving varieties. However, one social problem facing West Africa is the health of farmers who use agricultural chemicals for cotton cultivation. At the Benin station of IITA, research which focuses on developing cowpea varieties that do not require the application of chemicals.

Based on the findings of the field study in Benin, it was discovered that no vegetable markets sell the pods of pulse crops. In Southeast Asia, for example, the pods of one variety of yard-long bean, *Vigna unguiculata* (L.), are eaten as a vegetable. The introduction of this variety to West Africa would appear to be worthy of examination.

1-2 Origin and Diversification

1) Origin, Center of Diversity and Diffusion (Spread)

The center of cowpea diversity in West Africa is Nigeria, southern Niger, Burkina Faso and Togo. The oldest cowpea seeds (possibly wild cowpea judging from seed size) based on radiocarbon dating were exhumed from the Kintampo rock shelter in central Ghana, and dated at approximately 3,500 BP (Ng, 1997). Based on archeological data, animal husbandry was common in West Africa 5-3500 BP and it is believed that wild cowpea was a livestock feed. In 4000 BP domesticated cowpea spread throughout West Asia and then to India in the 2200 BP. In India, Catjang beans (*Vigna unguiculata* cultigroup Biflora), which has small pods that grow upward had developed. Based on a reference to cowpea in the diary of Todai-ji Temple, by 1100BP it appears cowpea spread to Japan via Southeast Asia.

It is recorded that cowpea was first introduced to Europeans when they were brought to Greece during the expedition of Alexander the Great. Although cowpea was thought to have been cultivated extensively in Germany until the middle Ages, their cultivation soon faded due to the introduction of common bean *(Phaseolus vulgaris* L.). Only the name remains to this day. Cowpea is still cultivated in the Mediterranean region in Southern and Eastern Europe. It was then brought to the New World by the Spanish who reached the West Indies in the 16th Century, and introduced from West Africa via the slave trade which also began in the 16th Century.

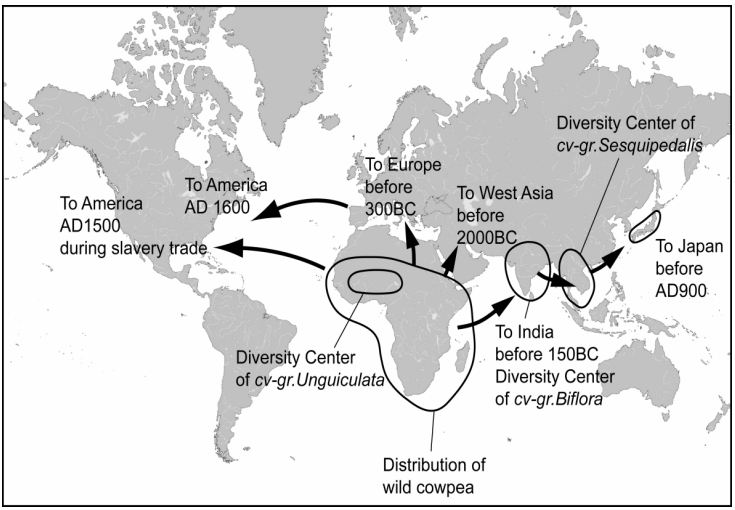


Fig.II-1-1 Origin and dispersal of cowpea

2) Classification of Wild Cowpea and Geographical Distribution

Table II-1-1　Taxonomic systems of cowpea

Maréchal et al. (1978)	Pienaar (1992)	Pasquet (1993a)	Padulosi (1993)
V. unguiculata	*V. unguiculata*	*V. unguiculata* ssp. *unguiculata* var. *spontanea*	*V. unguiculata*
ssp. *dekindtiana* var. *dekindtiana*	ssp. *dekindtiana* var. *dekindtiana* var. *huliensis*	ssp. *dekindtiana* var. *dekindtiana*	ssp. *dekindtiana* var. *dekindtiana* var. *huliensis* var. *congolensis* var. *grandiflora*
var. *mensensis*	ssp. *mensensis*	ssp. *letouzeyi* ssp. *burundiensis* ssp. *baoulensis*	var. *ciliolata*
var. *protracta*	ssp. *protracta*	ssp. *stenophylla*	ssp. *protracta* var. *protracta* var. *kgalagadiensis* var. *rhomboidea*
var. *pubescens*	ssp. *protracta*	ssp. *pubescens*	ssp. *pubescens*
ssp. *stenophylla* ssp. *tenuis*	ssp. *stenophylla* ssp. *tenuis* var. *tenuis* var. *ovata*	ssp. *stenophylla* ssp. *tenuis*	ssp. *stenophylla* ssp. *tenuis* var. *tenuis* var. *oblonga* var. *parviflora*

Source：Advances in Cowpea Research (1997)

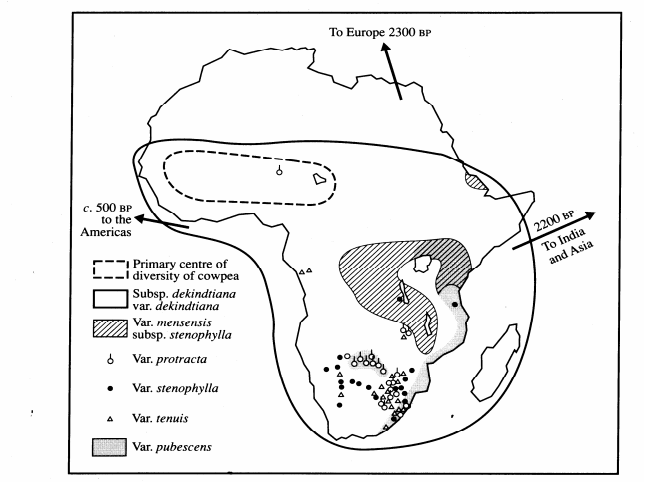


Fig.II-1-2　Geographical distribution of wild cowpea

（Diversity center of wild cowpea is in south and southeast Africa）

Source：Evolution of Crop Plants (1995)

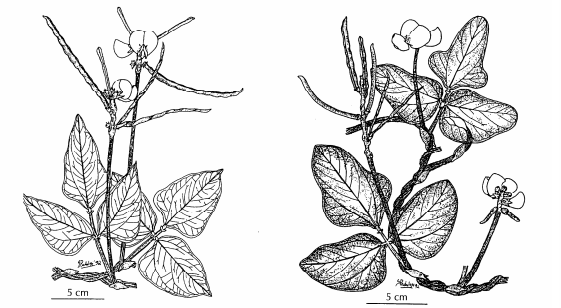


Figure 1. ***Vigna unguiculata*** **ssp.** ***dekindtiana*** **var.** ***dekindtiana*** **(left), and ssp.** ***pubescens*** **(right).**

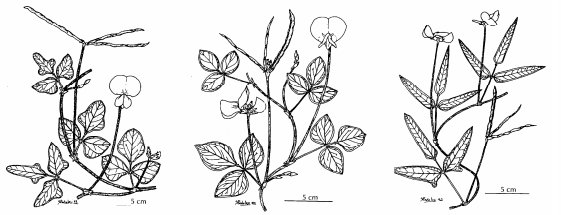


Figure 2. ***Vigna unguiculata*** **ssp.** ***protracta*** **var.** ***protracta*** **(left), ssp.** ***tenuis*** **var.** ***tenuis*** **(centre), and ssp.** ***stenophylla*** **(right).**

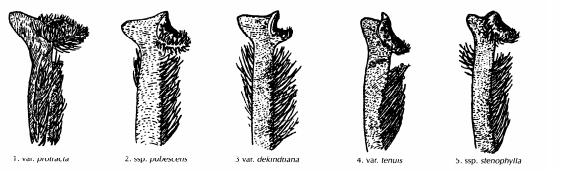


Figure 3. Stigmata of the indicated subspecies of ***Vigna unguiculata*** **(L.) Walp.**

Fig.II-1-3 Morphological characteristics of wild cowpea based on the taxonomic system of Padulosi et al. (1993)

(Source : Advances in Cowpea Research, 1997)

The classification system of the wild relatives of cowpea differs according to taxonomists.

Ancestral wild species (*V. unguiculata* subsp. *dekindtiana* var. *dekindtiana*) are distributed across the Sub Sahara, Africa, and Madagascar. On the other hand, diverse wild species closely related to cowpea are distributed in South and Southwest Africa. IITA collects and stores genetic resources of cultivated and wild cowpea for breeding purposes.

1-3 Production and Yield

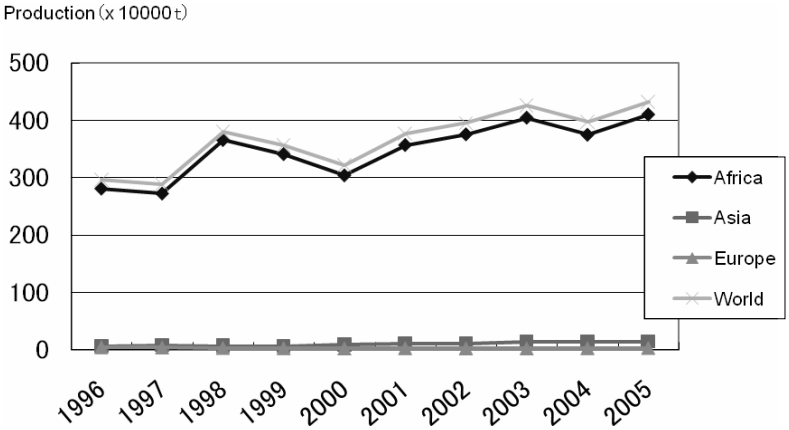


Fig.II-1-4　Production of cowpea

（source: FAO statistics）

Cowpea production has been increasing worldwide over the past ten years, with most of the production being in Africa.

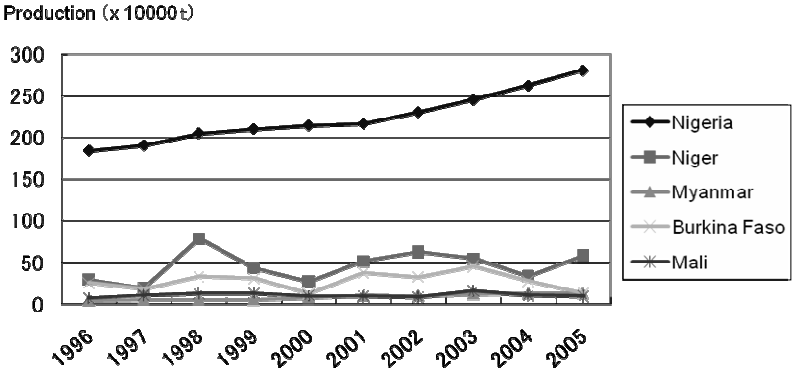


Fig.II-1-5　Main cowpea producing countries

（source: FAO statistics）

Viewed by country, Nigeria has seen the fastest increase in cowpea production. Aside from Africa, Myanmar is 3rd ranking (2005) in production.

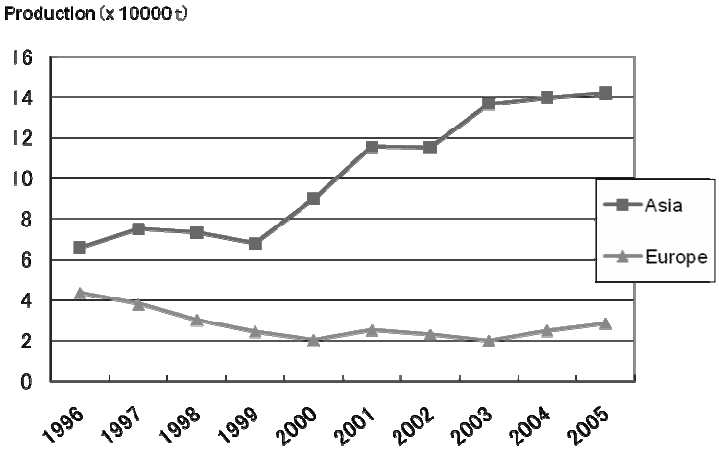


Fig.II-1-6 Cowpea production in Asia and Europe

(source: FAO statistics)

Production of cowpea has not been very high in Asia or Europe. However, production in Asia increased rapidly from year 2000. Production in Europe decreased from about 40,000t to 20,000t.

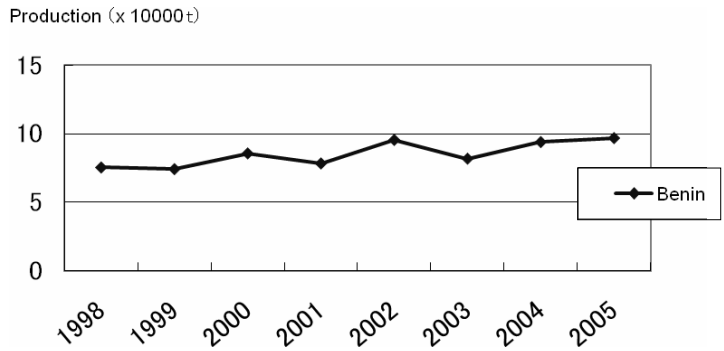


Fig.II-1-7 Cowpea production in Benin

(source: statistics of Benin)

Between 1998 and 2005 the production of cowpea in Benin fluctuates between 80,000t and 100,000t and it appears this will continue in the future.

1) Yield

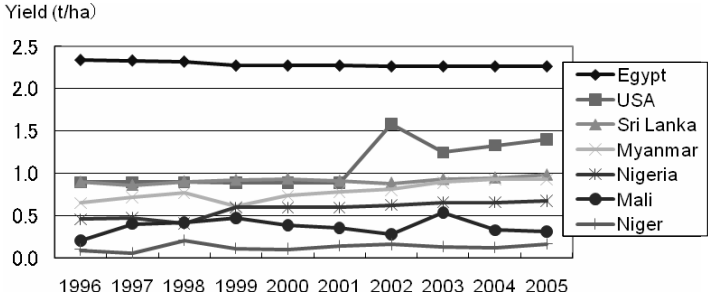


Fig.II-1-8 Cowpea yield of major producing countries

(source: FAO statistics)

The yield of cowpea in Egypt is between 2 to 2.5t/ha. The yield in Southeast Asia rose from 0.5 to 1 t/ha however in most African nations the yield does not usually exceed 0.5t/ha. The yield in Nigeria has surpassed 1 t/ha in recent years. The yield of cowpea in the United States was approximately 1 t/ha until 2002 then rose to about 1.5t/ha.

2) Production of Cowpea in Benin by Region

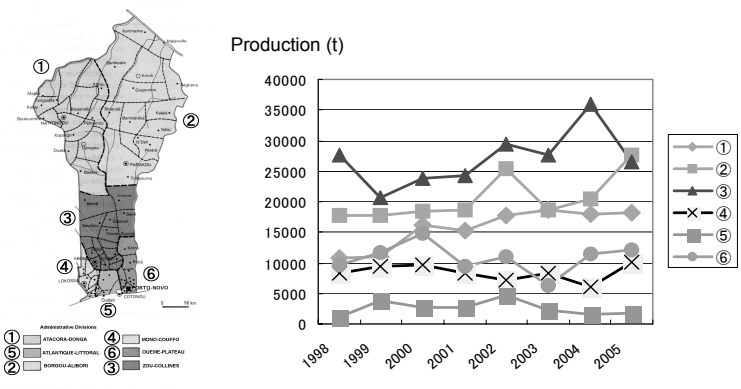


Fig.II-1-9 Cowpea production in each region of Benin

(source: statistics of Benin)

The production of cowpea in Benin is mainly concentrated in the central-north with some in the south. The largest production area used to be ③ Zou-Collines in the central region; however, it was overtaken by ② Borgou-Alibori in the northeast in 2005. Production in ① Atacora-Donga in the northwest has also been increasing.

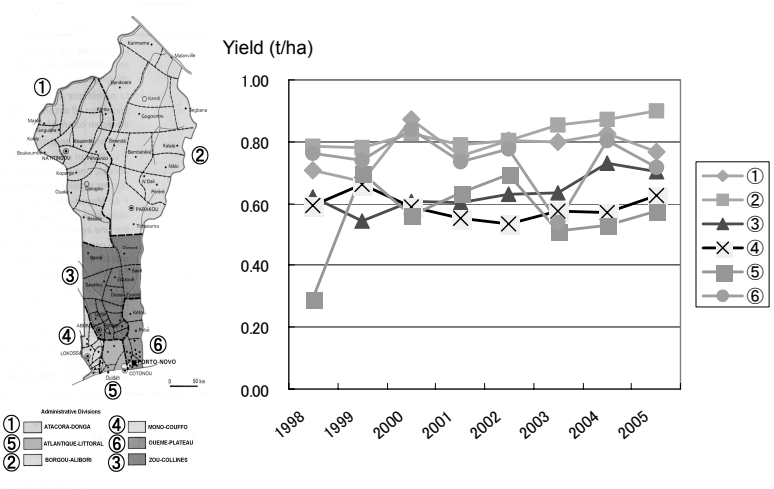


Fig.II-1-10 Cowpea yield in each region of Benin

(source: statistics of Benin)

According to Benin governmental data, the yield of cowpea in Benin is between 0.5 and 1t/ha, which is higher than the average for West Africa based on FAO statistics. It tends to be higher in ② Borgou-Alibori or ① Atacora-Donga in the north. With regard to yield, various factors including onsite environmental conditions, cultivation methods, cropping systems and varieties planted should be taken into account.

1-4 Cropping System, Cultivation Method, and Use

1) Cropping System

(1) Asia and Oceania Regions

Cowpea is widely cultivated as a subsistence crop, and is grown for mature dry seeds, for their immature pods, or for animal feed. Cowpea for dry seeds and for livestock feed is common in South Asia. From Southeast Asia to East Asia, immature cowpea pods are often used as a vegetable. One variety group developed in Southeast Asia is called yard-long bean, the long pods of which are specially grown for vegetable production.

Cowpea has diversified into various varieties from an early-maturing erect type, a late-maturing spreading type, and an indeterminate twining type. The early-maturing erect type variety is often cultivated mainly as a catch crop after rice or wheat, or sometimes it is cultivated as a single crop (monoculture). Although the late-maturing variety is frequently grown together with maize, sorghum or millets, usually the density of cowpea is low. Cowpea varieties that are grown for their pods are usually cultivated in home gardens and new pods are harvested regularly by hand at intervals of four to six days year-round. They are called "*Bori*" in India, Bangladesh and Nepal. With respect to young yard-long bean, which is cultivated extensively in East Asia or Southeast Asia, monoculture is applied with wide spacing between the mounds for poles (supporting) in many cases. There is a variety called "*bush sitao*" of which young pods are used and is characterized as an early-maturing semi-erect growth type. It has long flower stalks, about 30cm long succulent pods and is generally cultivated through monoculture without the use of poles. Cowpea for animal feed is cultivated as a monoculture or mixed with maize and sorghum. In the case of mixed cropping, the density of cowpea is usually high and cowpea is harvested at its flowering stage. At that time, cereal crops grown mixed with cowpea reached their maturity stage and is harvested together with forage cowpea.

(2) Europe and North America

Varieties for animal feed and varieties for mature dry seeds are cultivated as single cropping in southern Turkey, Spain, Greece, Italy, Bulgaria and the southern United States. In the Unites States, the large black eye or brown eye varieties are cultivated by machinery as a commercial crop in the states of Georgia, California, Texas, Mississippi, Arkansas and Tennessee. Varieties that are grown for their pods are cultivated together with yard-long beans or *bush sitao*, although the amount of production is relatively small.

(3) Central and South America

Cowpea is an important crop in Brazil, Venezuela, Peru, Panama, El Salvador, Haiti, Ecuador, Guyana and Suriname and is usually cultivated as monoculture. In some case, a mixed cropping with maize is applied. Both varieties for mature dry seeds and a variety for vegetables are produced. Cowpea in this region is characterized by highly diversified seed colors.

(4) East and South Africa

Cowpea is an extremely important crop. Although varieties for dry mature seeds and for vegetables are cultivated. In case of vegetable cowpea varieties, they are different from those in East Asia and Southeast Asia and the soft leaves instead of young pods are used as vegetables. The cowpea leaves are more important than the seeds in this region. Most farm households grow several

mounds of late-maturing spreading type varieties that are resistant to drought and their leaves are used as vegetables. For dry seeds, the same variety is cultivated under a mixed cropping system together with maize.

(5) Central and West Africa

In this region cowpea is a staple food crop. While mixed cropping with sorghum or millets is often applied in the dry savanna district in the North, this crop is cultivated together with yams, cassava and maize in the South where it is more humid. The primary purpose for its cultivation in Central Africa or West Africa is to utilize its dry mature seeds; whereas, in some areas in Benin and Eastern Nigeria the soft leaves or pods are used as vegetables. In the dry savanna zone, cowpea for animal feed is as important as cowpea for human food. In this zone, livestock are extremely important, and grass disappears during the dry season, farmers grow not only cowpea for food (early variety) but also cowpea for animal feed (late variety).

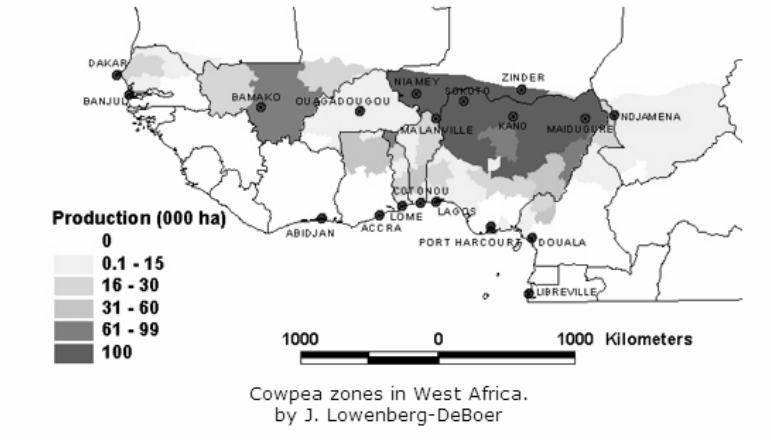


Fig.II-1-11 Cowpea cultivation area in West Africa

Source：Purdue University Network for the Genetic Improvement for Africa

http://www.entm.purdue.edu/ngica/photos/cowpea_in_the_field/picture0010.html

In West Africa diverse cowpea varieties are cultivated in various cropping systems. The importance of cowpea in the north area is greater since it is much drier and soil fertility is lower. In the north, cowpea is frequently used as animal feed.

Between 1988 and 1990 IITA carried out cowpea research in Nigeria, Benin, Niger, Togo, Cameroon and Burkina Faso and classified cowpea cultivation into 15 types of cropping systems in 4 ecological zones (A: Forest

and South of Guinea Savanna, B: North of Guinea Savanna, C: Sudan Savanna and D: Sahel Region) as shown in Table II-2.

In zone A, cowpea is cultivated together with maize, cassava, yam and groundnut, cowpea density is low (1,000 to 5,000 individual/ha). In Zone B, cowpea is cultivated by mixed cropping with groundnut and sorghum. In this case, the most common method is mixed cropping in rows using a systematic intercropping pattern. In Zone C, mixed cropping with millets or sorghum is common. Although cowpea is usually mixed with millets in Zone D, it is sometimes cultivated as monoculture.

Table II-2 Cropping System including Cowpea in Ecological Zones in West Africa

Zone A	Forest and Southern Guinea Savanna
	1. Cassava - Cowpea
	2. Maize - Cassava - Cowpea
	3. Maize - Cowpea
	4. Maize - Cowpea, Rely on second rainy season or double cropping
	5. Maize - Groundnut - Cowpea
Zone B	Northern Guinea Savanna
	6. Maize - Rely on cultivation of cowpea
	7. Groundnut - Cowpea
	8. Groundnut including (or excluding) Millets - Sorghum - Cowpea
	9. Sorghum - Cowpea
Zone C	Sudan Savanna
	10. Sorghum - Groundnut - Cowpea
	11. Millets - Sorghum - Rely on cultivation of cowpea including (or excluding) groundnut
	12. Millets - Sorghum - Cowpea - Groundnut
	13. Millets - Groundnut - Cowpea
Zone D	Sahel Region
	14. Millets - Cowpea
	15. Millets or Cowpea

Source: Advances in Cowpea Research (1997)

Major cereal crops mixed with cowpea gradually change from maize → sorghum → millet as the environment changes from humid to dry.

Fig. II-1-12 demonstrates a cropping system including cowpea seen in Kano district of Nigeria. At the beginning of the rainy season (between May and June), millets are seeded in a wide ridge of between 1.5m and 3m, and at approximately 1m intervals on each ridge. The planting density is 4,000 to 6,000 hill/ha. In late June, when the rainfall stabilizes, early cowpea grown for dry mature seeds is seeded in single rows between the millet ridges. The

distance between each mound is approximately 1m. Late cowpea for animal feed is seeded between the remaining millet ridges in mid July. In this manner, a mixed field of ridges of millet, early cowpea, millet and late cowpea that are seeded repeatedly is created. In some cases, sorghum or groundnut are planted instead of millet or added to the mixed crops creating a more complicated cropping system. Millet and early cowpea are harvested from late August to early September. Late cowpea or sorghum remains until the beginning of the dry season (between October and November). Farmers wait until the leaves of late cowpea variety used for animal feed become dry and withered, and then harvest the cowpea plants and wind them with leaves. Cowpea for animal feed which are wound are placed on roofs or hung from the branches of trees to dry. Dry cowpea plants prepared in this manner are sold or utilized between March and May when it is driest and when prices rise.

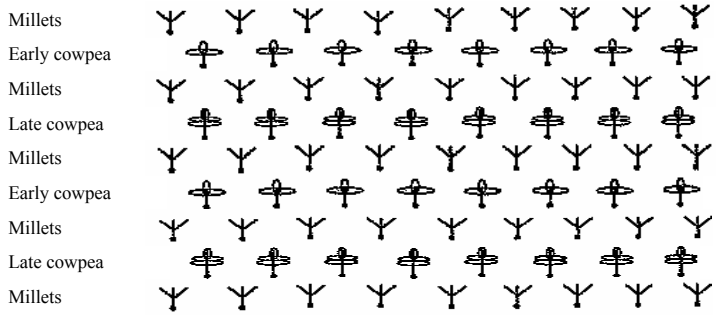


Fig.II-1-12　A representative cropping pattern in Kano district of northern Nigeria

source：Advances in Cowpea Research(1997)

Photo II-1-2　An example of cowpea-sorghum mixed cropping in West Africa

source：Purdue University Network for the Genetic Improvement for Africa Photogallery

http://www.entm.purdue.edu/ngica/photos/cowpea growers.html

Photo II-1-3　An example of cowpea-pearl millet mixed cropping in West Africa

source：same as left

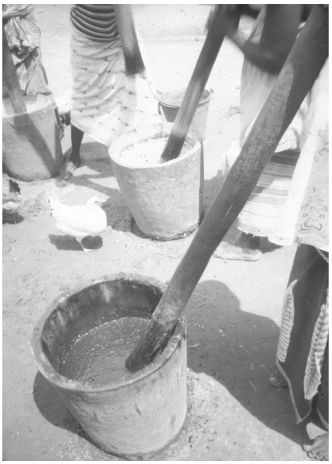
2) Utilization and Processing

Table II-1-3 Various Cowpea Utilization Methods in Benin

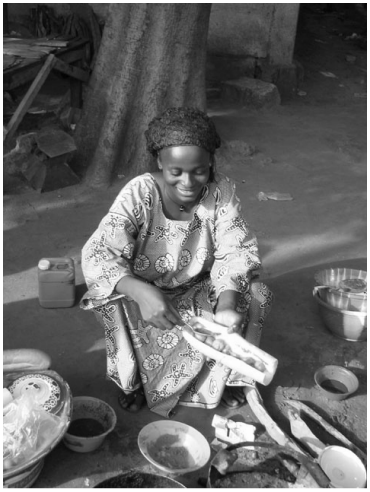
Name	Characteristics	Other Ingredients
Abobo	Seasoned boiled cowpea, frequently served as a side dish for fried food.	Red pepper, pepper, garlic, salt
Adwè	Cowpea paste (prepared by boiling cowpea until softened and making into a paste soaking and crushing to remove the thin skins); served as a snack or side dish for fried food or bread.	Salt
Ata	Cowpea dumpling fried in peanut oil (cowpea are soaked in water until they soften and crushed to remove the thin skins; spices are added and it is ground into a paste using a maize mill; the paste is made into small balls which are fried in peanut oil); served as a snack or eaten with spicy sauce.	Ginger, garlic, onions, red pepper, salt
Atachlè	Cowpea are made into fried dumpling using peanut oil (after grinding cowpea with a grinder, water is added and the cowpea are milled and kneaded; salt and spices are added to the paste and then it is shaped into dumplings and fried twice; fried dumplings are soaked in cold peanut oil for 1 hour to 24 hours); eaten with cassava or boiled yam, etc.	Red pepper, salt
Atassi	Cowpea red rice (boiled together with rice) (prepared by boiling red-seed cowpea with water and adding rice boiled with salt); served as a side dish for fried food or bread.	Rice, salt
Djogli	Boiled cowpea mixed with maize powder (prepared by adding spices or vegetables, or shrimp, etc. to boiled cowpea and then mixing in maize powder); eaten at breakfast or lunch together with fried or smoked fish or a meat dish.	Smoked shrimp, onions, red pepper, salt, palm oil
Doco	Fried cowpea dumplings (prepared by frying cowpea dumplings in oil; cowpea are ground, milled and mixed with water and spices and made into a paste, then dumplings made from the paste are fried); eaten at breakfast or lunch together with fried yam or fried cassava.	Ginger, garlic, onions, pepper, salt
Fèchaoda	Cowpea purée and boiled pork; a dish originating from Brazil (prepared by grinding with a mortar to remove thin skins and boiling; spices, oil and pork are then added to the purée); served with other dishes or bread	Peanut oil, smoked shrimp, tomatoes, onions, pepper, garlic, salt, pork
Magni-magni	Steamed cowpea dumpling wrapped in banana leaves (thin skins are removed from cowpea pounded in a mortar and then soaked in water to soften; spices and onions are added, then the seasoned paste is wrapped in banana leaves for steaming), which is served at lunch or as a snack.	Smoked shrimp, onions, garlic, red pepper, salt, palm oil
Vèyi	Cowpea are boiled until moisture evaporates (cowpea are boiled in spices until water has completely evaporated); eaten in the daytime or served with fried food, boiled cassava or boiled yam.	Red pepper, pepper, garlic, salt
Yoyouè	Fried roasted-cowpea powder (spices and shrimp are added to a paste of roasted cowpea powder and it is then fried); eaten with boiled cassava or boiled yam.	Oil, smoked shrimp, onions, garlic, pepper, red pepper, salt.

Source: Excerpt from the La transformation Alimentaire Traditionalle des Légumineuses et Oléagineux au Bénin (Pulses and Traditional Food Processing of Oil Seeds in Benin)

Cowpea seeds are soaked in water and seed coats are removed before make paste



Soaked cowpea seeds are squished to make paste



Cowpea paste used to make Kosai, a traditional fritter

Traditional cowpea food called “Abobo”

Photo II-1-4　Processed cowpea food

Source：Purdue University Network for the Genetic Improvement for Africa Photogallery

http://www.entm.purdue.edu/ngica/photos.html

1-5 Breeding and Production Restraint Factors

1) Breeding in Africa (by IITA)

According to Singh et al. 1997, the breeding efforts taken by IITA are as follows. Until around 1987, IITA has been conducting breeding procedure for cowpea on the assumption of monoculture. However, most cowpea in West and Central Africa are cultivated through mixed cropping. Therefore the breeding objectives were diversified.

(1) Breeding Objectives: Diverse varieties are required in Africa

The 10 breeding objectives are follows.

① To develop a day-length insensitive, very early variety for dry mature seeds production (60 to 70 days). This type of variety is for short duration monoculture crop in a cropping system crop for the area with shorter rainy season.

② To develop a day-length insensitive medium maturity variety for dry mature seeds production (75 to 90 days). This type of variety can be grown both as monoculture and mixed cropping.

③ To develop a day-length insensitive late variety for dry mature seeds production and also for green leafy vegetables production (85 to 120 days). This type of variety can be grown both as monoculture and mixed cropping system.

④ To develop a day-length sensitive early variety for dry mature seeds production (70 to 80 days). This type of variety is for the mixed cropping system.

⑤ To develop a day-length sensitive medium maturity variety for both dry mature seeds and animal forage production (75 to 90 days). This type of variety is for the mixed cropping system.

⑥ To develop a day-length sensitive late maturity variety for animal forage production (85 to 120 days). This type of variety is for mixed cropping system.

⑦ To develop a high yielding bushy variety for vegetables.

⑧ To develop a variety for high seed protein content, shorter cooking-time and preferred seed form and color which has high consumer's demand.

Photo II-1-5 Stems and leaves of cowpea are dried for forage. There is a high demand for cowpea forage in dry regions like northern West Africa.

Source: Purdue University Network for the Genetic Improvement for Africa Photogallery

http://www.entm.purdue.edu/ngica/photos.html

⑨ To develop a variety resistant to major diseases, pests and parasitic weeds.

⑩ To develop a variety resistant to drought, low pH and sandy soil with low fertility.

(2) Production Constraints and Solutions

① Virus Diseases

Varieties resistance virus diseases such as CPMV, CAMV, CGMV, CMV and SBMV have been developed. They are IT82D-889, IT83S-818, IT83D-442 and IT85F867-5.

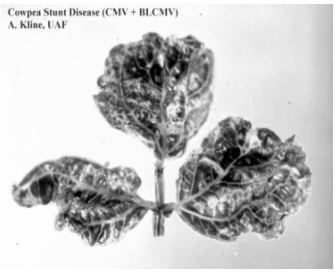


Photo II-1-6 Virus infected leaf

Source : Arkansas Univ. Cowpea viruses in Arkansas, http://comp.uark.edu/~morelock/cowpea_virus.html

② Bacterial Diseases

Two bacterial diseases, bacterial pustule (*Xanthomonas* spp.) and bacterial blight (*Xanthomonas vignicola*), cause extensive damage to cowpea worldwide. Breeding lines which is resistance to these two diseases have been developed by IITA. TVx1850-01E, IT90K-284-2, IT90K-277-2, IT86D-715, IT86D-719 and IT81D-1228-14 are promising lines.

Photo II-1-7 Bacterial blight infected leaf
(*Xanthomonas axonopodis* pv. *vignicola*)

Source : http://www.bspp.org.uk/ndr/july2006/2006-44.asp

③ Mold Diseases (Leaf Spots)

Anthracnose, Cercospora leafspot, Verticillium wilt, Phytophythora stem rot, Septoria leaf spot, Brown blotch, Scrab, Uromyces rust and Leaf smut are major fungal diseases. Resistant materials have been reported for these diseases. In most cases, resistance depends on a single gene. In the case of Fusarium wilt or Phytophthora stem rot, race differentiation has been reported, and so multiple resistance genes should been incorporated. The American cowpea race (variety), "Iron" is famous as a resistant material against Fusarium wilt and Charcoal rot. Resistant materials against other diseases have been detected in the IITA world cowpea collection.

Photo II-1-8 Cercospora leaf spot
Source : Texas A&M University,
Texas Plant Disease Handbook,
http://plantpathology.tamu.edu/Texlab/Vegetables/Southern_pea/vutop.html

④ Nematodes

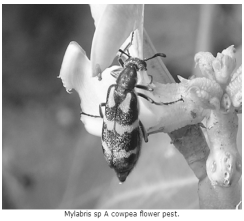
Approximately 55 species of nematodes parasites on cowpea have been reported, of which, the species that causes the most serious damage and distributes most widespread is *Meloidogyne incognita*. As a result of the intensive research in North America and Africa, a single superior resistance gene was discovered. IITA has developed breeding lines in which this resistance gene and a gene resistant to aphids and weevils (Bruchids) are incorporated (such as IT84S-2246-4, IT89KD-288, IT90K-59 and IT90K-76).

⑤ Insect Pests

The variety (IT84S-2246-4) to which compound resistance against important cowpea insect pests are incorporated has been bred. However, despite the intensive screening up to now, resistant lines effective against *Maruca virtrata* and shield bugs have not been discovered. Although the only method of controlling these pests is to spray with pesticide, taking the economic conditions of West African farmers into consideration, it is hoped that resistant varieties will be developed as soon as possible. Detailed information on cowpea pests can be found at http://www.larsen-twins.dk/204cowpea.html.

Maruca vitrata adult.

Maruca vitrata



Mylabris sp A cowpea flower pest.

Mylabris sp.

Cowpea grain can be ruined by the cowpea weevil after a two-three months.
by Matt Tarver

Cowpea seeds damaged by bruchid beetles (weevils)

Cowpea bruchid on CB#5 seeds; note the rough surface of the grain.
by Matt Tarver

Cowpea weevil (*Callosobruchus maculatus*)

Anoplocnemis curvipes

Clavigralla tomensicolis - The major pest of cowpea in Niger.

Calvigralla tomensicolis

Photo II-1-9　Major insect pests in West Africa

Source : Purdue Univ., Network for the Genetic Improvement for Africa Photogallery and the Web pages of Mr. Arne Larsen

⑥ Parasitic Weeds: *Striga* and *Alectra*

Weeds parasites on cowpea roots, *Striga* (commonly known as witch weed) and *Alectra,* have been reported. These parasitic weeds have damaged cowpea in Central to West Africa.

Photo II-1-10 *Striga gesnerioides*
Source : Purdue Univ., Network for the Genetic Improvement for Africa Photogallery

Photo II-1-11 *Striga* parasites to the root of cowpea

Six races of *Striga gesnerioides* have been reported, and geographical distribution is being surveyed. With all these races, resistant lines have been discovered and resistant varieties are being developed.

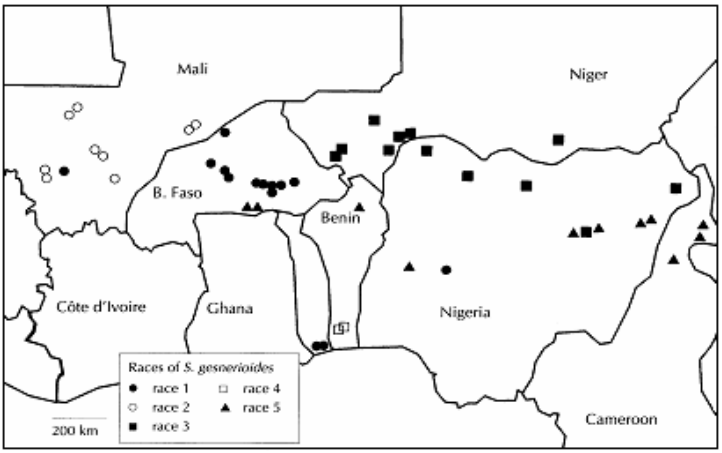


Fig. II-1-13 Five races of *Striga gesnerioides* and their distribution in West Africa
Source : Advances in Cowpea Research (1997)

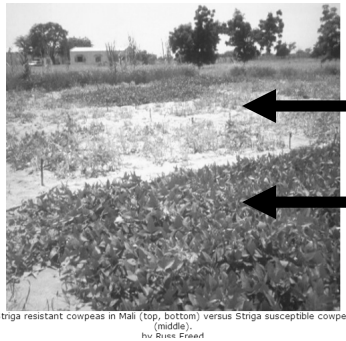


Photo II-1-12　Comparison between *Striga*-sensitive and resistant cowpea varieties.

Source：Purdue Univ., Network for the Genetic Improvement for Africa Photogallery

When a variety sensitive to *Striga* and a resistant variety were cultivated side by side in Mali the difference can readily be observed, as can be seen in the above photo.

Photo II-1-13　Another cowpea parasitic weeds: *Alectra* spp.

Source：*Alectra* spp. http://www.larsen-twins.dk/

⑦ Ecology of *Striga*

The small brown seeds of *Striga* germinate after they react with a chemical substance secreted by the roots of a host plant and then form a special organ called *haustoria* on the root of the host plant to absorb nourishment. Major damage by *Striga* therefore occurs before *Striga* appears above ground. After that, *Striga* grows its own leaves, and its dependency on the host plant decreases. *Striga* blooms 2 to 3 weeks later and produces about 20,000 seeds. These seeds become germinable after approximately six months and wait for the host plants to grow nearby.

⑧ *Striga* Control

Resistant varieties have not been disseminated among farmers. Herbicides are too expensive and too dangerous and therefore are not recommended. Before *Striga* blooms, it should be weeded by hand and soil fertility should be enriched with compost or small amounts of fertilizer to minimize damage by *Striga*.

1-6 Future Perspectives

Despite their low levels of resistance to major diseases and pests as well as their low yielding capacity, a demand for cowpea is very high. It appears they will continue to be an important food source in West Africa. Therefore, new varieties and new technologies should be developed and disseminated to improve their value.

Photo II-114 Farmers are selling cowpea powder. A trial of the profitability increase.

Source : Purdue Univ., Network for the Genetic Improvement for Africa Photogallery

Citations and Bibliography

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2. Groundnut (*Arachis hypogaea* L.)

English name: peanut, groundnut; Benin: arachide

Photo II-2-1 Groundnut

Flower (http://www.afftis.or.jp/SakumotsuHana/hana10.html)

Other pictures (http://www.ruralnet.or.jp/syokunou/200703/01_3.html)

2-1 Overview

Groundnut originated in central South America, probably in the highlands spreading from Argentina to Bolivia. Groundnut was first introduced to West Africa by the Portuguese in the 16th Century in the course of the slave trade. Its cultivation had gradually spread to all regions of Africa. After continuous hybridization between the Virginia and Spanish varieties and screening of the hybrids, local varieties adapted to Africa had been selected. Africa is currently considered as the tertiary center of groundnut genetic diversity. Today 37.2 million tons of groundnut are produced worldwide, most of which are from Asia. Nigeria is the third largest groundnut producing country, after the United States and Indonesia. In Benin, the production of groundnut has increased from 84,000t to 14,000t during the past 10 years. By region, ② Borgou-Alibori in northeast Benin and ③ Zou-Collines in the central region account for 70% of total production (Fig. II-2-7). In southern Benin, groundnut is planted twice a year, the first seeding is in April and the second is in mid-August. In this region, early Spanish and Valencia varieties are cultivated. On the other hand, in the north, mid to late varieties such as Virginia types are cultivated in the rainy season. Early variety such as Spanish types can also be seen. Groundnut is usually cultivated mixed with corn, sorghum or cassava without fertilizer. Large-scale monoculture of groundnut is not seen. Edible oils used in Benin include oil palm, peanut oil, shea butter and soybean. Small or medium scale

edible oil companies extract oil from groundnut, or farmers themselves extract oil for their own use. The main limiting factors for groundnut production are low productivity and price. Yield is low. Cultivation of local low yielding varieties and temporary drought in growing season is also the problem.

2-2 Origin and Diversification

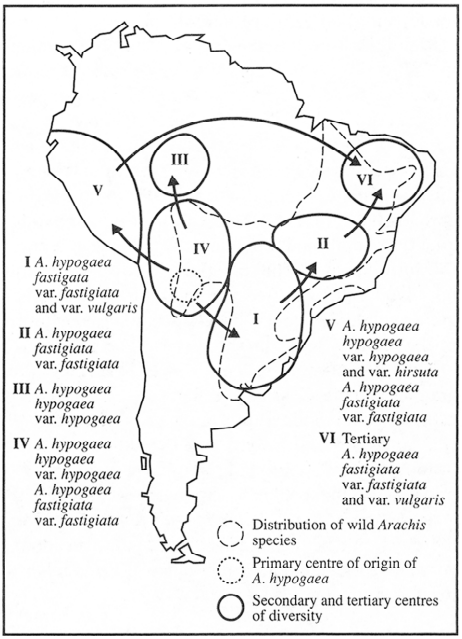

Fig.II-2-1 Origin and centre of diversity of groundnut

In the genus *Arachis*, 9 sections consisting of 69 pieces are described. The center of diversity for the wild *Arachis* species is in Gurarani region in Paraguay, and in eastern and central regions in Bolivia. The place of domestication is considered to be a Parana River valley area from Paraguay to Chaco region of Argentina. Although wild ancestral species of groundnut (*Arachis hypogaea*) have not been discovered, domestication may have occurred to the putative tetraploid wild ancestor (number of chromosomes: 2n=40) evolved by natural hybridization of two diploid wild species followed by chromosome doubling. The domestication of groundnut is considered to have started 300 to 2,500 B.C. and the ancestors of the Arawak linguistic group

are believed to have been involved in the domestication process. The long history of cultivation more than 3,500 years account for the considerable diversification of groundnut.

There are six well-known diversity centers for groundnut in South America. These diversity centers coincide well with the natural distribution of subspecies and/or variety of *A. hypogaea* (Fig II-2-1).

Table II-2-1 Taxonomic treatment of *Arachis hypogaea*

Subspecies	Variety	Botanical type	Branching pattern	Growth habit	Seed/ pod	Primary area of origin
hypogaea	hypogaea	Virginia	Alternatae	Prostrate to erect	2-3	Southern Bolivia and northern Argentina
	hirsuta	Peruvian	Alternatae	Prostrate	4	Peru
fastigiata	fastigiata	Valencia	Sequential	Erect	3-4	Peru, Brazil and Paraguay
	vulgaris	Spanish	Sequential	Erect	2	Paraguay, Uruguay and Brazil

Source : Singh 1995

Groundnut is classified into four variety groups, i.e., Virginia, Peruvian, Valencia and Spanish (Table II-2-1) based on their branching pattern and number of grains per pod.

Before the Europeans came to South America, groundnut had already spread all over South America and also to Mexico and Central America. The Portuguese introduced two types of groundnut varieties from the eastern coast of Brazil to India. Then the Spanish introduced groundnut to Indonesia and China at the beginning of the 16th Century. In the middle of 16th Century, it had spread to all over the world. In the 19th Century, groundnut became an important crop for West Africa, India and the United States. Groundnut was introduced to Japan from China in 1706, and they were named *Nannkinn-mame* (Nanking bean). Groundnut was reintroduced to Japan at the beginning of the Meiji era (1860s) and spread inside Japan.

To West Africa, the Virginia variety was introduced at the beginning of the 16th Century and spread from West Africa to North America in the 17th Century. In a similar manner, the Spanish variety was introduced by the Portuguese directly from Brazil at the beginning of the 16th Century. After continuous hybridization between the Virginia and Spanish varieties and screening of the hybrids, local varieties adapted to Africa had been selected. Africa is currently considered as the tertiary center of groundnut genetic diversity.

2-3 Production and Yield

The production of groundnut in the world is 37.2 million tons, and the majority of which is produced in Asia. Although the production in Asia and

Africa is increasing, there has been a decreasing trend during the past 10 years in Europe (Fig II-2-2).

The top groundnut producing country of groundnut is China then India. The production in China shows the increasing trends. On the other hand, the production in India remains unstable. In Africa, Nigeria is the top producing country and ranked as the 3rd position in the world, followed by the United States and Indonesia (Fig II-2-3).

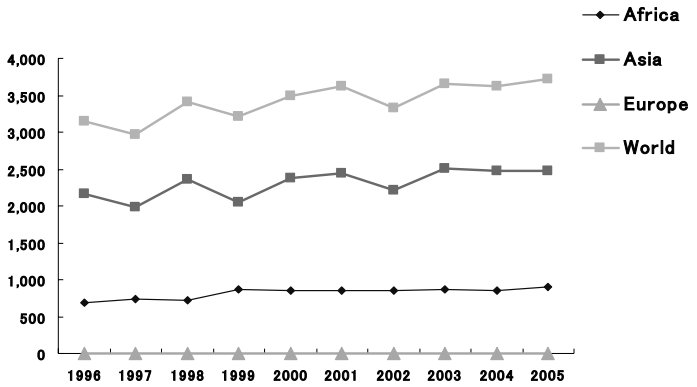

Fig.II-2-2 Production of groundnut in the world (x10000t)

Source：FAO statistics

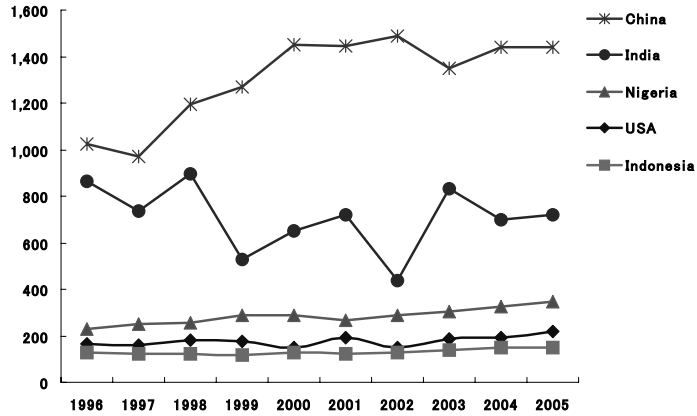

Fig.II-2-3 Major Groundnut producing countries

Source：FAO statistics

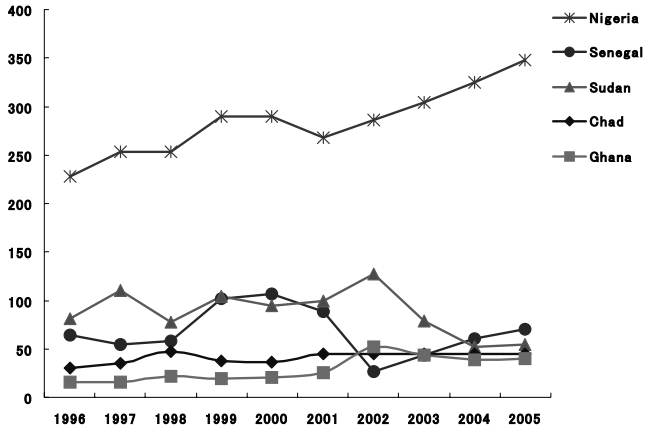

Fig. II-2-4 Major groundnut producing countries in Africa

Source：FAO statistics

Nigeria is the largest producer of groundnut in Africa, and its production has increased from 2.3 million tons to 3.5 million tons. Production in Ghana or Chad have been gradually increasing, whereas production in Senegal and Sudan are still unstable, fluctuating between 0.5 million tons and 1.3 million tons (Fig II-2-4).

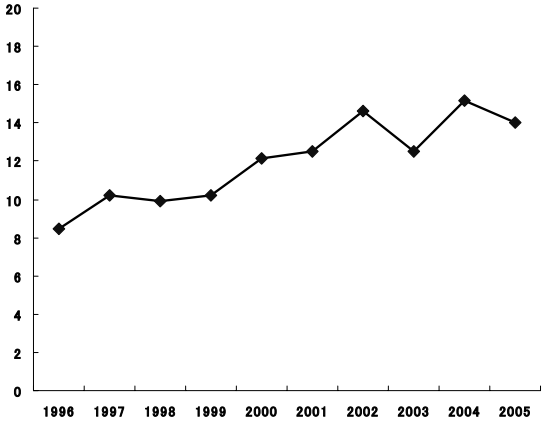

Fig.II-2-5 Production of groundnut in Benin

Source：FAO statistics

The production of groundnut in Benin increased from 84,000 tons to 140,000 tons during the past 10 years. This increasing trend will continue in the future (Fig II-2-5).

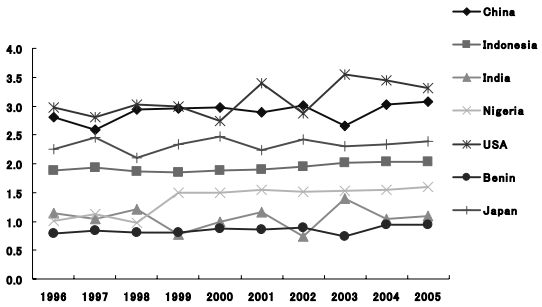

Fig.II-2-6　Yield (t/ha) of groundnut in selected countries

Source：FAO statistics

The United States gave the highest yield of groundnut in the world, ranging from 2.8t to 3.5t/ha. In China, the world top producer, yield is also high between 2.5 and 3t/ha. The yield in India, the world second highest producer, is unstable and low between 0.7 and 1.4t/ha. The yield in Nigeria is around 1.5t/ha. The yield in Benin is also low, ranging between 0.7 to 0.9t/ha. Average yield in Benin during the past 10 years is 0.85t/ha (Fig II-2-6).

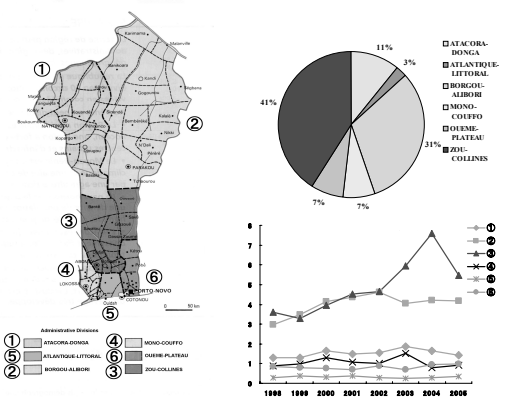

Fig.II-2-7　Production of groundnut in each region of Benin

Source：Benin statistics

In Benin, production in ② Borgou-Alibori region in the northeast and ③ Zou-Collines region in the central accounts for 70% of the total production (Fig II-2-7).

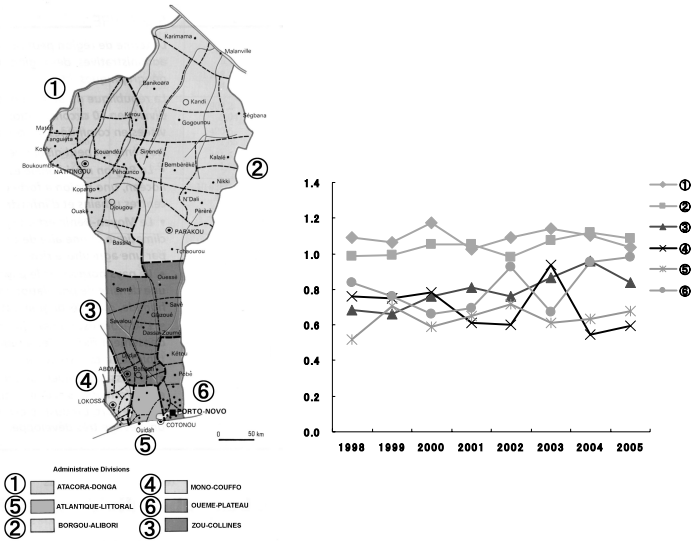

Fig.II-2-8 Yield (t/ha) of groundnut in each region of Benin.

Source：Benin statistics

The yield of groundnut in ① Atacora-Donga in northern Benin and ② Borgou-Alibori in northern Benin has been high and stable. The yield in ③ Zou-Collines, the highest groundnut producing region, is lower than Atacora-Donga and Borgou-Alibori regions. It is necessary to increase the yield in Zou-Collines by improving the cultivation methods and by introducing better varieties (Fig II-2-8).

2-4 Cropping System and Cultivation Method

The optimal temperature for growing groundnut is around 28 to 32℃, which make it a suitable crop for tropical climates. The plant begins to bloom approximately one month after seeding. The day length has little influence on the flower bud initiation, but the number of days to flowering is affected by the temperature and/or soil condition. It takes 50 to 60 days from flowering to maturity. Groundnut prefers well drained soil and requires precipitation between 600 and 800mm.

Groundnut cultivation is seen in all the regions in Benin. In southern Benin, groundnut is planted twice a year, the first seeding is in April and the second is in mid-August. In this region, early Spanish and Valencia varieties are cultivated. On the other hand, in the north, mid to late varieties such as Virginia types are cultivated in the rainy season. Early variety such as Spanish types can also be seen in the north. Groundnut is usually cultivated mixed with corn, sorghum or cassava without fertilizer. Large-scale monoculture of groundnut is not seen. The cultivars include TS-32-1, MOTO and TE-3. The number of days to grow TE-32-1 is 90 days and the average yield is 1.2t/ha. This cultivar has high oil content and appears to be highly resistant to Striga, a parasitic weed, so a planting density of 40×20cm is recommended. The INRAB central research center in Benin is selecting varieties with high oil content and high biomass production. They are also conducting field trials for selecting better varieties under the mixed cropping system with maize.

Shells thresher

Photo II-2-2　Groundnut production in West Africa

2-5 Utilization and Market

After soybeans, oil palms and rapeseed, groundnut is the fourth most important source of edible oil. The grains contain approximately 20% of carbohydrates, 25% of protein and 50% of lipids. About 50% of total groundnut produced in the world is used for producing high quality edible oil. Another 37% are used for peanut butter or confectionary ingredients, and approximately

12% is used as seed. In addition, the foliages of peanuts are used for livestock feed, and contain higher amount of protein compared with other forage crops. Groundnut forage is very palatable and digestible.

In Benin, edible oils are produced from oil palm, peanut, Shea butter and soybean. Small and medium oil extractors extract groundnut oil or the farmers themselves extract oil for their own consumption. The extraction method for peanut oil is quite simple; the roasted groundnut beans are grinded using a compressor (squeezer), mixed with water and left for a couple of days until the water and oil separate (Photo II-2-3). A traditional method of extracting peanut oil is shown in Fig II-2-9.


Photo II-2-3 Peanut butter and oil sold in Benin

Method of Extracting Peanut Oil

○ Characteristics of peanut oil: Peanut oil is a yellowish straw-colored liquid. It is mainly used for cooking such as preparing deep-fried food or salad. The oil is called ”Azimi” in the Fon language, “Epoepa” in the Yoruba language, “Demizi” in the Dandy language and “San Goune” in the Bariba language.
○ Ingredient: Peanut grains
○ Method of extraction: Shown in the following figures.

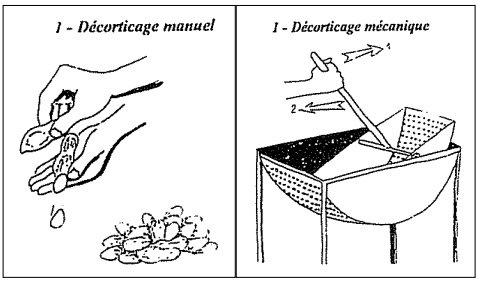

Fig. II-2-9a Peanut shells are peeled by hand or using a thresher

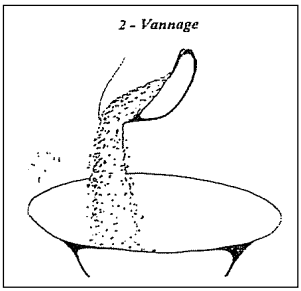

Fig. II-2-9b Threshed peanuts are separated from dust by wind, etc.

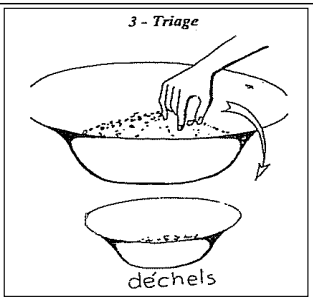

Fig. II-2-9c Spoiled grains and wastes are removed.

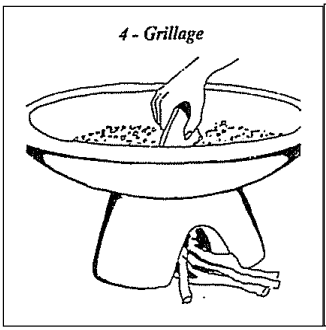

Fig. II-2-9d Threshed grains are roasted in a frying pan.

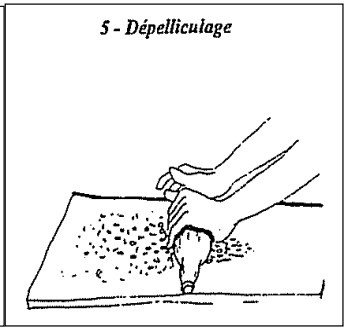

Fig. II-2-9e After cooling, thin skins are removed.

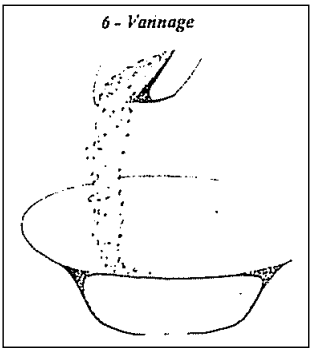

Fig. II-2-9f Grains and their removed thin skins are separated by winds, etc.

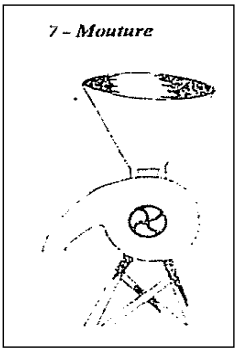

Fig. II-2-9g Peanuts are grinded in a mill.

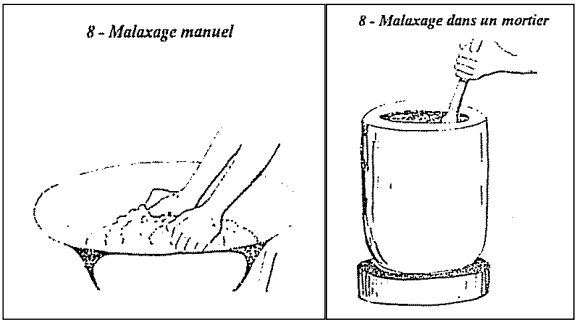

Fig. II-2-9h Paste is kneaded by hand or with a wooden pestle.

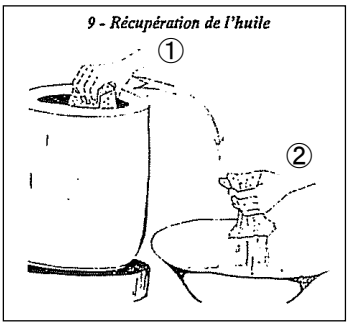

Fig. II-2-9i Oil is squeezed into a bowl using a sponge or cloth.

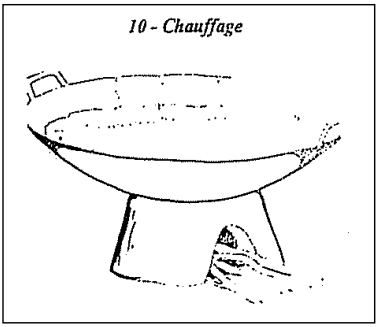

Fig. II-2-9j Oil is boiled to remove the remaining water.

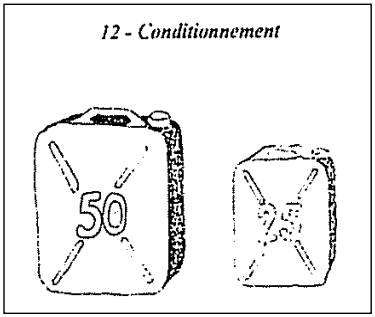

Fig. II-2-9k After cooling, it is stored in barrels or tanks.

Table II-2-2 Traditional Benin Food Made from Groundnut

Food Name	Processing Method
Andou	Snack made from a mixture of corn power and seasoned peanuts
Cacahuete	Snack made from boiled peanuts with sugar
Huile d'arachide	Peanut oil extracted using a traditional method
Kluiklui	Snack made from peanut paste after extracting oil
Kohuncada	Snack made from roasted peanuts with sugar
Nougat	Snack made from peanut flour
Tasso	Snack made from boiled peanuts which are then roasted in sand or ash

Photo II-2-4 A popular snack, Kluiklui, is prepared. It tastes sweet and hot.

As seen in Photo II-2-4, after the oil is extracted, peanut paste is processed into a deep-fried snack called ***"kluiklui"***, a very popular local snack. In addition to this, various traditional foods utilizing groundnut can be seen (Table II-2-2).

Table II-2-3 Grains price of groundnut in West Africa (FrCFA/kg)

Countries	Price
Senegal	375-500
Burkina Faso	312-380
Niger	280-375
Guinea	400-495
Côte d'Ivoire	600
Benin	300-675

(August 2006)

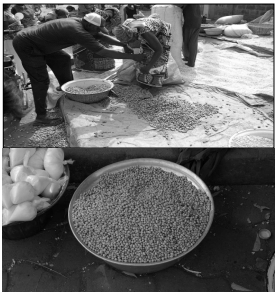

Photo II-2-5 Groundnut grains sold in the market of Benin

Information on the production and market prices of the main agricultural products in each country in West Africa is available at RESIMAO (Réseau des Systèmes d'Information des Marchés en Afrique de l'Ouest: www.resimao.org). The information on the market prices of farm products in ten West African countries is available at this Web site. This Web site is developed for the purpose of promoting the inter-regional trade among West African countries. The range of groundnut grain price in Benin is greater than those of neighboring countries (Table II-2-3). In Benin, groundnut is not exported and is only consumed domestically.

Table II-2-4 Price of grain and oil of groundnut in major market in Benin with a comparison of oil palm oil (FrCFA/kg, August 2006)

Regions	Market	Groundnut				Oil Palm	
		Grain		Oil		Oil	
		January	August	January	August	January	August
ATLANTIQUE	Dantokpa	810	675	700	770	500	615
BORGOU	Parakou	270	430	800	790	800	515
MONO	Come	540	610	800	800	605	545
OUEME	Ouando	475	655	700	715	700	450
ZOU	Bohikon	290	485	585	600	585	470
ATACORA	Tanguieta	400	545	650	650	650	650

If you want to know the trend in market prices of agricultural products in Benin, information is available at the ONASA (Office National d´Appui à la Sécurité Alimentaire) website (www.onasa.org). Grain price of groundnut at the Parakou market in Borgou region (northeast Benin) is lower; whereas, price at the Dantokpa market in Atlantique region (southern Benin) is the highest. The price of groundnut oil among markets in each region of Benin is relatively stable throughout the year. Compared with coconut oil, the price for groundnut oil is slightly higher (Table II-2-4).

2-6 Factors for Production Constraints and Breeding

The factors for production constraints of groundnut in Benin are low yield and price. The yield of groundnuts is low because local varieties are cultivated and/or growth is hindered due to a drought during the cropping period. In the south, groundnut planted in April encounters the difficulty to dry the harvested grains. Whereas groundnut planted in August gives low yield because of the low amount of rainfall available during growth period. Groundnut is usually cultivated without fertilizer.

Table II-2-5 Diseases and pests of groundnut

Diseases

Fungal Disease and Causal Agents
Anthracnose Colletotrichum mangenoti, C. arachidis, and C.dematium
Aspergillus crown rot aspergillus niger, A. pulverulentus
Alternaria leaf spot Alternaria arachidis
Black hull Thielaviopsis basicola
Botrytis blight Botrytis cinerea
Charcoal rot Macrophomina phaseolina
Cylindrocladium black rot Cylindrodium crotalariae
Diplodia collar rot Diplodia gossypina
Early leaf spots Cercospora archidicola
Late leaf spots cercosporidium personatum
Fusarium wilt Fusarium spp.
Melanosis Stemphylium botryosum
Foot rot Neocosmospora vasinfecta
Peanut pod rot Pythium myriotylum, Rhizoctonia solani, Fusarium solani
Powdery mildew Oidium arachidis
Verticillium wilt Verticillium dahliae
Sclerotinia blight Sclerotinia minor
Stem rot Sclerotium rolfsii
Rust Puccinia arachidis
Web blotch Phoma arachidicola
Yellow mold and aflatoxin Aspergillus flavus, A. parasiticus

Diseases caused by Bacteria and causal agents
Bacterial leaf spot Pseudomonas spp
Bacterial wilt Pseudomonas solanacearum

Diseases caused by virus and vectors
Tomato spotted wilt and peanut bud necrosis, Frankliniella fusca, F. Occidentalis, Thrips palmi
Peanut clump, Polymixa graminis
Groundnut rosette Aphis craccivora
Peanut mottle Aphis craccivora, A. gossypii, Myzus persicae, Hyperomyzus lactucae, Rhopalosiphum padi, R. maidis
Peanut stripe, Aphids
Peanut stunt, Aphis cracciovra, A. spiraecola, and Myzus persicae
Cowpea mild mottle Bemicia tabaci
Peanut chlorotic streak Aphis craccivora, Myzus persicae, Bemisia tabaci

Diseases caused by Nematodes
Root knot nematodes Meloidogyne spp
Root lesion nematodes Pratylenchus brachyurus
Sting nematodes Belonolaimus spp
Ring nematodes Criconemella ornate
Peanut pod nematodes Ditylenchus africanus

Insect	Latin Name	Damage
Foliage feeders		
Groundnut leaf miner	*Aproaerema modicella*	feeds between the epidermal layers of the leaf
Rednecked peanutworm	*Stegasta bosqueella*	feeds exclusively within a developing terminal
Corn earworm	*Helicoverpa zea*	consumes terminal, young foliage, and immature pegs
Army worms	*Spodoptera spp*	larvae feeds on the underside of leaflets, terminals
Bollworm, earworm	*Helicoverpa zea*	larvae feed on flowers and pods
Velvet bean caterpillar	*Anticarsia gemmatalis*	larvae feed on terminal and young foliage
Hairy caterpillars	*Amsacta spp*	larvae move and feed en masse on the underside of leaves
Intracellular feeders		
Leafhoppers	*Empoasca spp*	adults and nymphs feed on the undersides of leaves by inserting mouthparts.
Tobacco thrips	*Franklinella fusca, Thrips palmi, Scirtothrips dorsalis*	feed in leafbuds and flowers
Groundnut aphid	*Aphis craccivora*	adults and nymphs feed on leafbuds and unfurling leaves
Twospotted spider mite	*Tetranychus urticae*	adult injures plant by inserting the piercing mouth parts into plant cells and sucking the contents.
White flies	*Bemicia tabaci*	remove photosynthates directly from the phloem
Root and pod feeders		
Lesser Cornstalk borer	*Elasmopalpus lignosellus*	larvae feed on roots and developing pods
Southern corn rootworm	*Diabortica undecimpunctata howardi*	adult beetles feed on leaves, and larvae feed on below ground.
White grub	Species of *Lachnosterna, Adoretus, Anomala, Leucophilis*	larvae feed on the taproots
Termites	Species of *Odontotermes, Microtermes*	damage pods by scarifying the pod, and by feeding on the seed
Wireowrm	Species of *Conoderus*	damage all underground parts
Millipeds	*Peridontopyge spp*	feed on seedling plants, and developing pods
Stored-product feeders		
Indianmeal moth	*Plodia interpunctella*	larvae feed on shelled seeds, or seeds on damaged or cracked pods
Rice moth	*Corcyra cephalonica*	larvae feed loose shelled seed or on seed in cracked pods
Flour beetles	*Tribolium castaneum, T.confusum*	adults and larvae feed on the surface of the seed and burrow into the seed
Groundnut bruchid	*caryedon serratus*	attacks unshelled, undamaged pods
Pod sucking bug	*Elasmolomus sordidus*	adult pierces a pod with mouth parts and feeds on the oil.

Source: ICRISAT

There are many well-known diseases and pests damaging groundnut (Table II-2-5). Major diseases in West Africa are the groundnut rosette virus (*Aphis craccivora*) and fungal disease of early leaf spot (*Cercospora archidicola*). Insect pest causing severe damage is aphid, which is a vector of virus disease. In addition, damage by the nematode is common. In Benin, major diseases include rust (*Pucciniaarachidis*), early leaf spot and peanut clump (*Polymixa graminis*) in the northern region and groundnut rosette in the southern region.

2-7 Future Perspectives

The demand for groundnut in West Africa is high. Nigeria will continue to be one of the largest producing countries in the world. In Nigeria, groundnut is a cash crop. On the other hand, groundnut production in Benin is lower than those in the rest of West African countries. Accordingly, varieties with high yielding ability with drought resistance should be introduced.

Citations and Bibliography

1) Information disclosed on the website: World Geography of the Peanut (http://lanra.anthro.uga.edu/peanut/)
2) Maeda K., 1994, - Peanuts – Tropical Pulse Corps Cultivation Handbook, AICAF pp.39-67
3) C. C. Holbrook 2003 Peanut Breeding and Genetic Resources, Plant Breeding Reviews, Vol.22: 298-331

3. Bambara Groundnuts (*Vigna subterranea* (L.) Verdc.)

Benin: Voandzou

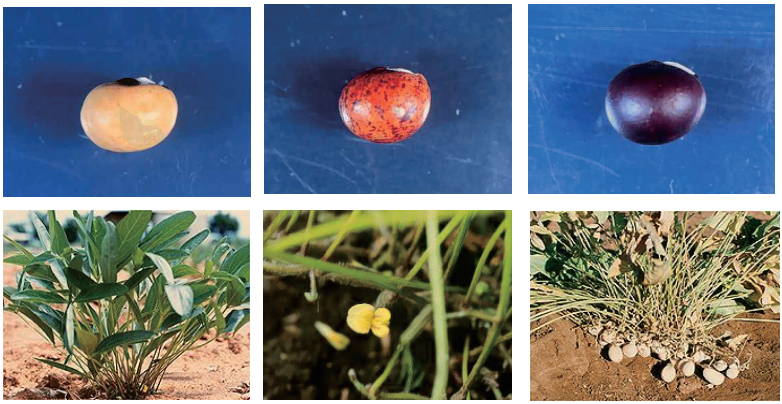

Photo II-3-1 Bambara groundnut

3-1 Overview

Bambara groundnut originated in West Africa and has been cultivated extensively throughout Sub-Sahara Africa. Bambara groundnut is the 3rd most important African leguminous crop after peanuts and cowpeas. In Africa it is called "*nyimo*", "*indlubu*", "*jugo*", "*njugo*" or "*voandzou*", and is cultivated under mixed cropping system with corn, millet, sorghum, yam, peanuts or cowpeas. Although bambara groundnut had spread to India, Sri Lanka, Thailand, Indonesia, the Philippines, Malaysia, New Caledonia and Brazil, it is rarely cultivated outside Africa today. Pods of bambara groundnut grows under the ground in the same manner as peanuts. Each pod contains only one grain. The average yield of bambara groundnut is estimated to be around 500kg /ha. It takes 110 to 150 days to harvest bambara groundnuts and it is a short-day crop. Since the grains of bambara groundnuts contain approximately 63% carbohydrates, 19% protein and 6.5% lipids, it is a more efficient crop to obtain energy compared with other leguminous crops such as cowpeas or lentils. Since bambara groundnut has been used for home consumption, there are various cooking methods.

3-2 Origin and Diversification

Bambara groundnut has pods that grow under the ground. Although the flowers bloom near the ground, each flower stalk stretches and the ovary penetrates the ground to produce about 2cm round shaped pod. The lateral branches emerged from the short internodes less than a few cm apart; it

becomes grass-like shape. It has trifoliate leaves with long peduncle. In West Africa, bambara groundnut is cultivated in a similar manner as cowpea. The origin of bambara groundnut is considered to be an area stretching from northeastern Nigeria to northern Cameroon. Wild bambara groundnut is widely distributed in this area. The name bambara groundnut originated from the Bambara tribe of Mali in West Africa. It is called *Voandzou* in French. The crop was recorded for the first time in a 17th century. After since it was first classified as *Voandzeia subeterranea* in 1806, this scientific name has been used

Table II-3-1 Germplasm conserved in each country or institute

countries/institutes	number of germplasm conserved
Benin	3
Botswana	26
Burkina Faso	143
France, ORSTOM	Ca. 1000
Ghana, University of Ghana	80
Ghana, SARI	90
Ghana, PGRC	166
Guinea	43
Kenya, National Genebank	6
Kenya, KARI	2
Kenya, National Museums	2
Mali	70
Mozambique	12
Namibia	23
Nigeria, IITA	2035
Nigeria	n.a.
Niger	79
South Africa, Grain Crops Institute	198
South Africa, Institute for Veld and Forage Utilization	117
South Africa, Department of Agriculture	20
Tanzania, NPGRC	22
Zambia, University of Zambia	463
Zambia, NPGRC	124
Zimbabwe	129

Source: Proceeding of the workshop on Conservation and Improvement of Bambara Groundnut (*Vigna subterranea* (L.)Verdc.), 1995.

for more than a century. However in 1980, it was re-classified in the genus *Vigna* as *Vigna subterranea* (L.) Verdc. (Verdocurt 1980). Bambara groundnut is cultivated extensively in the Sub-Sahara Africa. Wild relatives and weedy races grow naturally in this area. Wild relatives are distributed throughout the Jos Plateau in Nigeria and from Yola to Garoua in Cameroon.

Genetic resources of bambara groundnut are conserved at research institutes and private institutions in each country in Sub-Sahara and throughout African (Table II-3-1). Of those, the International Institute of Tropical Agriculture (IITA) has 2,008 accessions collected from 25 countries and that is the largest source of genetic resources (Table II-3-2).

Table II-3-2 Number of accessions conserved in the genebank of International Institute of Tropical Agriculture (IITA)

Countries	No. of accessions	Countries	No. of accessions
Benin	27	Mali	28
Botsuwana	5	Niger	33
Burkina Faso	97	Nigeria	310
Cameroon	207	Senegal	36
Central African Republi	103	South Africa	1
Chad	70	Sudan	7
Congo	42	Swaziland	11
Cote d'Ivoire	4	Tanzania	28
Ethiopia	1	Togo	139
Cambia	11	Zimbabwe	245
Ghana	120	Zambia	284
Kenya	2	Unidentified	101
Madagascar	49		
Malawi	59	**Total**	2208

Source: IITA data base

Photo II-3-2 Gene bank of the southern center of INRAB in Benin

Photo II-3-3 Seed storage room (seeds were conserved at 10℃)

Only three accessions of bambara groundnut were conserved in the gene

bank at the southern center of INRAB in Benin (Photos II-3-2 and II-3-3). At the Parakou market in northern Benin, four varieties based on the seed coat color, white, red, black and mottled were sold.

3-3 Production and Yield

According to FAO statistics (2005), cultivation area of bambara groundnuts is 79,120ha and its production is 74,751t in Africa (Fig. II-3-1). In this figure, statistics for three nations, Burkina Faso, Cameroon, and Congo are compared. There is little information available for each African nation regarding to the production of bambara groundnut, since it is cultivated mainly for home use.

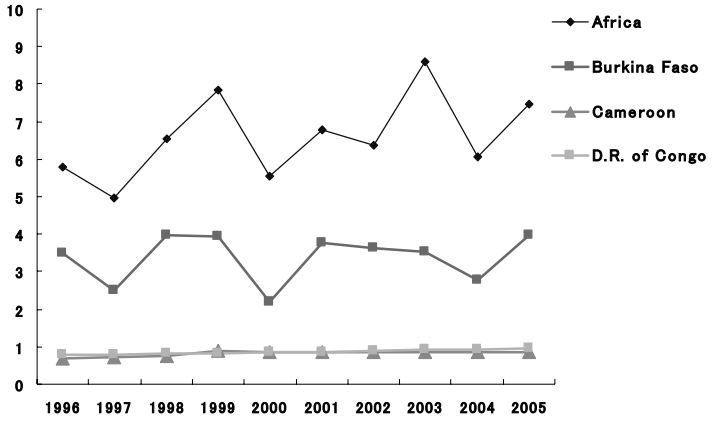

Fig.II-3-1 Production of bambara groundnut (x10000t)
(Based on FAO statistics)

Judging from the fact that IITA collected bambara groundnuts from 25 nations in Africa, the actual production and cultivated area of bambara groundnut seems to be higher than FAO's estimation. In a workshop proceedings entitled "Conservation and Improvement of the bambara Groundnut (*Vigna subeterranea* (L.) Verdic.)" held in 1995, sponsored by IPGRI (International Plant Genetic Resources Institute), cultivation area and production for Nigeria, Ghana, Togo and Zimbabwe, etc. was listed in the country reports (Table II-3-3). Based on that data, the production in Nigeria is 100,000t.

The average yield of bambara groundnuts is estimated to be around 500kg/ha. The yield in Burkina Faso fluctuate significantly from 0.7 to 1.6t/ha (Fig. II-3-2).

Table II-3-3　Production of bambara groundnut（x10,000t）

Countries	Producti	Source
Botswana	400	(Country report)
Burkina Faso	39,572	(2005 FAO)
Cameroon	8,500	(2005 FAO)
Nigeria	100,000	(Country report)
Togo	4,403	(Country report)
Zimbabwe	2,200	(Country report)
Mali	17,169	(2005 FAO)
Congo	9,510	(2005 FAO)
Benin	11,321	(Country report)

（Based on FAO statistics）

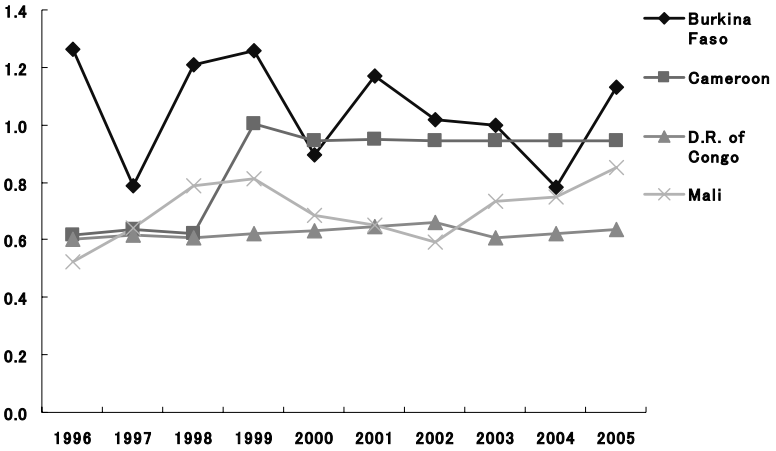

Fig.II-3-2　Yield (t/ha) of bambara groundnut

（Based on FAO statistics）

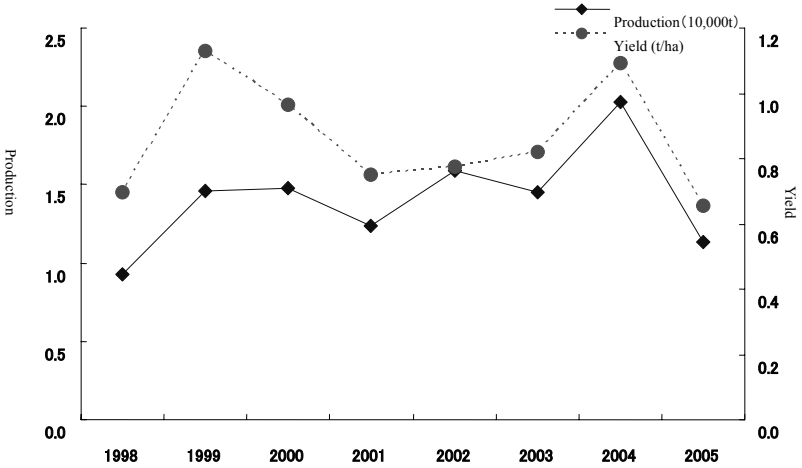

Fig.II-3-3　Production and yield in Benin

(Based on the statistics of Benin)

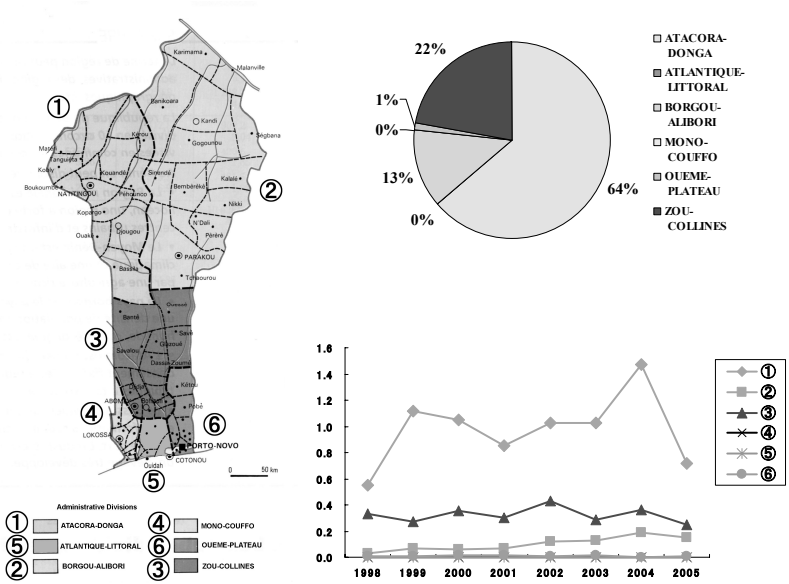

Fig.II-3-4　Production of bambara groundnut in each region of Benin

(Based on the statistics in Benin)

In 2005, the cultivation area of bambara groundnut in Benin was 17,232ha and the production was 11,321t. From the results of experimental fields the yield up to 4000kg/ha were reported. The yield from farm households was approximately 500kg/ha. The yield of bambara groundnut in Benin from 1998 to 2005 increased substantially from 657kg/ha to 1130kg/ha. The average yield over the past 8 years is 860kg/ha (Fig. II-3-3).

The production of bambara groundnut in Benin differs for each region. The largest cultivation area in Atacora-Donga in northwestern Benin is 12,142ha and the production is 7,192t, followed by Zou-Collines in central Benin and Borgou-Alibori in the northeast. These three regions are major bambara groundnut production zones in Benin (Fig. II-3-4).

3-4 Cropping System and Cultivation Method

Bambara groundnuts are cultivated under small-scale monoculture or mixed cropping with corn, millet, sorghum, cassava, yam, peanut or cowpea (Photo II-3-4). The incorporation of bambara groundnuts into a cropping system is considered to be effective for soil improvement.

Small-scale single cropping

Grain of bambara groundnut

Bambara groundnut is called "woman's crop", the women cultivate mainly

Photo II-3-4 Bambara groundnut cultivation in West Africa

Source: Arne Larsen's homepage

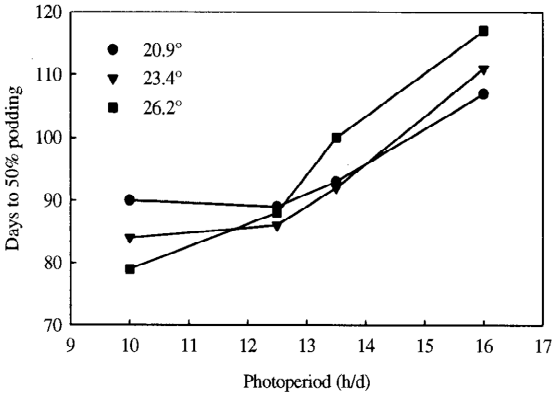

Fig.II-3-5 Effects of temperature and photoperiod on maturity

(Adapted from Collinson 1995.)

It takes 110 to 150 days for bambara groundnuts to mature. Stored seeds germinate well if they are seeded within one year. Seeds germinate 7 to 15 days after sowing. Bambara groundnut start flowering at 30 to 35 days after sowing. Although the bambara groundnut is generally a shot-day crop, it reacts differently depending on the variety. For example, some varieties show day neutral flowering response but growth of pods delayed under long-day, while other varieties decreased pod setting rate under long-day conditions. It has also been reported that the number of days necessary to produce pods is related to the temperature (Fig. II-3-5). Bambara groundnuts are cultivated at less than 1,600m elevation, with rainfall between 600 and 700mm and temperatures between 20 and 28℃. It prefers well-drained soil with pH5.0 to 6.5.

It is generally cultivated on the flat land with low population density. The seeding density is recommended to be 25 to 75kg/ha, at approximately 10 to 15cm planting intervals and 45 to 90cm of row spacing. Although farm households usually do not use fertilizer, it is reported that the amount of nitrogen required by bambara groundnuts could be supplied through root nodule bacteria. So it is a crop suitable for low-fertilized land (Doku 1969a; Somasegaran, et al. 1990). In dry regions it is harvested when the foliage withers; whereas in humid regions it should be harvested before the foliage becomes withered since the pods are either likely to spoil or seeds germinate. After sun drying the harvested pods are threshed. Seeds for the following year are stored within their pods, which can act as an effective barrier against insects.

3-5 Use and Market

Table II-3-4 Nutrients in bambara groundnut seeds

Components		Platt (1965)	Kinyawa (1969)
Major (%)	Water	10	11
	Protein	18	15.6-21.9
	Fat	6	5-7.5
	Carbohydrates	60	64
	Fibre	3.3	n.a.[†]
Minor (mg/100 g)	Calcium	65	30-100
	Phosphates	n.a.	100-200
	Iron	6	7
	Magnesium	n.a.	100
	Potassium	n.a.	1.2
	Thiamin	0.3	n.a.
	Riboflavin	0.1	n.a.
	Nicotinamide	2	n.a.
	Ascorbic acid	insufficient	n.a.

[†] Analyzed by Kinyawa (1969) at Ukiriguru.
[†] n.a. = not available.

Source：Ntundu,1995

Grains of bambara groundnuts contain approximately 64% carbohydrates, 19% protein and 6.5% lipids. It has high methionine content, an essential amino acid.

Photo II-3-5 Young pods of bamabara groundnut eaten boiled with chili pepper and salt.

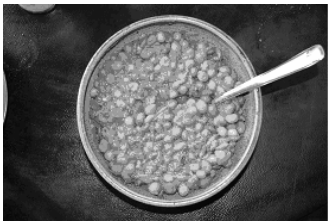

Photo II-3-6 Abobo

- Seeds soaked overnight and boiled
- Seasoned with oil. salt, peppers, onions, tomatoes and shrimps

There are various cooking methods. The pods of bambara groundnut can be eaten raw or roasted. Young pods boiled together with salt and red pepper is

a popular snack in West Africa (Photo II-3-5). Although the oil content of bambara groundnut is less than rich content of peanut, some tribes in Congo extract the oil after roasting and grinding the beans.

One method of cooking bambara groundnuts in Sub-Saharan African regions is to make a thick porridge by grinding the beans. In addition, the roasted beans are grinded to make seasoning. Dough made from the ground to flour is processed into deep-fried or steamed products.

In recent years, an attempt was made to make bean milk from bambara groundnut. It is reported to have a better taste than cowpeas, pigeon peas or soybeans and has a higher nutritional value.

In Benin, there is a traditional dish called "*abobo*". To make this, grains of bambara groundnut are soaked in water for twenty-four hours together with red peppers, tomatoes, onions and shrimps. It is often served together with "*gari*" made from cassava flour or "*plantain*" (Photos II-3-6 and II-3-5) and is a typical home cooked dish in West Africa.

Table II-3-5 Use of bambara groundnut in Africa

Country	Cooking and Processing Method
Ghana	● Immature beans are boiled and seasoned with salt. ● After boiling and grinding mature seeds, it is hardened into flat cakes or dumplings and steamed. ● Beans soaked in water for twenty-four hours are boiled to make porridge or blanc-manger. ● Beans soaked in water for twenty-four hours are fried. Red pepper, tomatoes and onions are added to the water. A side dish for "*gari*" made from cassava flour or "*plantain*".
Nigeria	● Immature beans are eaten raw or seasoned by boiling with salt. ● Beans are ground into a flour and used as an ingredient in traditional cooking or processed into products such as "*alele*", "*alelen ganye*", "*gauda*", "*kosai*", "*kunu*", "*tuwo*" and "*waina*".
South Africa	● Immature pods are boiled and eaten as a snack. ● After dried grain flour is boiled with corn or other grain flour, it is formed into dumplings. ● It is boiled and mixed to make porridge (*thipupu*). ● It is grinded together with corn to make sticky dough (*dithaku*).
Togo	● Mature seeds are ground into flour to make dough for various cooking dishes.

Country	Cooking and Processing Method
Zimbabwe	● It is boiled to make porridge. ● It is utilized in cooking as a seasoning.

Photo II-3-7　Bambara groundnut sold in a market in Benin

In the markets of Benin, the seed coat color of most varieties is white or red (Photo II-3-7).

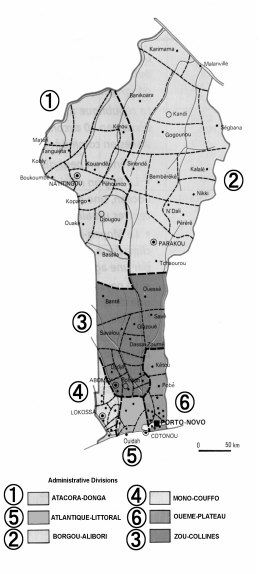

Table II-3-6　Price of bambara groundnut in Benin

（FrCFA/kg，2006）

Regions	Market	Grain	
		January	August
ATLANTIQUE	Dantokpa	415	585
BORGOU	Parakou	175	290
MONO	Come	335	335
OUEME	Ouando	435	450
ZOU	Bohikon	245	335
ATACORA	Tanguieta	165	245

In the markets of Parakou (northern Benin), the price of red-colored varieties is 350FrCFA/Tongolo* and the price of white-colored varieties is 450FCFA/Tongolo; suggesting the white-colored varieties are favored by consumers.

The prices are lower in Atacora and Borgou in northern Benin, which are major bambara groundnut production areas, and there is a significant difference in prices between areas. The price of Bambara groundnut is the highest in August (before harvesting), and lowest in January (after harvest) (Table II-3-6).

3-6 Breeding and Restricting Factors

Bambara groundnut is a suitable crop for semi-arid climates. It is resistant to drought and low fertility soil. In addition, it is a good source of carbohydrates. However, its cultivation is still limited to Sub-Sahara Africa. Some of the reasons for this are 1) unavailability of modern improved varieties because of the difficulty of artificial hybridization, 2) time consuming process of cooking because of its hard seeds.

Powdery mildew (*Erysiphe* sp.)

Aphids (*Aphis* sp.)

Termites

Nematodes

Photo II-3-8 Pests and diseases

1) Diseases and Pests

Fungal diseases of bambara groundnut include leaf spot (*Cercospora canescens*), powdery mildew (*Erysiphe* sp.), leaf spot (*Phyllosticta voandzeia*),

* Bowl-shaped measuring gauges approximately 800 to 900g in volume.

wilt (*Fusarium* sp.), leaf blotch (*Phomopsis* sp.) and *Sclerotium rolfsii*. Although these diseases occur mainly in humid regions, prevention is possible by spraying the fungicide, such as Benomyl (Benlate). Viral diseases include cowpea mottle virus (CMeV) and cowpea aphid-borne mosaic virus (AbMV). Insect damages from aphids (*Aphis* sp.), bruchids (*Callosobruchus* sp.), leafhoppers (*Hilda patruelis*) and termites have been observed. In addition, significant damages from nematodes are also reported (Photo II-3-8). Little researches had been conducted for disease and pest control. It is important to select varieties with multiple resistances from wide range of genetic resources or to establish more effective control methods.

2) Breeding

Research of bambara groundnut had started in recent years. In the proceedings of the workshop "Conservation and Improvement of Bambara Groundnut (*Vigna subeterranea* (L.) Verdc.) sponsored by the International Board for Plant Genetic Resources (IBPGR) (presently Bioversity International) held in 1995 in Zimbabwe, the production conditions and breeding research in African nations and information on genetic resources were reported (Proceedings available from www.bioversityinternational.org/publications/Pdf/499.pdf). IITA reported a wide variation for morphological and agronomic traits among 1,384 accessions collected from Africa (Table II-3-7).

Table II-3-7 Variations for morphological and agronomic characters among bambara groundnut germplasm

Character	Min.	Max.	Mean	N*	SD	Variance	CV	Skewness	Kurtosis
Days to 50% emergence	7	14	8	857	1.06	1.13	12.88	1.27	2.76
Days to first flower	37	55	38	849	2.2	4.84	5.71	1.98	5.78
Days to 50% flowering[1]	37	70	43	810	5.54	30.69	12.96	1.87	4.4
Days to maturity[2]	90	165	128	1309	15.3	235	11.93	0.35	-0.82
Vigour index[3]	1	9	5	1292	1.52	2.31	31.42	0.19	-0.32
Plant height[4] (cm)	10	38	22.3	1321	4.8	20.11	20.13	-0.06	-
Canopy width[5] (cm)	11	90	47	1321	13.10	171.67	27.91	0.37	0.79
No. leaves/plant[6]	8	328	106	1293	48.5	2352	46	1.29	3.03
Terminal leaflet length[7] (mm)	7	124	61	1293	11.80	139.20	19.21	0.34	2.14
Terminal leaflet width[8] (mm)	3	72	28	1293	6.44	41.48	23.02	0.82	4.34
Petiole length[9] (cm)	1.2	34	15.1	1293	39.46	1556	26.12	0.69	1.94
No. stems/plant[10]	1	20	8	1284	2.14	4.58	24.85	0.06.	0.45
No. branches/stem[10]	2	12	4	1284	1.22	1.48	28.38	0.67	2.28
No. nodes/stem[10]	2	25	12	1284	3.90	15.19	33.04	0.68	0.56
Internode length[10] (mm)	3	21	11	876	2.5	6.11	21.55	0.21	0.86
Pod length[11] (mm)	5	37	20	1284	3.92	15.37	19.97	0.38	0.58
Pod width[11] (mm)	5	22	13	1284	2.40	5.77	17.69	0.23	0.44
Shell thickness[12] (mm)	0.1	2	0.35	1275	0.21	0.05	61.7	2.5	9.3
Shell percentage[13] (%)	5	90	29.7	1256	9.93	98.57	33.42	1.49	4.96
Seed length (mm)	7	18.0	11.8	1260	1.5	2.11	12.25	0.16	0.65
Seed width (mm)	6.2	12.5	9.3	1260	0.97	0.95	10.45	-0.04	0.12
No. pods/plant[14]	10	201	23	1381	22.49	505.75	97.78	2.38	8.76
No. seeds/pod[15]	1	2.0	1.11	1262	0.16	0.03	14.86	2.57	8.38
Weight of 100 seeds (g)	1	98.00	42.44	1266	15.64	244.62	36	0.41	0.52
Seed yield/plant[16] (g)	0.03	97.00	11.51	1262	12.57	157.92	109.22	2.36	7.49
Virus resistance[17]	1	8.0	3.6	1320	1.5	2.24	41.08	0.42	-0.21
Cercospora disease resistance[18]	1	7.0	2.15	1320	1.04	1.09	48.57	1.30	2.55

* Number of observations.

(Source : Goli,1995)

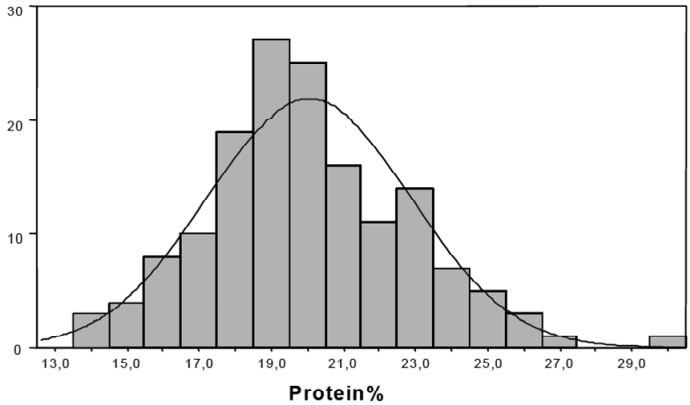

Fig.II-3-5 Variations of protein content in bambara groundnut germplasm

Source：Wenzel et al. 2003

In the research project named BAMFOOD Project Research conducted by Nottingham University in England, extensive researches including cultivation experiments to molecular diversity analysis were carried out. One of the researches has revealed that bambara groundnut germplasm showed a wide range of protein content (Fig. II-3-5). Evaluation of genetic resources of bambara groundnut revealed that the genetic diversity is high. However, since the success rate of hybridization in bambara groundnut is very low, development of a new hybridization technique is essential.

In Benin the National Institute of Agricultural Research (INRAB) is responsible for the research on bumbara groundnut. Although the Central and North Centers of INRAB selected varieties suitable for central and northern Benin and have been conducting regional field trials, there appears to be some problems. Shortage of researchers interested in bambara groundnut and low research priority for this crop are the main issues.

3-7 Future Perspectives

The network “BAMNET” (www.genres.de/bambara/index.htm) was established for the purpose of sharing research information on bambara groundnut. The database includes information on the characteristics of genetic resources, products and grain prices in each nation with the aim of promoting bambara groundnut production (Fig. II-3-6).

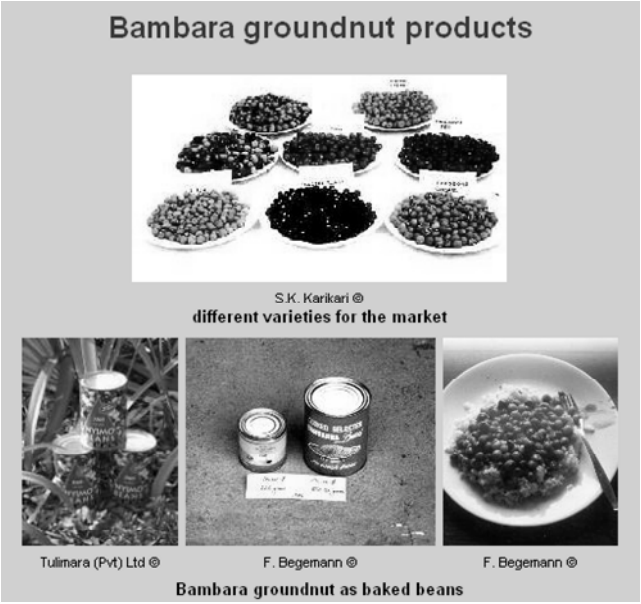

Fig.II-3-6 Bambara groundnut products

Source : BAMNET

Although bambara groundnut is potentially a good crop, efforts for the breeding of new varieties and the development of new utilization methods need to be done. The main factor to prevent bambara groundnut breeding is the difficulty in hybridization. However, an efficient pollination technology has been developed by researchers in Thailand. Suwanprasert et al. (2006) discovered that success rate of hybridization increased if flower was pollinated within a one-hour period between 2:30 and 3:30 a.m. The report also stated that it should be done when the flower stalks of the mother plant begin to elongate. On the other hand, an attempt was made to conduct a mutation breeding through irradiation to improve the yield (H.K. Adu-Dapaah, et al. 2004).

Major breeding objectives include “high yield”, “large pods”, “large grain”, “wide-area adaptability”, “earlier maturity” and “shorter cooking period” (Table II-3-8).

Bambara groundnut is produced mainly in Africa for home consumption. A large quantity of bambara groundnut is sold in the market of Benin. In order to encourage the production of bambara groundnut in Benin, development of new ways of cooking and processing in addition to the traditional cooking

methods appears to be important.

Table II-3-8 Preferred characters of bambara groundnut

Ideotype trait	Preference	Percentage
Yield	High yielding	100
Seed Colour	Cream	90
Pod and seed size	Large	100
Seeds per pod	2-4	90
Emergence	Early and uniform	60
Pod retention at harvest	High	60
Plant size	Large and spreading	90
Crop duration	Early maturing	60
Cooking quality	Cooks fast	100
Management requirement	Drought tolerant, no earthing up	100

Source：Khonga et al. 2003

Citations and Bibliography

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2) Information disclosed on the website of C.J. Swanevelder Bambara-food for Africa (*Vigna ubterranea* . bambara groundnut) (http://www.nda.agric.za/docs/Bambara.pdf)
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4. Soybean [*Glycine max* (L.) Merrill]

English Name: Soybean; Benin (French): Soja

Photo II-4-1 Soybean

Source：NIAS Genebank・Illustrated legume genetic resources database
http://www.gene.affrc.go.jp/plant/image/legume.html

4-1 Overview

Although soybean originated in East Asia, most production is now in North and South America. In recent years, the production volume has rapidly increased in various places around the world. Soybean was first cultivated in West Africa in the mid 1980s primarily for the purpose of improving diets. Soybean was not quickly adopted at the beginning. Since a traditional fermented food (hard Japanese *miso*-like seasoning: it is called *Afitin* in Benin) made of the seeds of a native leguminous tree called *Nélé* (*Parkia biglobosa*) is common in West Africa, soybean was gradually accepted as a substitute ingredient. Then, thanks to the efforts of NGOs, processing methods such as *tofu* (soybean curd) and soybean milk were disseminated and cultivation has gradually increased.

Cotton has been the most important export crop supporting the regional economies of some nations in West Africa, including Benin. However, a sudden fall in international cotton prices in the late 1990s had a serious impact on these nations. Since 2002, international market prices for cotton became lower than the production cost of cotton in West Africa; farmers began to search for

substitute crops. Cotton production in Benin fell suddenly in 2005 and soybean production has increased rapidly in its place. One reason for this could be that soybean meal produced after processing oil, tofu or soybean milk can be sold as livestock feed (partially exported to Europe). In addition, since soybean is a newly introduced crop, it is not affected by many diseases or pests, which could also explain the rapid increase in production. The nutritional value of soybean has also attracted public attention, so that hospitals in Nigeria have begun to utilize it in treatment for malnourished children. It appears the increasing trend in soybean production in Africa will continue.

4-2 Origin and Diversification

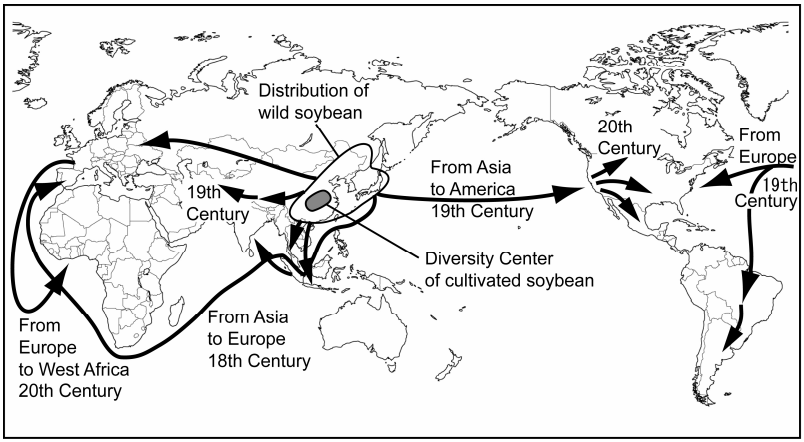

Fig. II-4-1　Origin and dispersal of soybean

（Source：modified from Hoshikawa 1981）

1) Origin, Center of Diversity and Dispersal

The center of soybean diversity appears to be midway up the Yangtze River in China to the Yellow River in North China. In addition to China, soybean has been cultivated on the Korean Peninsula and Japan since ancient times where diverse native (indigenous) varieties exist. The ancestral wild species of soybean is a *Glycine soja* Sieb. and Zucc. is distributed across China to the Korean Peninsula, the Japanese islands and far Eastern Russia. It is said that soybean was cultivated about 5,000 years ago. It is thought that soybean were brought from China to Japan at the beginning of the Yayoi period, and a description of soybean can be found in the *Kojiki* (Records of Ancient Matters) or the *Nihon Shoki* (Chronicles of Japan). It is also probable that soybean was

cultivated since ancient times in the northern mountainous areas of Southeast Asia to Bhutan, Nepal and the northern Pakistan. Soybean appears to have spread from China or Japan to Europe by sea in the 18th Century. It is said that Japanese soybean were introduced to Europe in 1712, Chinese soybean were introduced in a botanical garden in Paris in 1739 and it was cultivated experimentally at the Kew botanical garden in England in 1790. The first introduction of soybean into the US was by Samuel Bowen who introduction them from China in 1765. Soybean are also thought to have been brought to the United States by Perry, Commodore of the East Indian Squadron, who requested trade with Japan during his visit to Uraga in 1853. Since 1924, following trials at the US Department of Agriculture, soybean began to spread and the US is presently produces more soybean than any other. Although the

Table II-4-1 Wild Species of the genus *Glycine* and Major Distributed Areas

Species	No. of Chromosomes	Distribution
Subgenus, *Glycine*		
G. albicans	40	Australia
G. arenaria	40	Australia
G. argyrea	40	Australia
G. canescens	40	Australia
G. clandestina	40	Australia
G. curvata	40	Australia
G. cytoloba	40	Australia
G. falcate	40	Australia
G. hirticaulis	40, 80	Australia
G. lactovirens	40	Australia
G. latifolia	40	Australia
G. latrobeana	40	Australia
G. microphylla	40	Australia
G. pindanica	40	Australia
G. tabacina	40, 80	Australia, Midwest and South Pacific Islands, Taiwan and Japan
G. tomentella	38, 40, 78, 80	Australia, Papua New Guinea, Indonesia, the Philippines, Taiwan
Subgenus, *Soja*		
G. max	40	Cultigen
G. soja	40	Russia, China, Korea, Japan
G. gracilis	40	China
G. formosana	40	Taiwan

(Source: Science on Edible Pulses, 2003)

route to South America is unclear, they appear to have been brought there from Europe in the 19th Century. In recent years, cultivation has increased rapidly in Brazil and Argentina and it appears production will continue to grow.

2) Introduction to Africa

Soybean was first introduced in West Africa around 1900 by colonial governments and Christian organizations. Soybean was promoted as a miracle crop in West Africa. From a dietician's point of view, soybean is cheaper and higher in protein than other foods. Many regions in Africa have a suitable climate for cultivating soybean and there are few soybean-related diseases and pests in Africa. Moreover, the capability to restore symbiotic nitrogen through the root nodules of soybean makes it possible to cultivate soybean under conditions where there are insufficient nutrients in the soil. Despite these many advantages, soybean did not spread quickly at the beginning.

The full-scale spread of soybean in West Africa began in 1987 when the International Institute of Tropical Agriculture (IITA) began dissemination activities with the financial assistance of the International Development Center (IDC). These activities were concentrated mainly in Nigeria. And in the recent years, soybean production in Africa has been increasing rapidly.

Glycine plants, which are wild relatives of soybean, are classified into the subgenus *Glycine* and subgenus *Soja*. Subgenus *Glycine* plants are perennial herbs distributed mainly in the tropical zone of Australia and are distantly related to cultivated soybean, so they cannot be directly hybridized. Subgenus *Soja* plants are annual herbs distributed in Asia. Soybean had been domesticated from *G. soja* (Japanese name: *tusru-mame*). *G. gracilis* is a species described from northeastern China, its form is considered to fall somewhere between cultivated soybean and wild soybean, so it is called weed soybean. There is some discussion on the taxonomical handling of this *G. gracilis* and it is not treated as an independent species in some cases. *G. formosana* (*hosoba-tsuru-mame* in Japanese) was discovered in very few areas, such as northern Taiwan. It has a smaller seed than wild soybean (*G. soja*) and its small leaves are narrow and long.

The ancestral wild species of soybean, *tusru-mame* (*G. soja*) is distributed from southern to northeast China, the entire eastern region of China, the Korean Peninsula, and even the Ussuri River basin in far eastern of Russia. Although it is widely distributed from southern Hokkaido to Kyushu in Japan, it cannot be seen in the Okinawa islands. Since it is relatively easy to hybridized *tusru-mame* (*G. soja*) with cultivated soybean, it is expected to become a genetic source for the improvement of soybean varieties. China has placed much emphasis on the use of wild soybean for breeding. For example, China collected *tusru-mame* (*G. soja*) from many areas and enthusiastically conducted

a characterization and evaluation. As the result, a lot of useful genetic information was discovered. For example, some accessions of wild soybean in China have developed its unique organ called a salt gland which enables these accessions to be highly salt tolerant. One wild accession is extremely resistant to aphids. Some show a stable cytoplasmic male sterility, and can be used for creating F_1 soybean, and a fertility restoring line. In the United States, a gene resistant to cyst nematodes parasites on soybean roots was discovered from wild soybean and introduced to cultivated soybean.

Photo II-4-2 Wild soybean *Glycine soja* growing in Japan

Fig. II-4-2 Distribution of *G. soja* Collections in Taiwan, China are for *G. formosana*

Wild soybean is usually found close to human dwellings in places where the ecology has been disturbed such as riverbanks, paddy fields or grassy areas along the side of upland fields, or waste land.

4-3 World Soybean Production

The global production volume of soybean has increased rapidly over the past 10 years and in 2004 it exceeded 200 million tons. The production volume in Asia remains relatively stable at 25 million tons.

The United States is the world's largest producer of soybean. Production in Brazil and Argentina has also increased remarkably over the past 10 years. In Brazil, the Amazon forests have been cut down due to the expanding soybean fields, and the problem of environmental destruction has attracted much public attention.

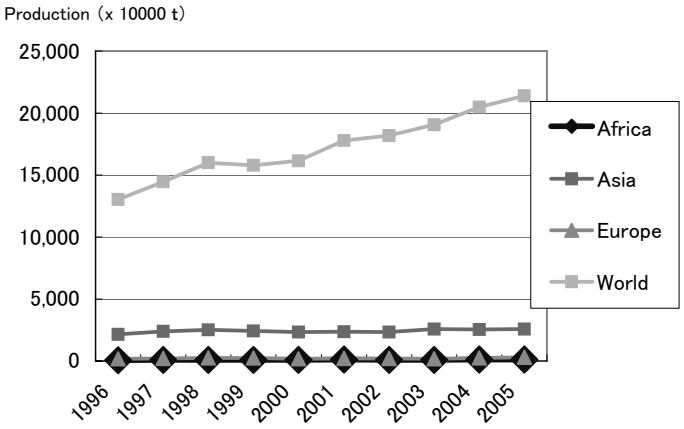

Fig. II-4-3 World production of soybean

(source : FAO statistics)

1) Soybean Production in Africa

In the ten-year period between 1996 and 2005, the production volume of soybean in Africa increased from 750,000 tons to 1.25 million tons, an increase of 166%.

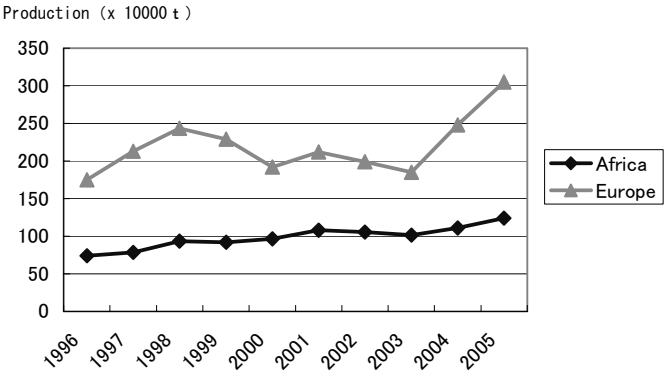

Fig. II-4-4 Soybean production in Africa and Europe.

(source : FAO statistics)

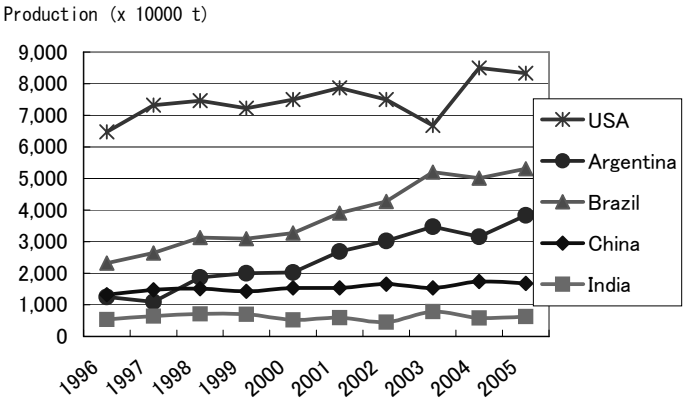

Fig. II-4-5 Soybean production in major producing countries

(source : FAO statistics)

Although the soybean production volume in Africa is less than 1% of the world total, Nigeria has the largest production among African nations, and this has increased rapidly.

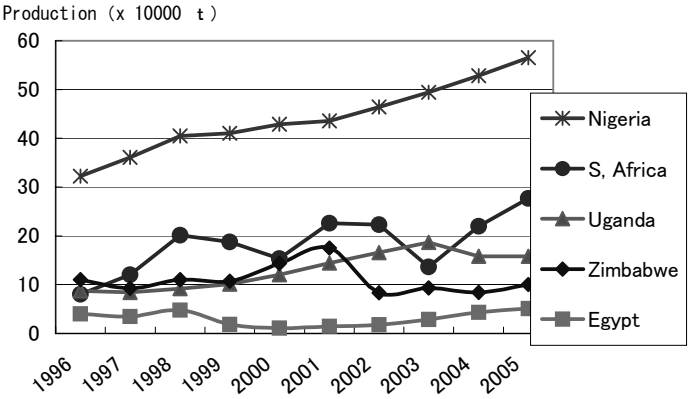

Fig. II-4-6 Soybean production in Africa

(source : FAO statistics)

2) Soybean Production in West Africa and Benin

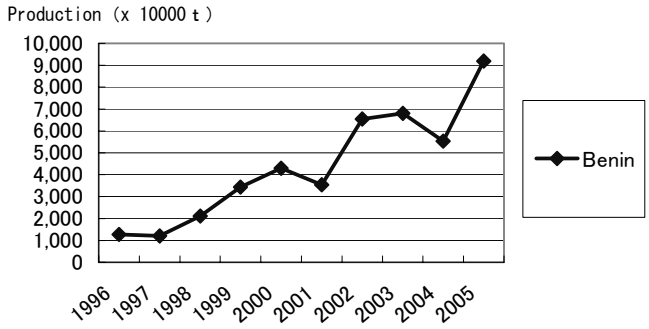

Fig. II-4-7 Soybean production in Benin, West Africa

(source : FAO statistics)

Soybean production in Benin began to grow rapidly in the late 1990s at about the same time as the cotton crisis, mentioned later. And it appears this trend will continue for some time.

3) Soybean Yield

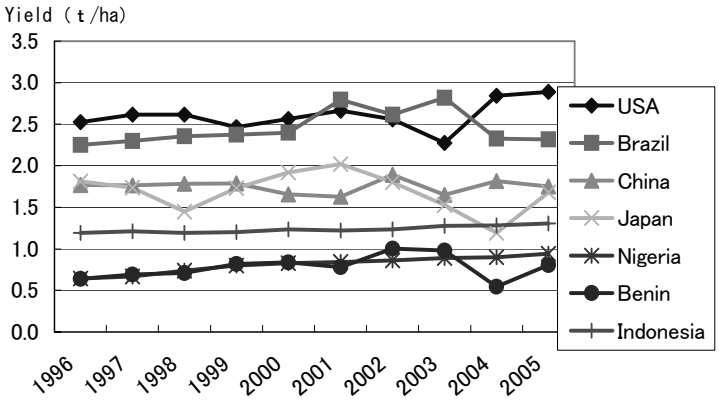

Fig. II-4-8 Soybean yield in major producing countries

(source : FAO statistics)

The soybean yield in Africa is less than 1t/ha, which is much lower than the world average (approximately 2.2t/ha). The main reason for this could be that improved varieties have not been utilized effectively and fertilizers have not been applied due to the small-scale of cultivation.

4) Soybean Producing Regions in West Africa and Benin

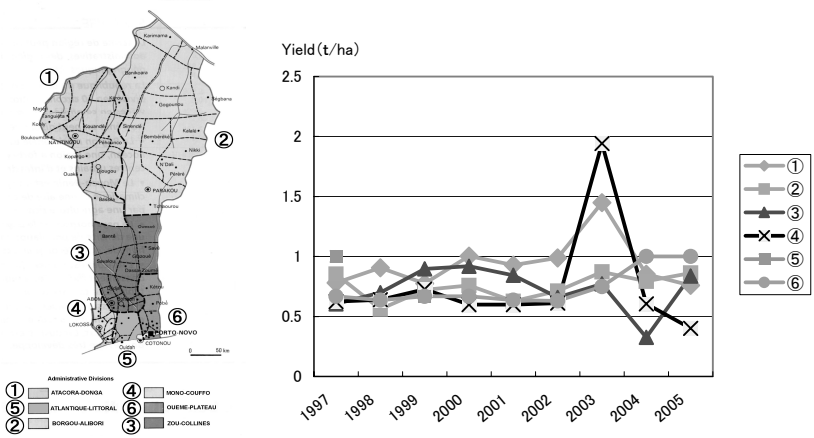

Fig. II-4-9 Soybean production in each region of Benin

(source：Statistics of Benin)

In the late 1990s, cultivation expanded rapidly in ③ Zou-Collines, where farm households began to cultivate soybean as a substitute for cotton. At the beginning of the 2000s, two northern regions, ② Borgou-Alibori and ① Atacora-Donga began to rapidly boost their production.

5) Soybean Yield in West Africa and Benin

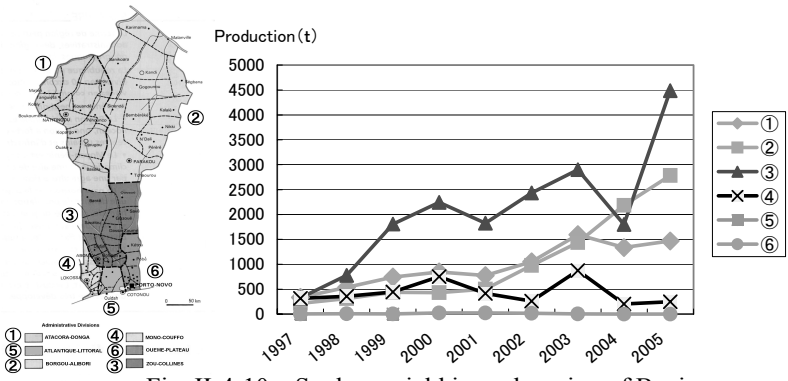

Fig. II-4-10 Soybean yield in each region of Benin

(source：Statistics of Benin)

6) Relationship between the Increase in Soybean Production in West Africa and the Cotton Crisis

As a backdrop for the recent rapid increase in soybean production volume in Benin, the recent change in cotton cultivation in this region should be mentioned. Known as the cotton crisis in West Africa, the phenomenon was a major social concern. In many countries in West Africa, cotton plays a major role in the economy. In the 2001 statistics, Burkina Faso was the largest exporter of cotton accounted in West Africa, at nearly 50% of the national export, followed by Chad at 36%, and Benin at approximately 33%.

With the opportunity of economic liberalization in the 1980s, cotton production and exportation in West Africa increased rapidly. In the 2004 statistics, cotton from West Africa reached 13% of the global international market, making it second to the United States.

Since the late 1990s, due to an increase in the use of synthetic fibers and the policies of agricultural subsidiaries in some nations, international cotton prices fell suddenly. Particularly in 2002, the international cotton price per pound fell to 35 cents. This price is lower than the production cost in West Africa. As shown in the following figure (Fig. II-4-11), the international prices for cotton put downward pressure on production prices, and as a result the cotton production volume in Benin dropped rapidly in 2005. Faced with this problem, cotton farmers began to replace cotton with soybean, which was one cause for the rapid increase in soybean production. Soybean meal produced after edible oil is extracted from soybean seeds can be exported to Europe. This is also considered to be one reason for the increasing interest in soybean.

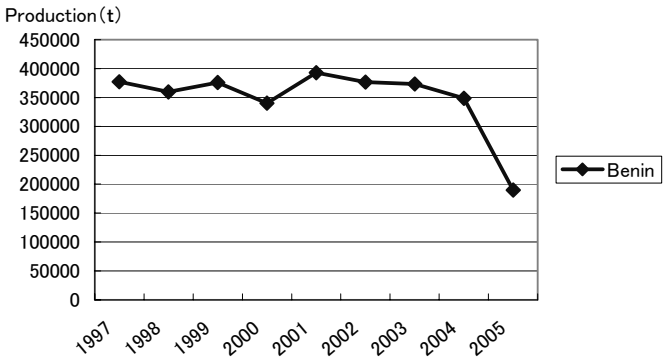

Fig. II-4-11 Cotton production in Benin

(source：Statistics of Benin)

4-4 Cropping System, Cultivation Method and Its Utilization

1) Soybean Cropping System and Cultivation Method in West Africa

In the Sub-Sahara region in West Africa, soybean is usually cultivated on small-scale farms without the use of pesticides or fertilizers or through monoculture or mixed cropping with sorghum, corn or cassava, etc. The planting, weeding and harvesting are done by hand. Soybean in West Africa is harvested 100 to 150 days after planting. After harvesting, threshing is also done by hand in most of cases. According to recent research conducted by IITA, it was found that mixed cropping in a ratio of two rows of cereals and four rows of soybean has better yielding ability than mixed cropping in a ratio of one row of cereals and one row of soybean.

2) Utilization of Soybean from a Global Point of View

Approximately 75% of the soybean consumption in the world is for processing, and the consumption for eating is small. The breakdown for consumption for processing is mainly soybean oil and soybean meal after extracting oil and most of soybean meal is used as ingredients for livestock feed. The global consumption of soybean oil and meal has been increasing, especially in China and India where consumption has grown in tandem with the increase in population.

In the United States and Europe, soybean seeds are used only for edible oil and soybean meal which is fed to livestock; whereas, in Asia, the place of origin, soybean is used in various forms as human food. For example, they are roasted, boiled, fermented (*natto*), made into *tofu*, soybean milk, *miso* (soybean paste), green soybean and soybean sprouts. In addition, depending on the use, various varieties have been bred, e.g., small grain varieties for fermented soybean and soybean sprouts, high protein with white seed coat varieties for tofu or soybean milk, smooth and large seeded varieties for green vegetable soybean, and extremely large-sized black grain varieties for New year dishes.

In recent years, the healthy qualities of isoflavone or saponin have attracted public attention. Various foods that use soybean protein are also sold in markets.

3) Utilization of Soybean in West Africa

Soybean was first cultivated in West Africa in the mid 1980s mainly for the purpose of nutritional improvement (Photo II-4-3: A). As can be seen in this photo, various processed foods are made from soybean for the purpose of improving infant nutrition. In Benin the University of Abome-Carabi promotes the development and diffusion of soybean-processed products. Professor Hounhouigan (left) and Professor Adjahossou (right) (Photo A) play a key role. Soybean was not disseminated well initially. A traditional fermented food made of the seeds of an indigenous leguminous tree, which is called Nélé (*Parkia*

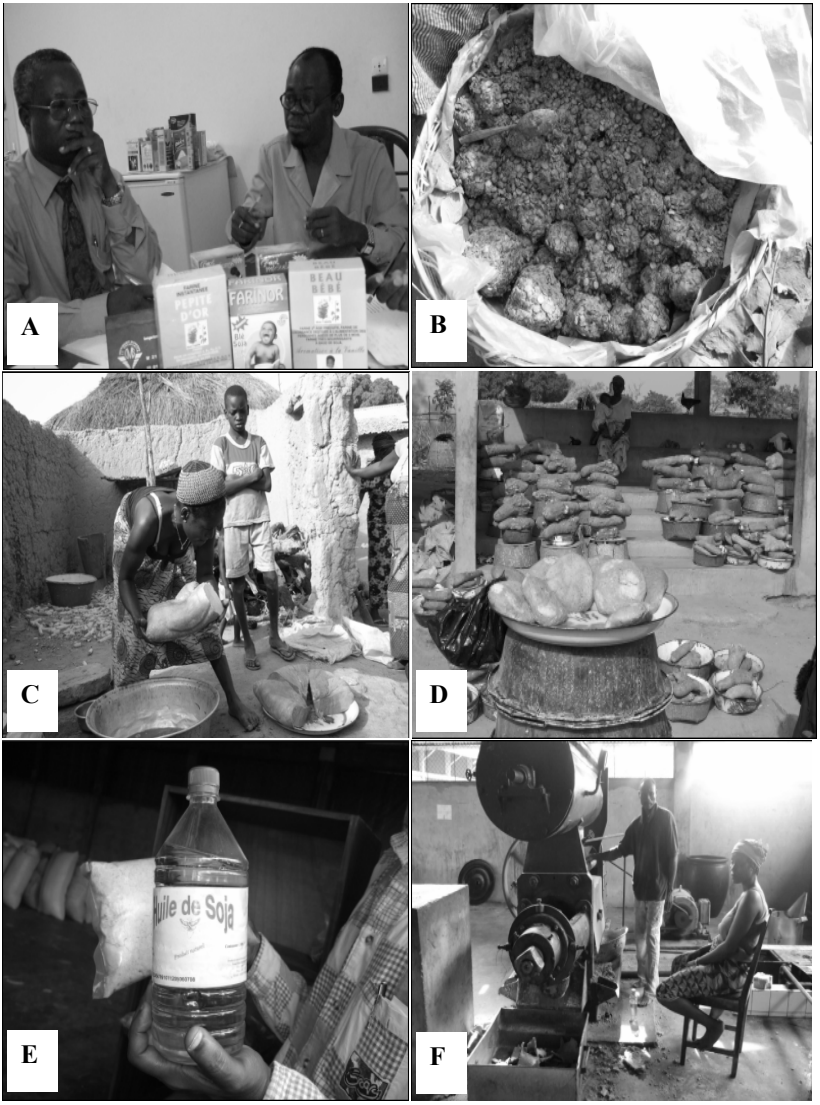

Photo II-4-3 Methods of using Soybean in Benin

A: Soybean processed products for nutritional improvement; B: Afitin, *miso*-like fermented seasoning made from pulse trees; C: *Tofu*; D: Cheese; E: Soybean oil; F: Soybean oil extraction site; Centre Sonqhai, NGO

biglobosa), (Photo II-4-3: B, hard *miso*-like seasoning: it is called *Afitin* in Benin) are popular throughout West Africa, and soybean began to be accepted as a substitute for this. Since then, thanks to the efforts of NGOs, processing methods such as *tofu* (soybean curd: Photo II-4-3: C) or soybean milk have spread and cultivation has gradually increased. Soybean curd making appears to have spread to villages in northern Benin at the present time, and we could observe the case that it was supplementing the income of women in rural communities. In Ina village in N'dali department, we visited many farm households where soybean curd was being made (Refer to the materials attached at the end of the document for details on soybean curd preparation). As seen in the photo, *tofu* (soybean curd) is usually dyed red using red sorghum stems. Cheese (Photo II-4-3: D), which was introduced before *tofu*, was introduced during the French colonial period and is also dyed red in the same way, so this custom appears to have been copied. The red color of anthocyan was considered to have an antibacterial action. Since cheese was introduced earlier than *tofu*, this helped the spread of *tofu*. *Tofu* is called *fromage de soja* (which means cheese made from soybean). It takes almost one day to make *tofu*, and the expected income is estimated to be 500FrCFA (approximately ¥ 125). At the Centre Songhaï, NGO, edible oil is squeezed from soybean (Photos II-4-3: E and F) and soybean meal is used for livestock feed. Since the soybean meal of *tofu* is dried to produce feed even in villages in the north where *tofu* is made, nomads often visit to purchase it.

4-5 Breeding and Production Restraints Factors

1) Breeding

(1) Goal of IITA soybean breeding

The IITA (International Institute of Tropical Agriculture) in Nigeria, an international research institution, has bred soybean since the 1970s. The aim of the soybean breeding program presently conducted by IITA in West Africa is to breed soybean varieties that are resistant to soil lacking in phosphoric acid, soybean varieties that can kill parasitic weeds, *Striga hermonthica*, which damages cereals crops such as corn, and varieties that can produce symbiotically fixed nitrogen without inoculating root nodule bacteria. In addition, IITA also emphasizes the breeding of multi-purpose varieties that produce a high seed yield and high biomass yield for soil improvement or animal feed.

(2) Measures for Disseminating Soybean Taken by IITA

IITA not only breeds varieties but also develops various processing machinery such as mills or threshers that are easily adaptable to the Sub-Sahara region and suitable for small-scale processing, and develop diversified processed foods. IITA lists the following advantages in relation to the

dissemination of soybean in West Africa.

(3) Soybean Protein

Soybean seeds contain approximately 40% protein, which is the highest of all the food crops, and approximately 20% oil, which is the 2nd highest next to peanuts. Compared to other protein foods such as meat, fish and eggs, soybean is much cheaper. Soybean also has a better amino acid composition than other high-protein plants. Although the amount of soybean protein used for human consumption is relatively small at the present time, since soybean began to attract international attention, a huge potential demand as a future protein source is anticipated.

(4) Soybean Oil

Soybean oil is extremely easy to digest and does not contain cholesterol. In addition, after extracting the oil, soybean meal can be utilized as high-protein livestock feed.

(5) Improvement in Soil Fertility

Soybean restores nitrogen so that soil fertility can be improved. This is important for African agriculture.

2) Factors for Restraint

Soybean was only recently introduced to Africa and cultivation areas are still few, so they are still quite resistant to disease and pests.

(1) Disease Damage

Major diseases in Africa include frogeye leaf spot, bacterial pustule, bacterial blight and soybean mosaic virus, and in recent years, leaf blotch and soybean rust have been reported. The characteristics of the soybean rust diseases and spread in outbreak areas are shown below.

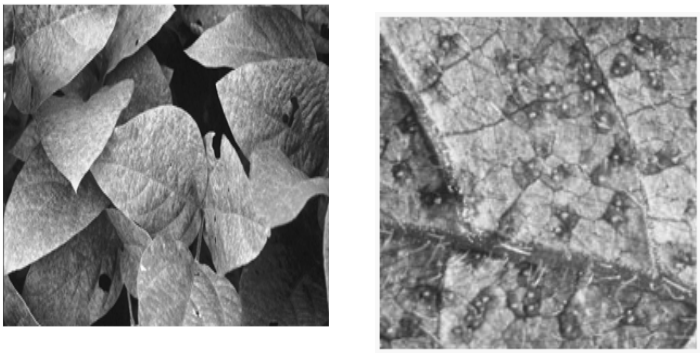

Photo II-4-4 Soybean rust (*Phakopsora pachyrhizi*)

(source：Kentucky University www.uky.edu/Ag/CAPS/calendar06/jun06pom.htm)

(2) Nematode

Damage by nematodes has also been reported. Roots damaged by nematodes are susceptible to blight intrusion thus inviting more serious damage.

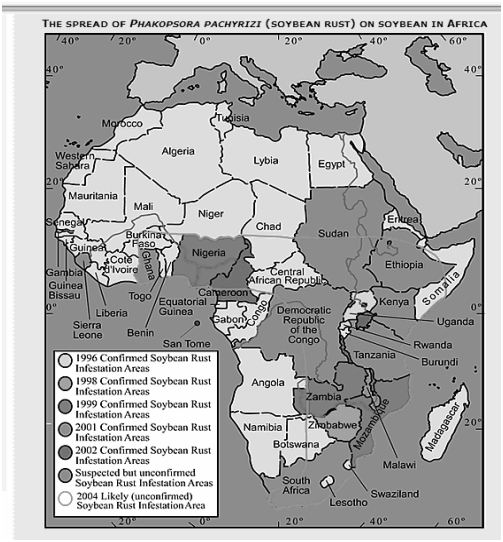

Fig. II-4-12 Distribution of soybean rust (*Phakopsora pachyrhizi*) in Africa

(source：Penn State University www.ceal.psu.edu/afmap.htm)

(3) Insect Damage

Pests that do the most serious damage to soybean in the tropical zones are *Pentatomorpha* (stinkbugs) damage on pods. Bean flies also do serious damage. However, there appears to be little damage from the pests in Benin probably because soybean cultivation is new to the area.

4-6 Future Perspectives

Since soybean was always seen sold in the markets of Benin, the utilization of soybean for food appears to be considerable. In addition, *tofu* making has spread to rural communities. On the international markets, the soybean distribution volume continues to increase. If exporting soybean meal to Europe continues, soybean production in West Africa will continue to increase.

It was above our expectation that *tofu* has spread to rural communities in West Africa. Cheese, a similar food which has already spread, appears to be a

major reason for this. Diversified processed foods utilizing soybean are developed in Japan. In addition, there are many researchers involved in soybean breeding and cultivation. Moreover, since 2007, the National Institute of Agrobiological Sciences (NIAS) has started conducting a soybean genome project. Taking these matters into consideration, there will be many opportunities for Japan to take in active role in soybean–related research and development through technical assistance.

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6) Hoshikawa K. 1981. New Edition Food Crops, Yokendo Co., Ltd.

5. Other Pulses

5-1 Pigeon Pea [*Cajanus cajan* (L.) Millsp]

English: Pigeon pea; Benin (French): *Pois d'angole*

Photo II-5-1a Pigeon pea
(source : upper left from USDA site, others taken by the author)

Overview

Pigeon pea is cultivated extensively in tropical zones in South Asia, Southeast Asia, Africa and the Americas. They are produced approximately in 50 nations worldwide. India is the top producing country and the cultivation area is about 3.8 million ha, accounting for 85 to 90% of the world cultivation area (2003). In addition to India, Myanmar, China and Nepal produce large quantities in Asia. Production in Africa is 420,000 ha (2003) and the East African countries of Kenya, Uganda, Malawi, Tanzania and Mozambique are the exporting nations. Pigeon pea production in Africa is 260,000t and it has increased 96% since 1972. In the future, it appears the production of pigeon peas in Africa will increase further. The Dominican Republic in the Caribbean is also a major producer.

The pigeon pea (*Cajanus cajan*) is a perennial plant. The genus *Cajanus* contains 32 species, and there are two cultivated varieties of *Cajanus cajan* (L.) Millsp. *Cajanus cajan* var. *flavus* is early maturing and small in size, each pod having three seeds and a yellow seed coat. *Cajanus cajan* var. *bicor* is early

maturing and larger in size and each pod has 4 to 7 seeds and is dark red in color or spotted. The center of diversity of pigeon pea is India where *Cajanus* is thought to have evolved from the genus *Atylosia* that grows naturally in southern India. Pigeon pea was spread to Africa by about 2,200 B.C. East Africa is a secondary center of diversity. Pigeon pea is resistant to drought and they can grow well even in low-phosphoric acidic soil in the tropical zones. This is because pigeon pea can specifically absorb phosphorus from phosphoric acid connected to iron through an organic acid secretion from the root. The pigeon pea is an important crop in India where it is intercropped with other crops such as corn, sorghum or millet. Pigeon pea is high in protein, and the dried seeds are used in India as *dal*. In addition, the young pods are eaten as a vegetable and the soft young leaves can be utilized as a green vegetable. The foliage of pigeon pea is utilized for animal feed or green manure, and is also used for shading vanilla or as a windbreak for other crops. In Bengal in northern India and Thailand, pigeon pea is also utilized as a host for *Laccifer lacca* (scale insect) which secretes the natural resin lacca. In Africa, seven varieties with special qualities such as resistance to damping off disease or early maturity have been developed by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and have become major varieties. ICRISAT succeeded in its development of cytoplasmic male sterile lines using mutation breeding in 1991. Through this, hybrid pigeon peas using cytoplasmic nuclear male-sterility (CMS) systems have been established and this technology is being disseminated to public and private institutions.

The cultivation areas or production volumes is unclear in Benin, the cultivation of pigeon pea can be seen from the central to the north where dry condition prevails. By conducting experiments on mixed cropping of groundnut and pigeon pea at farm households, ICRISAT has suggested that mixed cropping could provide additional income. Although pigeon pea has been cultivated through monoculture at farms in Benin, a mixed cropping system with other crops should also be examined.

Photo II-5-1b Pigeon pea cultivated in central Benin

Citations and Bibliography

1) L.J.G. van der Maesen 1995. Pigeon pea *Cajanus cajan* (Leguminosae-Papilionoideae) In Smartt & Simmonds (eds.) Evolution of Crop Plants (Second Edition). Longman Scientific & Technical. pp. 251-254.
2) Hoshikawa K. 1981, New Edition Food Crops Chapter 31 Other Pulses Yokendo Co., Ltd. (in Japanese)

5-2 Common Bean (*Phaseolus vulgaris* L.)

English: Common bean, Kidney bean; Benin (French): *Haricot*

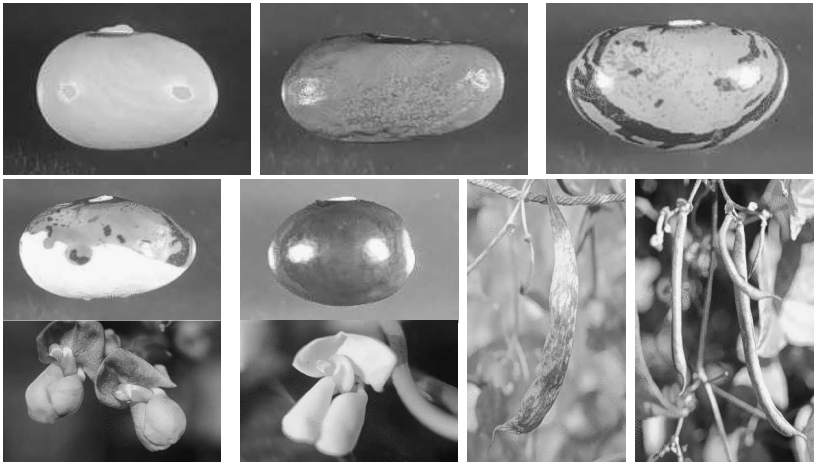

Photo II-5-2 Common bean (*Phaseolus vulgaris*)
source：NIAS Genebank・Illustrated legume genetic resources database
http://www.gene.affrc.go.jp/plant/image/legume.html

Overview

The common bean originated in the Americans. Current opinion is that a small-grain variety group from the Mexico area and a large-grain variety group from the Andes in South America were domesticated independently. Kidney beans were brought to Europe by the Spanish in the 16th Century and were introduced to West Africa via Europe (Hoshikawa, 1981). Its heat tolerance is low especially during the flowering period, so it is cultivated at high altitudes and in cooler locations in the tropical zones. Although information on cultivated areas and cultivation in Benin could not been collected, white round-grain type kidney bean seeds were being sold in both central Bohicon and southern Cotonou. At the Bohicon market, a metallic bowl (called tongoro) of cowpea approximately 800 to 900g) was sold for 175 to 275FrCFA (¥1 ＝

about 4 FrCFA); whereas, white-seeded common bean was sold at nearly double the price (400 FrCFA). At the Cotonou market, one tongoro of cowpea was 250 to 400FrCFA; whereas, white common bean was more expensive at 600FrCFA. The Tropical Agriculture Research Front (formerly Okinawa Branch) of the Japan International Research Center for Agricultural Sciences (JIRCAS) has bred a highly heat resistant common bean called "*Haibushi*", which has potential as a useful genetic resource in tropical Africa (Nakano et al., 1997). In addition, as kidney beans are totally resistant to the azuki bean beetle, *Callosobruchus chinensis* (L.), there appears to have a significant merit to cultivating them in West Africa. Although the sale of common bean seeds could be observed in Benin markets, the sale of young pods was not seen. At the present time, there appears to be no custom of using the young pods of leguminous crops as vegetables in Benin. From a nutritional point of view, use of the young pods of leguminous crops as vegetables should therefore be promoted.

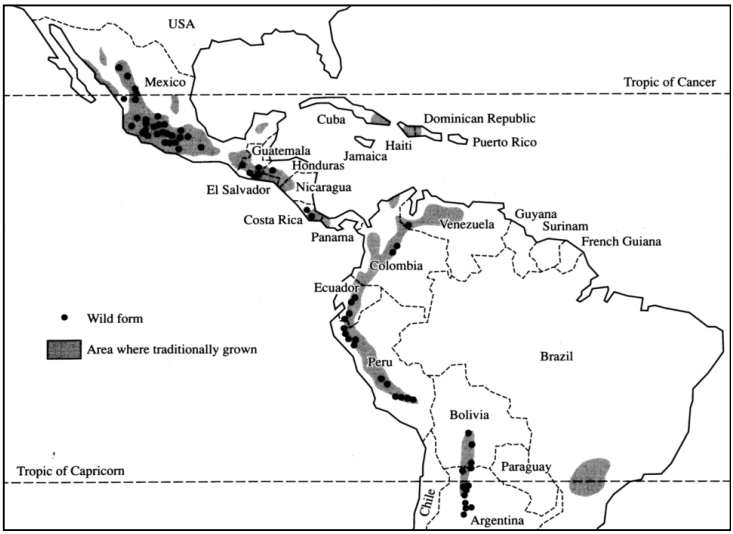

Fig. II-5-1 Traditional area of common bean cultivation and distribution of wild form (●).

Citations and Bibliography

1) Debouck D.G. and J. Smartt 1995. Beans *Phaseolus* spp. (Leguminosae - Papilionoideae) In Smartt & Simmonds (eds.) Evolution of Crop Plants (Second Edition). Longman Scientific & Technical. pp. 287-294.

2) Hoshikawa, K. 1981. New Edition Food Crops, Chapter 23 Kidney Beans, Yokendo Co., Ltd. (in Japanese)
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5-3 Lima Bean (*Phaseolus lunatus* L.)

English: Lima bean, Butter bean, Madagascar bean;
Benin: Akpakou (based on a interview at the north of Bohicon, central Benin)

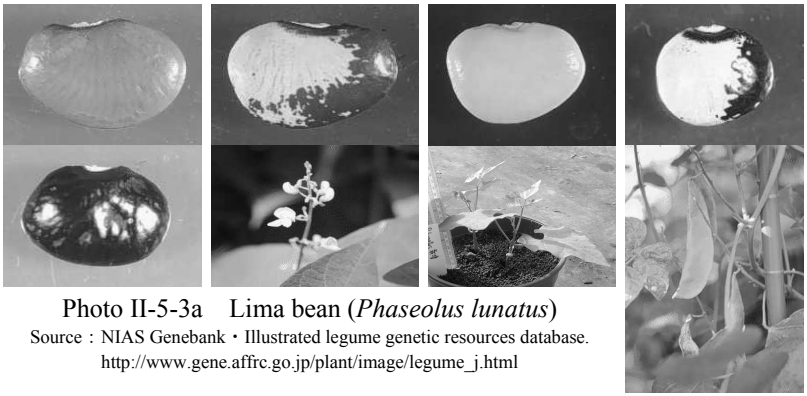

Photo II-5-3a Lima bean (*Phaseolus lunatus*)
Source：NIAS Genebank・Illustrated legume genetic resources database.
http://www.gene.affrc.go.jp/plant/image/legume_j.html

Overview

The lima bean originated in the Americas. In a similar manner to common bean, many data point to dual origin in Mesoamerica and Andes of South America. A group of small-grain varieties called Sieva were domesticated in Central America (near Guatemala) from a tropical small-grain wild species and a group of large-grain varieties called Big Lima were domesticated in the Andes from a large-grain wild species (Fig. II-5-2).

Lima bean is believed to have spread to West Africa from Brazil via returning slave vessels in the 16th Century (Hoshikawa, 1981). The mature seeds contain cyanide or hydrocyanic acid glycoside that has unique smell, and can be poisonous. If lima beans are soaked in water for twenty-four hours, boiled well and water is replaced several times, the poison can be removed. A higher amount of hydrocyanic acid (cyanide) is contained in varieties with colored seed coats, and it is said that in general white seed varieties do not contain hydrocyanic acid. In addition to boiled fully-matured beans, boiled young pods is said to be the tastiest of the pulses, and so it is called sugar bean. In the United States, canned immature beans or frozen or processed pulses are

important products.

Although lima bean varieties could not be seen sold in the markets of Benin, at one farm household that sold cassava powder (*gari*) on the roadside a little north of Bohicon town in central Benin, dozens of pigeon pea and several lima bean plants were cultivated (Photo II-5-3b). According to the woman of this farm household, she purchased lima bean seed at the market. The variety is characterized by small-sized grains and with black spots on a flat white base. As lima bean is also cultivated in tropical areas in Southeast Asia and it is often growing naturally escaped from cultivation, they appear to be superior in heat tolerance than common bean. They are also considered to be quite resistant to diseases and pests.

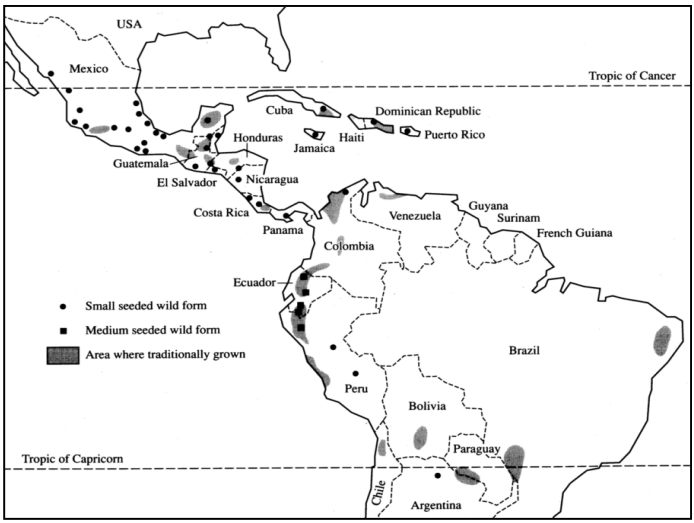

Fig. II-5-2 Traditional cultivation area (shade) and distribution of wild lima bean (●)
(source：Debouck and Smartt 1995)

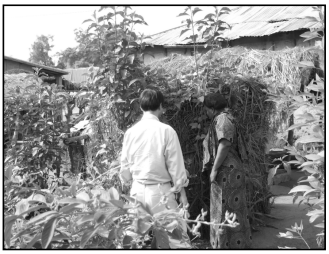

Photo II-5-3b A lima bean plants cultivated at north of Bohicon, central Benin

Citations and Bibliography

1) Debouck D.G. and J. Smartt 1995. Beans *Phaseolus* spp. (Leguminosae-Papilionoideae) In Smartt & Simmonds (eds.) Evolution of Crop Plants (Second Edition). Longman Scientific & Technical. pp. 287-294.
2) Hoshikawa, K. 1981. New Edition Food Crops, Chapter 24 Lima Bean, Yokendo Co., Ltd. (in Japanese)

Chapter III　Possibility (Future) of Introducing New Pulse Crops in West Africa

1. Mungbean (*Vigna radiata* (L.) Wilczek)

English: Mungbean, green gram

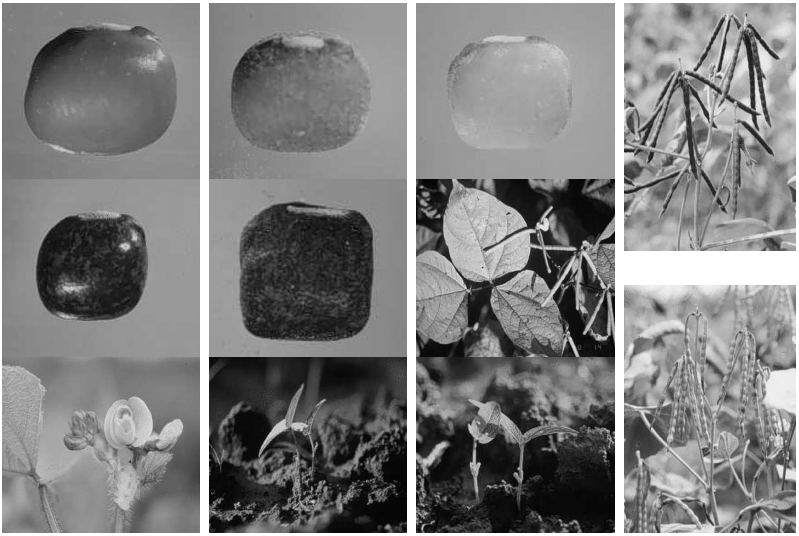

Photo III-1　Mungbean (*Vigna radiata*)

source：NIAS Genebank・Illustrated legume genetic resources database
http://www.gene.affrc.go.jp/plant/image/legume.html

Overview

Mungbeans have the shortest harvesting period (between 60 and 90 days) among leguminous crops, so they are characterized by their easily incorporation into various cropping systems, and production has been increasing in recent years, mainly in India. The cultivation period is short and easily incorporated into diversified cropping systems, which is the largest merit supporting their introduction to West Africa.

However, they are susceptible to pests and diseases, especially the bean weevil, which has also become a problem for cowpea cultivation in West Africa. Resistance to drought also appears to be lower than that of cowpea. Therefore, mungbean should be cultivated during the cropping period and region that is not subject to severe drought conditions.

Although it is possible to use mungbean in a manner similar to cowpea, mungbean has a smaller seed size so the market price may be lower. In areas

where mungbean is presently cultivated, mungbeans is eaten as a bean soup (*dal*) on the Indian subcontinent, mixed with rice, made into a thick bean-meal soup and bean jam in Southeast Asia. In addition, they are used for bean sprouts or used as an ingredient for noodles (vermicelli). Although bean sprouts or vermicelli noodles have not been introduced into West Africa except among the Asian community, one idea is to spread this type of utilziation method of mungbean in cooperation with local NGOs. Since the demand for bean sprouts as a healthy food source has increased in the U.S., it will be possible to increase the demand globally in the future. The relationship between Africa and China has been gradually strengthened, Chinese restaurants are becoming more common mainly in urban areas. In Chinese cuisine, bean sprouts and vermicelli gelatine noodles are indespensable ingredients, so they may gradually become more common among local people.

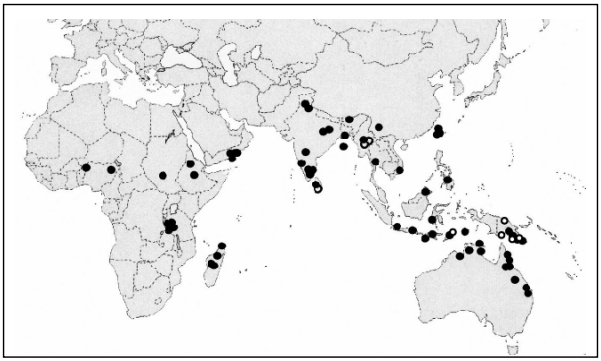

Fig. III-1-1　Distribution of wild mungbean（*V. radiata* var. *sublobata*）

（source：modified from Tomooka et al., 2002）

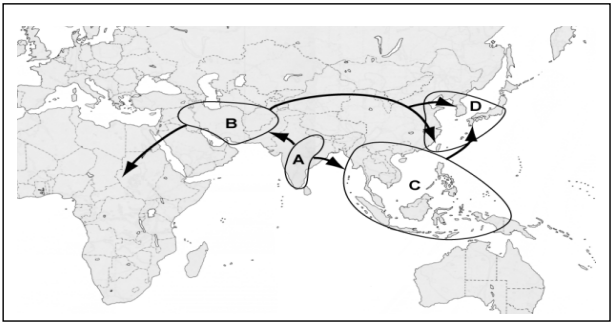

Fig. III-1-2　Origin (A) and dissemination of cultivated mungbean

（source：Tomooka et al., 2005）

The World Vegetable Center (AVRDC), which is the leading international institution for vegetable research and development, whose head office is in China (Taiwan) takes initiatives in breeding mungbean, and is actively involved in breeding activities in India and Thailand.

Based on the protein types, growth characteristics and its geographical distribution of mungbean, the center of diversity is considered to be in India (Figure III-1-2: Zone A), and is regarded as the origin of mungbean. Mungbeans in Afghanistan, Iran and Iraq (Zone B) represent a secondary center of diversity. Mungbeans in Southeast Asia (Zone C) appear to have been affected by intensive selection by farmers due to the environment and preference, so there are many bright green-colored, late-maturing varieties prevailed in this zone C. Because of the strong selection pressure in zone C, protein type constitution became quite simple. There are many dull-green colored, medium-grain seeds and early-mature varieties in East Asia (zone D).

Mungbean appear to have spread from India to throughout Asian since ancient times. One route was from India to Southeast Asia and varieties consist of mainly protein type 1 have disseminated. The other route to the East is considered the Silk Road. Protein type 7 or 8 lines are thought to have been disseminated through this route from India or West Asia to China, then to Taiwan (Tomooka et al., 2005).

The mungbean is locally called *yaenari, fundou, bundou, ao-mame or ao-mami* in Japanese. Until recently, mungbean was cultivated widely in southwest Japan. In the 1950s the cultivation area was approximately 200 to 220ha and approximately 210t of mungbean was produced (Hoshikawa, 1981). Nowadays however, the cultivation of mungbean has almost completely disappeared in Japan. We were able to collect some lines of native mungbean varieties that remained, on the South-West Islands (Katsuta and Takeya, 1992, Tomooka, et al., 1994). In this region, mungbean was used for making bean sprouts or was eaten mixed with rice. On Tanegashima Island, slender bean sprouts were an important offering during the Bon Festival (Tomooka, et al., 1994).

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improvement. Vol. 1. Grain Legumes. Chapter 10, 325-345. CRC Press.
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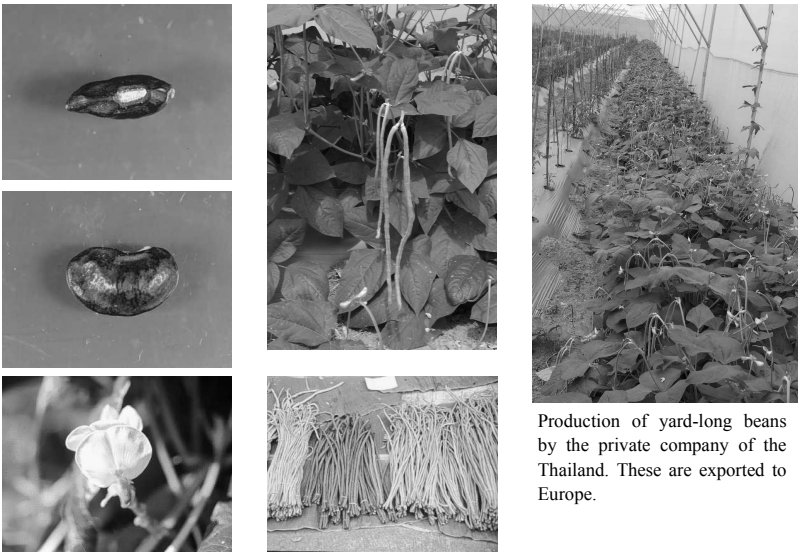
5) Tomooka, N. H. Nakayama, K. Yamada and A. Sugimoto, 1994. Exploration for collecting landraces of cultivated crops in Tanegashima and Yakushima islands, Kagoshima prefecture. Search for Native Species on Tanegashima and Yakushima Islands. Annual Report on Exploration and Introduction of Plant Genetic Resources., Vol.10 : 15-24.

2. Yard-long Beans *Vigna unguiculata* (L.) Walpers cv-gr. Sesquipedalis E.Westphal *Cajanus cajan* (L.) Millsp)

English: Yard-long bean



Production of yard-long beans by the private company of the Thailand. These are exported to Europe.

Photo III-2-1 Yard-long Beans

Overview

Another name for the yard-long bean is "*Naga-sasage* (long cowpea)". The young pods are raw, which differentiates it in Southeast from the cowpea which originated in and spread from Africa. Southeast Asia is the center of the diversification of yard-long beans. The leavers of yard-long beans are slightly glossy and the followers are purple or white. The yard-long bean flower is larger than that of the cowpea. Its seed is slightly curved and more slender than the cowpea. Its length is 8 to 12mm. Seed colors are diversified and range from black, brown, brown-spotted on a white base and black-spotted on a white base. Many varieties have creeping stems and long hanging pods that grow 30 to 90cm. The yard-long bean is resistant to drought and is easily cultivated in any soil or land type. In a similar manner as cowpeas, it is weak against disease and pests. Young pods of yard-long beans are utilized as vegetables due to their soft, juicy quality and can be eaten raw. In Southeast Asia, it is a popular vegetable and can be seen everywhere in the markets. In Thailand, private vegetable production companies export yard-long beans to Europe. In the markets in Benin, there is a shortage of vegetables, so only the young pods of kidney

beans could be seen. In the future, to promote the expansion of vegetable consumption, the introduction of easily-cultivated yard-long beans appears to be worthy of examination.

Citations and Bibliography

Mitsuru Hotta (editing representative), 1981. Useful Plants of the World, p.1092 Heibonsha Limited, Publishing

3. Black Gram [V*igna mungo* (L.) Hepper]

English: Black gram, black matpe, urd

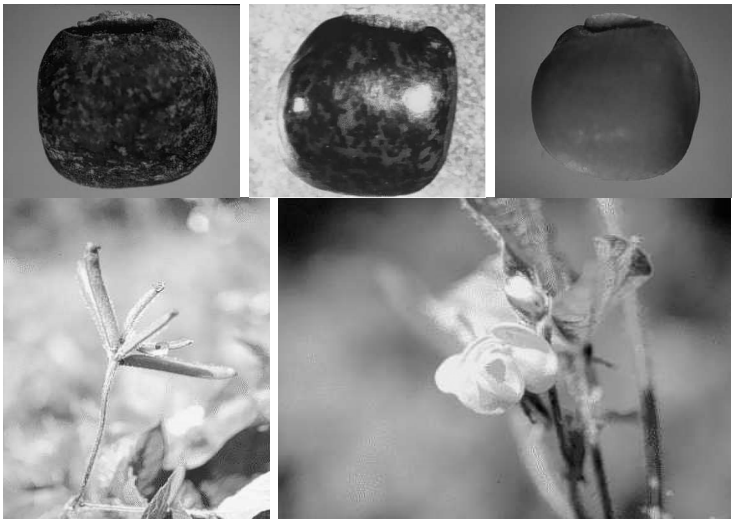


Photo III-3　Black gram (*Vigna mungo*)
source：NIAS Genebank・Illustrated legume genetic resources database
http://www.gene.affrc.go.jp/plant/image/legume.html

Overview

Black gram is closely related to the mungbean, and is thought to have originated in India. The largest merit of introduction of black gram into West Africa is its resistance to bean weevils. Although evaluation with African bean weevils has yet not been conducted, it was entirely resistant to *azuki* bean weevils (*Callosobruchus chinensis*) in Japan and Thailand and had the effect of delaying the growth of cowpea weevil (*C. maculatus*), whose larva took twice as long duration to become adults compared with cowpea (Tomooka, et al. 2000). In addition, black gram generally tends to be resistant to diseases and pests in comparison with mungbean. Although the growth period for black gram is slightly longer than that of early-maturing varieties of mungbean, it is still possible to harvest black gram in 80 to 90 days, which is the same as cowpea. Drought resistance has not yet been evaluated and it is necessary to study.

Black gram is used mainly in South Asia and is often eaten as bean soup (*dal*). They are imported exclusively from Thailand for bean sprout production in Japan. According to Japanese bean sprouts producing companies, black gram

sprouts are slightly harder than mungbean sprouts, and have an advantage of being more resistant to spoilage during transportation. It is possible to introduce black gram into West Africa and use in a similar way to cowpea. Compared with mungbean, black gram has the nutritional advantage of being higher methionine content, an essential amino acid. However, considering the smaller grain size compared with cowpea, it may give a lower price than large-grain cowpea in the markets in Benin. Although white cowpea seeds or Bambara groundnut seeds were traded at a better price in Benin, there are no white seeded varieties of black gram available. One possibility is to try to develop a market for bean sprouts in West Africa.

Although there are no international institutions conducting research on black gram, the The Asian Vegetable Research and Development Center (AVRDC), presently the World Vegetable Center, has its genetic resources. In addition, the Gene Bank at the National Institute of Agrobiological Sciences (NIAS) has abundant black gram genetic resources.

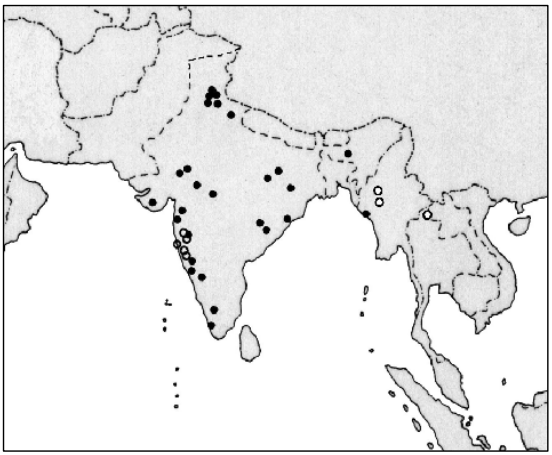


Fig. III-3-1 Distribution of wild black gram（*Vigna mungo* var. *silvestris*）
（source：Tomooka et al., 2002）

Although the distribution of wild black gram is almost entirely limited to India, its distribution has been confirmed in Myanmar and northern Thailand in recent years. Unlike mungbean traditional areas of cultivation of black gram are limited to South Asia.

Citations and Bibliography

1) Tomooka, N., K. Kashiwaba, D.A. Vaughan, M. Ishimoto and Y. Egawa. 2000. The

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2) Tomooka N., D.A. Vaughan, N. Maxted and H. Moss. 2002. The Asian *Vigna*. Genus *Vigna* subgenus *Ceratotropis* genetic resources. 270 pages. Kluwer Academic Press.

4. Rice Bean [*Vigna umbellata* (Thunb.) Ohwi & Ohashi]

English: Rice bean

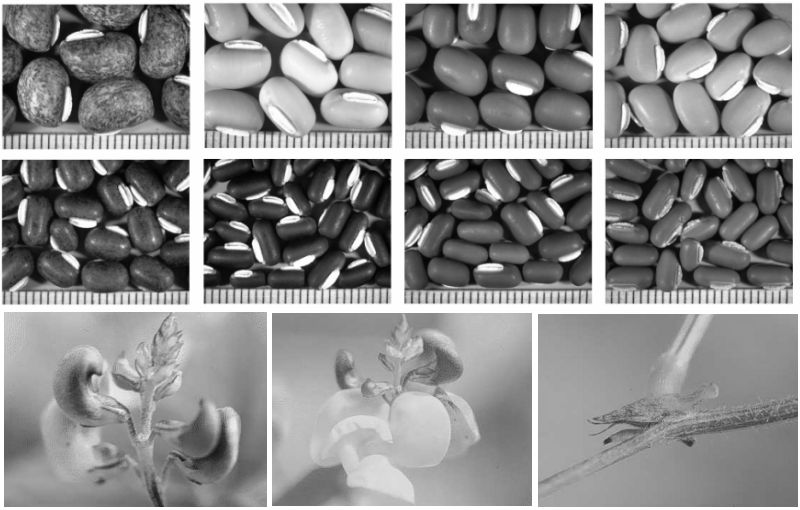

Photo III-4-1 Rice bean (*Vigna umbellata*)

source：NIAS Genebank・Illustrated legume genetic resources database
http://www.gene.affrc.go.jp/plant/image/legume.html

Overview

The rice bean is closely related to the azuki bean (*Vigna angularis*). This is the most important pulse crop in slash-and-burn fields throughout the mountainous regions of Southeast Asia. Rice beans appear to have been cultivated mainly in slash-and-burn fields until the 1950s, even in Japan (Noda, 1951). Although the cultivation of rice beans is rare in Japan at the present time, some are imported from Thailand and China and used as a substitute for azuki bean in making bean jam (paste) (Tomooka, 2005).

The merit for introducing rice bean to West Africa is that it is completely resistant to bean weevils (Tomooka et al., 2000, Kashiwaba et al., 2003, Somta et al., 2006). It shows almost complete resistance to *azuki* bean weevils (*Callosobruchus chinensis*) and cowpea weevils (*C. maculates*) which is a most serious problem in cowpea cultivation in West Africa. The level of damage from bean weevils is reported to differ depending on the variety, so resistance against bean weevils in West Africa should be tested. Rice bean has considerable resistance against other diseases and pests and their yield is also high. Rice bean is a creeping or climbing plant, and are usually mixed cropped with crops such as corn and millets by twining around the stems. Judging from

the habitat of wild species, rice bean appears to have a low resistance to drought. Most of the varieties are photoperiod-sensitive. Large-grain varieties tend to be late maturing. The weight of 100 seeds of the largest-sized rice bean seed is 37g.

Photo III-4-2　Rice bean mixed with corn.
Steamed young pods sold in a market of Chiang Rai, northern Thailand.

Rice bean is used in a similar way to cowpea. They can be used for bean jam, a thick sweat bean-meal soup or mixed with rice. In Southeast and East Asia, the young pods are steamed as shown in the photo and eaten like green vegetable soybean. In Laos, farmers also eat the young pods or flowers as fresh vegetables. Although there are no white seed varieties which color was traded at a higher price in Benin, there are various seed colors available in the germplasm. According to Thai farmers, rice bean tends to hinder the growth of other weeds.

The origin of rice bean appears to be the mountainous regions of Southeast Asia, based on the distribution of wild and cultivated rice bean and molecular diversity study (Tomooka, 2007).

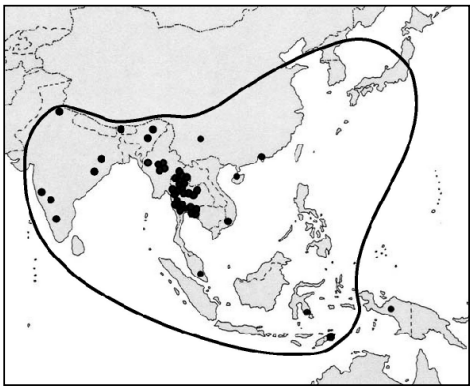

Fig. III-4-2 Traditional cultivation area（within line）of rice bean and collection sites of wild ancestral species（●）.

Citations and Bibliography

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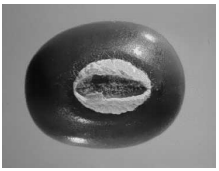
5. Winged Bean (*Psophocarpus tetragonolobus* (L.) DC.)

English: Winged bean





Tuberous roots of winged bean in Myanmar.

Photo III-5 Winged bean

Overview

The winged bean is a perennial, creeping or climbing herbaceous plant that has underground tuberous roots. There are two hypotheses with respect to the origin of winged bean. One hypothesis is that the origin is Africa based on comparative linguistics research. The other hypothesis is that the origin is tropical Asia. Winged beans are widely cultivated mainly from India to Southeast Asia, all of Malaysia and the humid highlands of New Guinea and New Caledonia. The flower is purple tinged with blue and the pod length is 15 to 30cm. The pod cross section is square, which gives its name "*shikaku-mame* (square bean)". The seeds are round and black, brown, yellow or white. Some seeds have mottles. The young pods, flowers and leaves are used as vegetables. The seeds contain as much protein as soybean. The root stock (rhizome) can be eaten raw or eaten after cooking in the same manner as potatoes. In Indonesia, the seeds are called *Botor*, where is utilized as remedy for pimples, conjunctivitis and pneumonia. Cultivation for the root stocks can be seen in the New Guinea Highlands and Shan State in Myanmar. On the other hand, the young leaves and pods are utilized as vegetables in home gardens in Southeast Asia. Even in Japan, winged bean have begun to be cultivated in Okinawa and Kyushu, JIRCAS bred an early-maturing variety "*Urizun*" suitable for

cultivation in Okinawa.

Citations and Bibliography

Mitsuru Hotta (editing representative), 1981, Useful Plants of the World, p.859, Heibonsha Limited, Publishing

Appendix

1. Overall Conditions in Benin

1) General Situation

(1) Area: 112,622km^2 (approximately 1.3 times the area of Japanese)

(2) Population: : 8.20 million persons (United Nations estimate, 2004), 2.6% of annual increase rate (2000 to 2005, %/year)

(3) Major Cities: Cotonou, pop. 690,600 (2005 estimate, hereinafter the same applies)
Porte-Novo (capital), pop. 234,000
Djougou, pop. 202,800
Parakou, pop. 163,800

(4) Climate: Tropical, dry zone in the north

(5) Language: French (official language), *Fon*, *Yoruba* and others

(6) Tribe: *Fon* and *Yoruba* tribes (south)
Aja tribe (Mono and Couffo river basins)
Bariba and *Peulh* tribes (north)
Somba tribe (Atacora mountain range, between Togo), etc. 46 tribes

(7) Religion: Traditional religion (65%), Christianity (20%), Islam (15%)

(8) Currency: FrCFA, 1 Euro ＝ 655.96FrCFA franc (official rate)

(9) Time: Greenwich Mean Time (GMT) 1-hour behind

(10) Holidays: January 1, January 10 (Vodoun Day), January 16 (Martyr's Day), April 1 (Youth Day), May 1 (May Day), August 1 (Independence Day), August 15 (Assumption Day), October 26 (Armaments Day), November 1 (All Saints' day), November 30 (Benin Day), December 25 (Christmas), other transitional holidays from the Christian and Muslim calendars (such as Tabaski, foreteller's birthday, Id al-Fitr, Easter, Ascension Day and Whit Monday)

2) Political System and Internal Affairs

(1) Regime: Republic institutions

(2) State Head: President Yayi Boni (5-year term of office, next election is March 2011)

(3) Parliament: National assembly (83 seats in total, 63 for the ruling party and 20 for the opposition party, 4-year term of office, next election is March 2007)

(4) Government: Ministry of Development, Economy and Finance (*Ministère du Développement, de l'Économie et des Finances*: MDEF), Ministry of African Integration and Benin External Affairs Delegate Charge of Minister of Foreign Affairs (*Ministère Délégué chargé de l'Intégration Africaine et des Béninois de l'Extérieur auprès du Ministre des Affaires Etrangères* : MDCIABE/MAE), Ministry of Tourism and Handicraft (*Ministère du Tourisme et de l'Artisanat* : MTA), Ministry of Environment and Natural Conservation (*Ministère de l'Environnement et de la Protection de la Natur*e:

MEPN), Ministry of Mining, Energy and Water Resources (*Ministère des Mines, de l'Energie et de l'Eau*: MMEE), Ministry of Micro Finance and Smaller Enterprises Promotion (*Ministre Délégué, Chargé de la Micro -finance et de la promotion des petites et moyennes entreprises auprès du Ministre du Développement, de l'Économie et des Finances*: MDCMFPP/MDEF), Ministry of Culture, of Youth, of the Sports and Leisure (*Ministère de la Culture, de la Jeunesse, des Sports et Loisirs*: MCJSL), Ministry of Health (*Ministère de la Santé*: *MS*), Ministry of Industry and Commerce (*Ministère de l'Industrie et du Commerce*: MIC), Ministry of Budget attached to Miniter of Development, Economy and Finance (*Ministère Délégué Chargé du Budget auprès du Ministre du Développement, de l'Économie et des Finances*: MDCB/MDEF), Ministry of Administrative and Institutional Reform (*Ministère de la Réforme Administrative et Institutionnelle*: MRAI), Ministry of Justice charged of the relations with the Institutions, Spokesman of the Government (*Ministère de la Justice chargé des relations avec les Institutions, Porte-parole du Gouvernement*: MJCRI-PPG), Ministry of Agriculture, Livestock and Fisheries (*Ministère de l'Agriculture, de l'Élevage et de la Pêche*: MAEP), Ministry Delegate Charge of the Communication and the New Technologies Delegate Charge of the President of Republic (*Ministère Délégué Chargé de la Communication et des Nouvelles Technologies auprès du Président de la République*: MDCCNT/PR), Ministry of Labor and Public Affairs (*Ministre du Travail et de la Fonction Publique*: MTFP), Ministry of Foreign Affairs *Ministère des Affaires Etrangères*: MAE), Ministry of National Land and Transportation attached to President (*Ministère Délégué chargé des Transports, des Travaux publics et de l'Urbanisme auprès du Président de la R*épublique: MDCTTP/PR), Ministry of Primary and Secondary Education (Ministère des Enseignements Primaire et Secondaire: MEPS), Ministry of Internal Affairs, Public Security and Local Governments (*Ministrère de l'Intérieur, de la Sécurité Publique et des Collectivités Locales*: MISPCL), Ministry of Family, Women and Children (*Ministère de la Famille , de la Femme et de l'Enfant*: MFFE), Ministry of Higher Education and Professional Training (*Ministère de l'Enseignement Supérieur et de la Formation Professionnelle*: MESFP), Ministry of National Defense (*Ministère de la Défense Nationale*: MDN)

(5) Internal Affairs: Since its independence, military coups have frequently occurred. President Kérékou assumed the premiership in 1972 and declared socialism in 1974 based on the Marxism-Leninism principles. Since then, although a stable political situation has been maintained through moderate and realistic policies, the Marxism-Leninism principles were abandoned in 1989 due the deteriorating economic conditions and turbulence in the Eastern Europe.

Soglo, who was a former World Bank official, was elected Prime Minister in March 1900. With the establishment of the Supreme Court and the Social and Economic Council in May 1994 and the Press Surveillance Committee in June 1993 and in May and July 1994, the development of democratic national institutions was completed. During presidential election in March 1996, President Kérékou was returned to power and continued to promote democratization and economic structural adjustment. At the presidential election in March 2001, President Kérékou was elected once again. During the parliamentary (national assembly) election held in March 2003, the president's party obtained a majority of seats. At the time of the presidential election in March 2005, Yayi Boni, former president of the African Development Bank, was elected. Since former presidents Kérékou and Soglo strictly observed the provisions of the Constitution, they did not represent the president in this election.

(6) Diplomacy: As a socialistic country, Benin had a close relationship with Eastern European nations. However, Marxism-Leninism principles were officially abandoned in 1989. In response to the recent democratization and liberalization in Africa, its relationship with advanced nations has been enhanced. Its economic relationship with Korea, a nation with which diplomatic relations did not previously exist, has rapidly developed, and diplomatic relations were established in September 1990. Relations with Thailand and Morocco have also been strengthened. Diplomatic relations were also established with Singapore, Brunei and Indonesia in 1994 and with Malaysia in January 1995. In addition, regional cooperation has been enhanced through the Consultative Council (*Conseil de l'Entente*) of the Economic Community of West African States (ECOWAS).

3) Economy

(1) Leading Industry: Agriculture (cotton, palm oil), services industry (port industry), ratio by industry in GDP is 36.0% in primary industry, 14.0% in secondary industry and 50.0% in tertiary industry either ratio as estimated by Bank of France in 2002))

(2) GNI: $3.7billion, $450 per capita, (2004, World Bank)

(3) Economic Growth Rate: 2.7% (2004, IMF)

(4) Inflation: 0.8% (2004, IMF))

(5) Total Trade: $555.6 million in export and $744.2 million in import (2003)

(6) Major Item (Unit: One billion FrCFA)

Item＼Year	1999	2000	2001	2002	2003*
Exports (FOB)	**259.5**	**279.4**	**273.9**	**312.1**	**322.8**
Cotton	113.4	101.6	93.1	95.6	95.8
Re-exported products	111.6	118.3	98.2	104.0	109.2
Imports (FOB)	**391.1**	**367.4**	**405.7**	**473.1**	**432.2**
Capital goods	79.6	61.2	72.1	71.1	78.7
petroleum products	32.0	56.7	55.0	63.3	71.9
Foods	91.7	84.5	86.3	120.1	123.8

Source: Banque de France (Bank of France) (*Estimation)

(7) Major Trade Partners (Unit: one million dollars)

	Country＼Year	1999	2000	2001	2002	2003
	China	3	1	1	16	62
Export	India	32	61	61	42	53
Destination	Thailand	11	7	9	13	20
	Ghana	-	5	15	13	17
	Niger	5	8	5	5	13
	China	43	30	47	46	518
Import	France	185	151	144	173	261
Origin	England	33	18	21	36	83
	Côte d'Ivoire	88	52	34	41	82
	Thailand	23	15	19	20	81

Source: Direction of Trade Statistics Yearbook, IMF

(8) Economic Overview: As primary industries account for approximately 50% of GDP and approximately 36% of the working population, 25% of the population is directly or indirectly engaged in the cotton industry, which accounts for 30% of the leading trade items. In June 1989, the 1st structural adjustment program was formulated with the receiving of aid from the World Bank and IMF in order to recover financial conditions which failed in the 1980s due to an increase in trade deficit and accumulated debts, etc. Subsequently, the 2nd and the 3rd structural adjustment programs came into effect respectively between 1992 and 1995 and from February 1996, and since then efforts for economic reform have been taken. As a poverty reduction strategy paper (PRSP) was approved in September 2002 and reached the completion stage in March 2003, so an external debt of $460 million could be saved. Aid-providing nations and organizations have highly evaluated this country.

4) Development Assistance Performance

(1) Japan Assistance Results

Yen loans (until FY2004, EN <change of notes> base) ¥75.31 billion

Grand aid cooperation (until FY2004, EN <change of notes> base) ¥24.696 billion

Technical cooperation (until FY2004, EN <change of notes> base) ¥23.6 billion

(2) Major ODA Results (Unit: $ 1 million, 2003)

Bilateral cooperation: Total (196.1), France (36.8), United States (32.5), German (31.3)

Multilateral: Total (97.5), IDA* (23.9), ADF** (7.3), EU (51.0)

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3) Government of Benin: http://www.gouv.bj/

* International Development Association (IDA)

** African Development Bank (AfDB)

2. Examples of Processed Foods Utilizing Major Pulse Crops

In Benin where the study was implemented at this time, in similar manner as with other African nations, traditional food processing techniques have been handed over and discharge a major role in the daily lives of local residents in urban areas as well as rural communities. Such techniques make it possible to store and process diversified farming products (such as grains, beans, oil seeds, root-vegetables or potatoes and livestock products). In this manner, the techniques enhance the value of products in a rural society and also hold an important position among skills thus greatly contributing to the food supply in urban or rural areas. Accordingly, the processing skills for pulse crops, which should be handed down for future generations, and the crop process (soy beans) recently introduced are taken up and introduced as follows.

1) Peanuts

(1) *Kluiklui*

Kluiklui is a fried snack made from strained peanut lees after the oil is extracted (Refer to Photo 1 in Frontispiece). To make 680 pieces of this snack, the following ingredients are necessary: ① 2kg peanuts without shells and ②200g salt. The cooking method is described below.

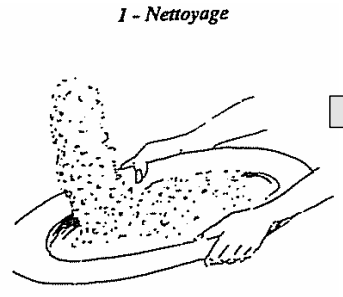

Fig. 1 Impurities are removed from peanut grains.

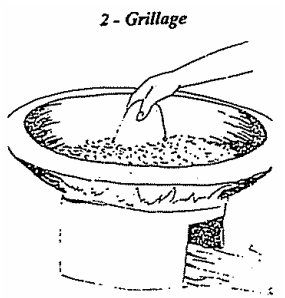

Fig. 2 Peanuts are lightly roasted in a fry pan-like tool.

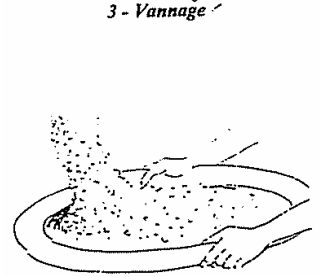

Fig. 3 Roasted peanuts are sifted to gradually remove the thin skins.

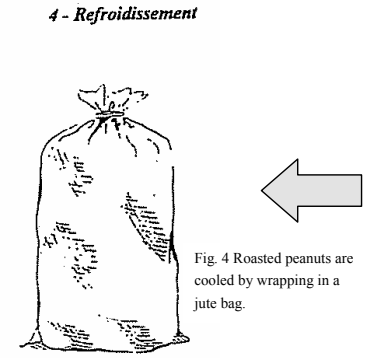

Fig. 4 Roasted peanuts are cooled by wrapping in a jute bag.

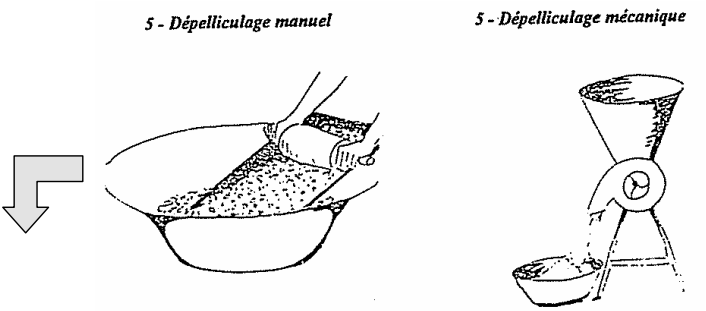

Fig. 5 Thin skins of the roasted peanuts are removed with a corn mill or wooden cooking bar while crushing.

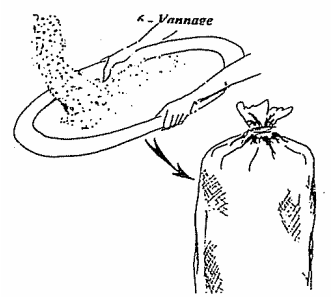

Fig. 6 After screening to remove thin skins, Skinless peanuts is wrapped in a jute bag.

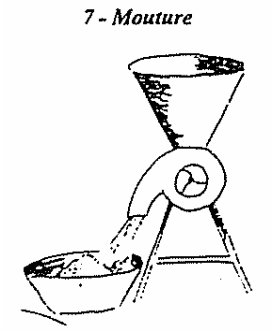

Fig. 7 Skinless peanuts are finely crushed.

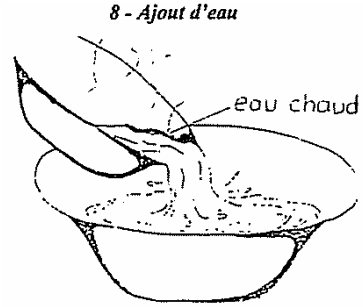

Fig. 8 4ℓ of lukewarm water of is gradually added to the dough.

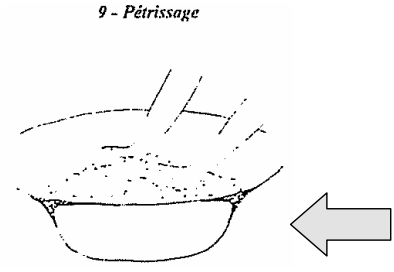

Fig. 9 Peanut dough is evenly kneaded by gradually adding water until hard ragged texture.

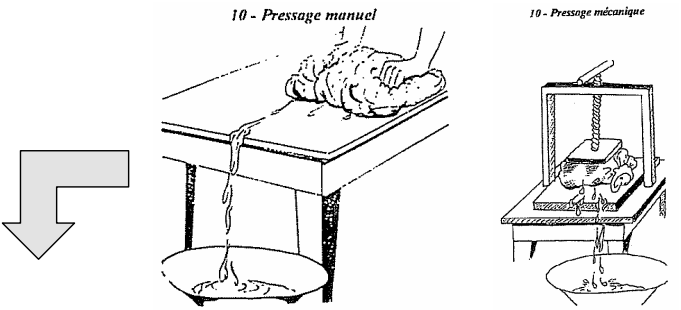

Fig. 10 Dough is strongly squeezed to extract oil onto the table (left) or similarly squeezed using a screw press.

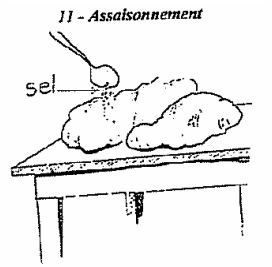

Fig. 11 Salt is added to squeeze dough.

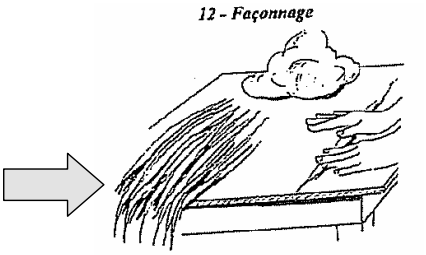

Fig. 12 Dough is formed into about 20-cm long bars.

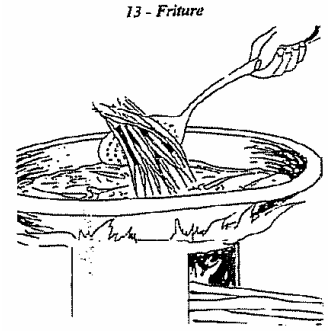

Fig.13 Bar-shaped peanuts are fried in extracted peanut oil for 5 to 10 minutes.

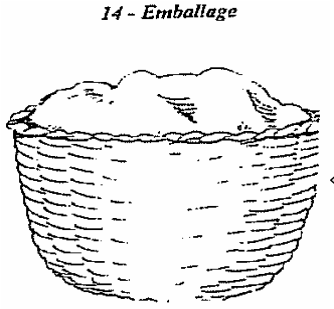

Fig. 14 After coking, the fried bar snacks are removed and placed into baskets lined with plastic and are wrapped and perfectly covered with cloth to prevent moisture from getting in.

Fig. 15 The fried snack is called *kluiklui* and is eaten as is as a side dish for *gari*.

(2) *Tasso*

Tasso is a product made of roasted peanuts heated in sand or ash and dried. It is called *Tasso* or *Azin-sisso* in the *Fon* language or *Azin-toto* in the *Mina* language. The ingredients are ① 2kg peanuts without shells and ②200g salt. The cooking method is described below. (The time required is about one hour and a half.)

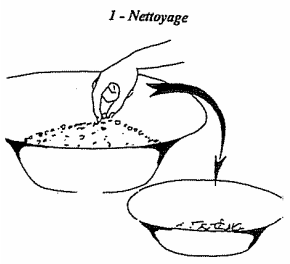

Fig. 1 Impurities are removed from peanut grains.

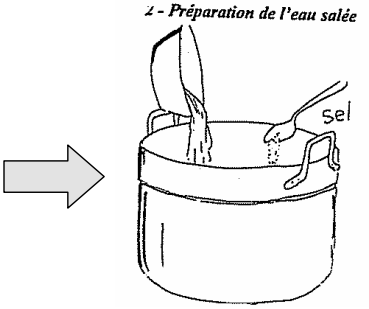

Fig. 2 Salt 200g is added to 2ℓ of water.

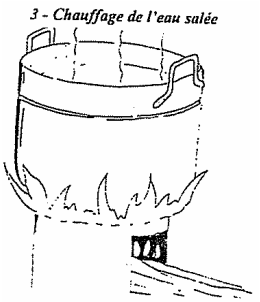

Fig. 3 Salt water is boiled.

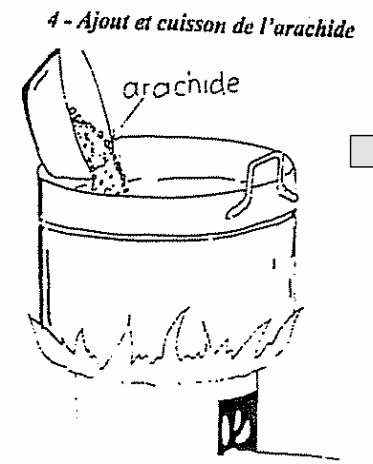

Fig. 4 Peanuts are put in boiling water and boiled for 3 to 5 minutes.

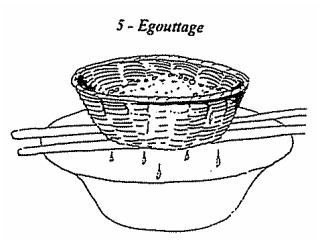

Fig. 5 Peanuts are drained.

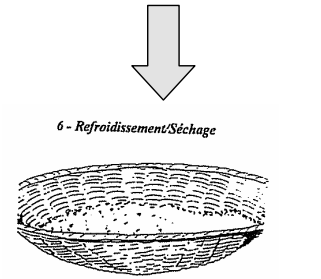

Fig. 6 Drained peanuts are spread out onto a basket and dried.

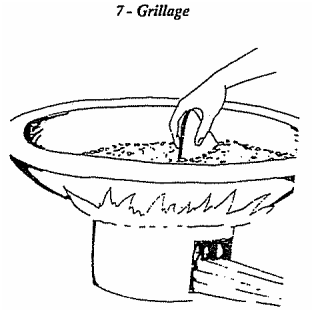

Fig. 7 Peanuts are roasted in a fry pan using sand or vegetable ash.

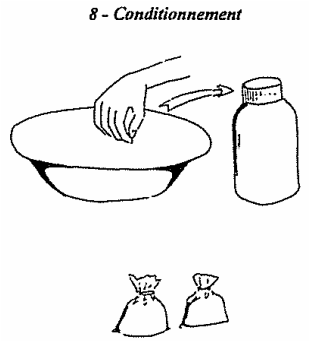

Fig. 8 Roasted peanuts are quickly stuffed by jar or plastic bag.

Fig. 9 *Tasso* is eaten as a side dish with alcohol, as it is, or mixed into boiled or grilled corn. In the same manner, it is eaten with fermented porridge or *gari*.

2) Cowpeas

(1) *Abobo*

This is a food in which cowpeas are oiled and seasoned (Refer to Photo 3 in Frontispiece). The ingredients for 5 persons are ①1 kg white cowpeas, ② 10g red pepper, ③ 5g pepper, ④ 5g garlic and ⑤15g salt. The cooking method is described below (The required time is about 1 to 2 hours).

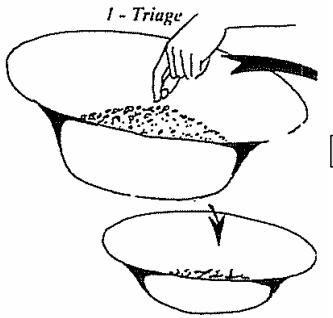

Fig. 1 Cowpea grains are screened.

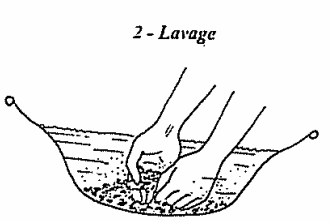

Fig. 2 Cowpea grains are washed.

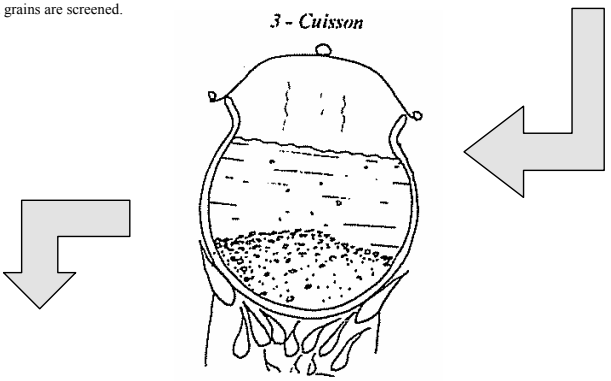

Fig.3 Cowpeas are boiled with 3-times the amount of water for 1 hour.

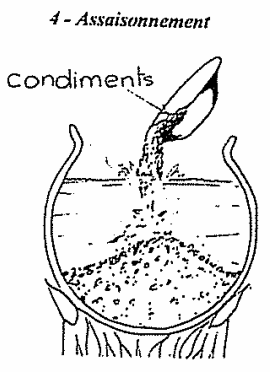

Fig. 4 Cowpeas are seasoned with pounded spices (garlic, pepper and red pepper).

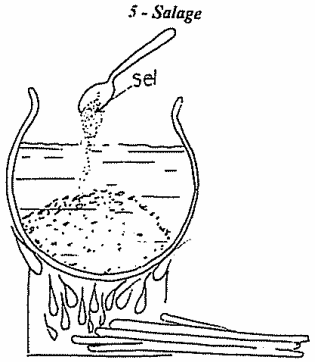

Fig. 5 Slat is added and cowpeas are brought to a simmer and boiled for a few minutes.

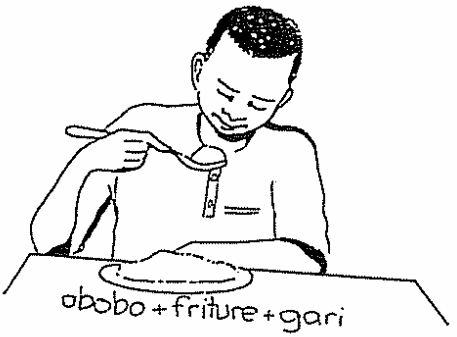

Fig. 6 *Abobo* can be eaten at any time of the day. Here it is being served as a side dish with fried-dish *gari* (cooked with tomatoes, onions, garlic, smoked shrimp and salt, or simply cooked with palm oil, peanuts oil or coconut oil), bread, boiled cassava or yam.

(2) *Magni-magni*

Magni-magni is called *Nago* in the *Yoruba* language or *Olélé* in the *Fon* language, and is a paste made from seasoned cowpea powder. The ingredients for 5 persons are ①1kg cowpeas, ② 35g smoked shrimp, ③ 140g onions, ④ 30g ginger, ⑤ 35g red pepper, ⑥ 35g salt, ⑦ 375mℓ palm oil, and ⑧ banana leaves. The cooking method is described below (The required time is 3 to 4 hours).

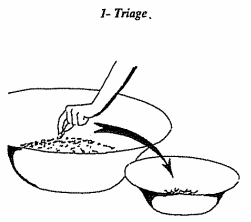

Fig. 1 Cowpea grains are screened.

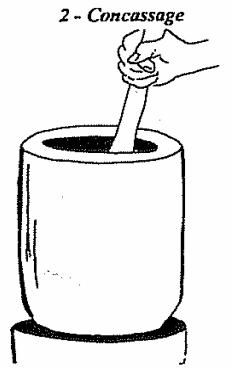

Fig. 2 Small amount of water is added to cowpeas and mixture is crush finely with a mortar.

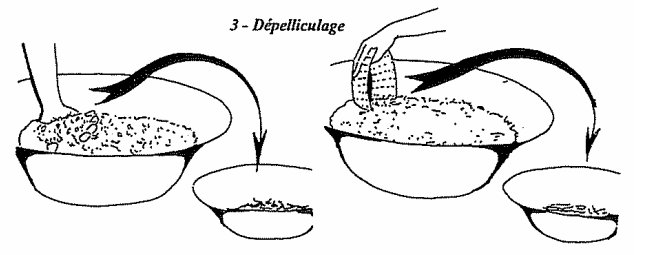

Fig. 3 Water is added to the finely crushed cowpeas. Thin skins float to the top and are removed by hand or with a strainer.

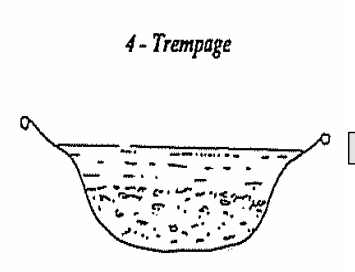

Fig. 4 To soften, cowpeas are soaked in water for about 30 minutes.

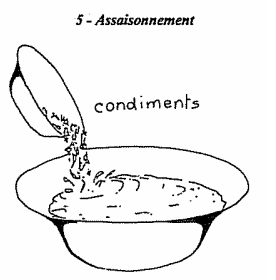

Fig. 5 Spices (onions, smoked shrimp, ginger and red pepper) are added whole.

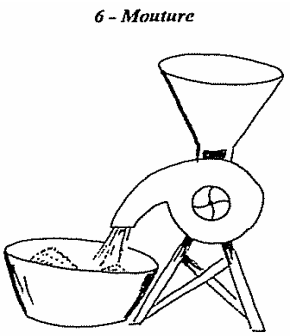

Fig.6 Cowpeas are milled together.

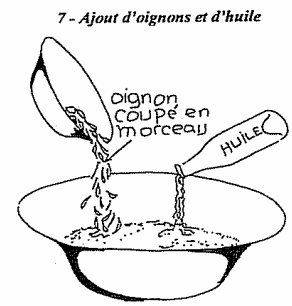

Fig. 7 Small-sized cut onions and palm oil are added to the milled powder.

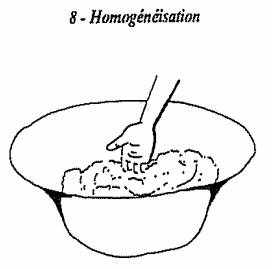

Fig. 8 Mixed well.

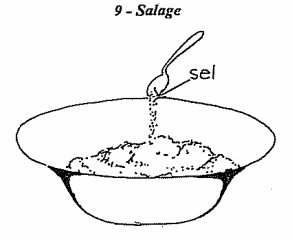

Fig. 9 Salt is added to freshly prepared paste.

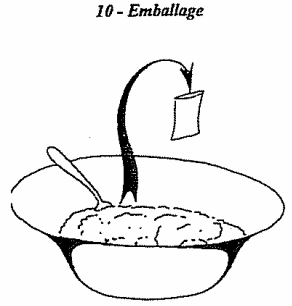

Fig. 10 About 85g of paste is wrapped in a banana leaf.

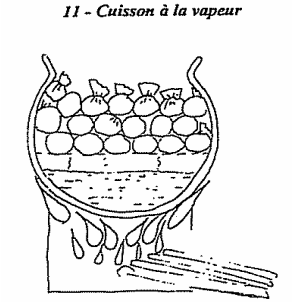

Fig. 11 *Magni-magni* dough is steamed for 1 hour.

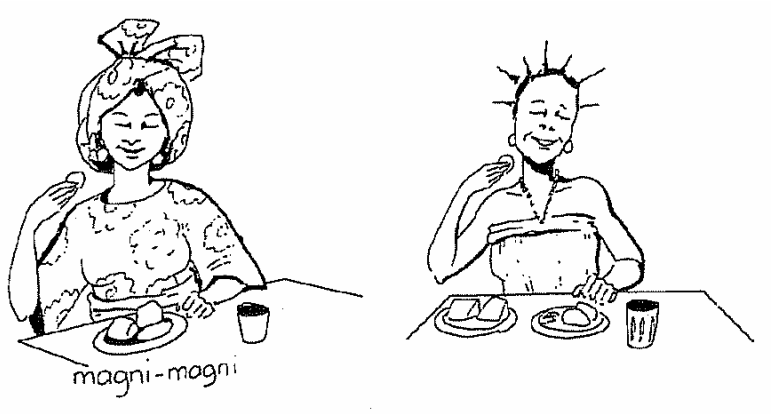

Fig. 12 *Magni-magni* is usually eaten as a lunch time snack, as it is, or with other dishes.

3) Soybeans

(1) Soy cheese (*Tofu*)

Over the past few years, soybeans have been promoted for their nutritional value, mainly for children at nutrition improvement centers in cooperation with NGOs or UNICEF and are consumed as processed food such as soybean milk, powder (*kinako*-like) or tofu. In Ina in the north, many women can be seen making *tofu* in their gardens. The method for making tofu is described as follows.

Photo 1 Soybeans are soaked in water for a few

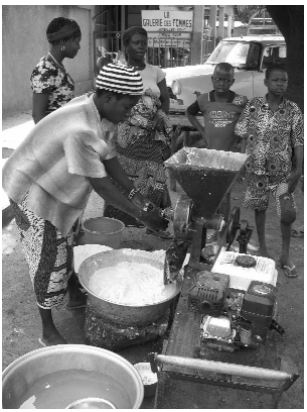

Photo 2 Soybeans are milled with a mill with an external engine. @100FrCFA/3kg。

Photo 3 Cooled boiled water is added to soybeans.

Photo 4 Soybeans are strained into large pots (40ℓ). (Soy milk and lees are separated)

Photo 5 Strained lees.

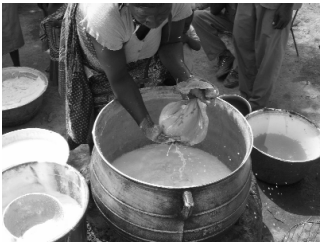

Photo 6 This operation is repeated.

Photo 7 After straining is complete; fire is applied to the oven.

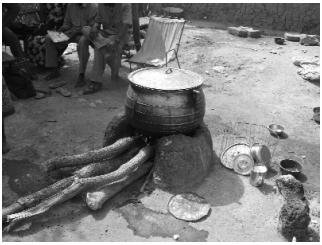

Photo 8 Boiling with the lid covered. (About 1 hour)

Photo 9 Remove the lid and remove the lye.

Photo 10 Still soybean milk remains. Boiled soybean milk is then subdivided (20ℓ pots).

Photo 11 Remaining soybean milk is added to large pots and boiled again.

Photo 12 A fermenting liquid called corn starches (left corner) is added to promote coagulation.

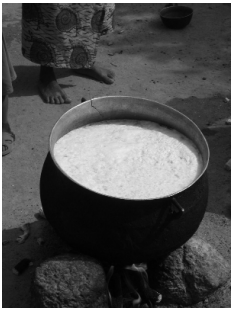

Photo 13 Soybean milk begins to Coagulate.

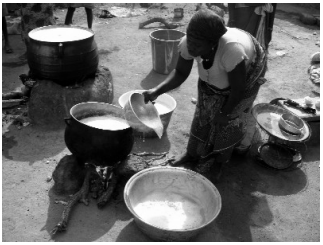

Photo 14 Excess water is removed. This is utilized as the next coagulant.

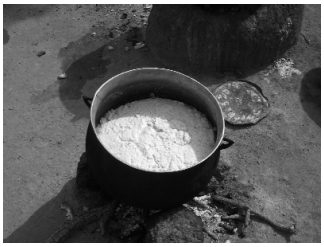

Photo 15 Coagulation is almost complete.

Photo 16 A pinch of salt, stir slightly.

Photo 18 It is transferred to a grain bag for dehydrating.

Photo 17 The bag is squeezed on a stone.

Photo 19 Sorghum stems are soaked for coloring, dehydrated *tofu* is removed and divided into large pieces (left corner).

Photo 20 *Tofu* is dyed a red color.

Photo 21 Although visibly unappetizing, the taste of tofu is preserved. In areas where there are no refrigerators, preservation the red coloring improves preservation.

(2) Bean curd (for livestock feed)

Bean curd lees remain following the above-mentioned operation and are an important livestock feed, especially in the north where livestock is common.

Photo 1 As above in Photo 4, soybeans is strained in a large pot (40ℓ) (divide soybean milk and bean curd lees).

Photo 2 Strained bean curd lees

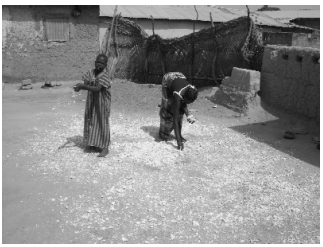

Photo 3 Strained bean curd lees are dried for livestock feed.

Photo 4 Bean curd lees are sold to livestock farmers in the north for livestock feed.

4) Néré

○ *Afitin*

Afitin is a mustard product * as Néré (Refer to Photo 5 in Frontispiece) and is a primary ingredient and traditional solid seasoning utilized for sauces (sticky sauce, vegetables or leaf sauces, etc.) or *Moyo* (tomato and onion salad). The ingredients for a portion of 4.5kg *Afitin* are ① 1 kg *Néré* seed and ② 250g salt. Its preparation method is described below (Required time is 2 to 3 days).

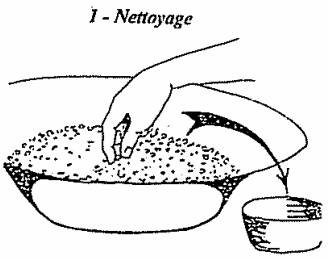

Fig. 1 Impurities and other objects are removed from seed.

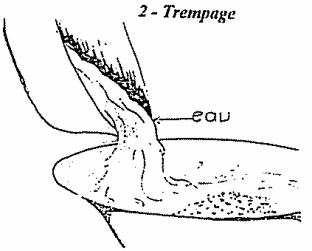

Fig. 2 Seeds are soaked in 20ℓ of water.

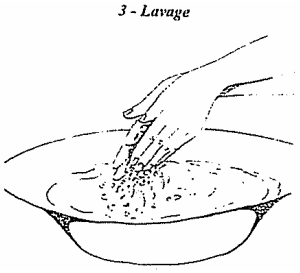

Fig. 3 Carefully washes seeds.

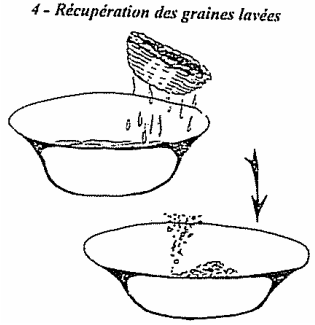

Fig. 4 Dirt discharged by washing is removed.

* Although it is called mustard in French, it is actually a fermented seasoning.

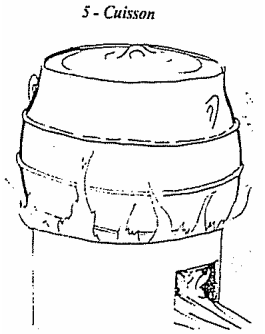

Fig. 5 Seeds are boiled with a considerable amount of water until they become softer. When the thin skins can be easily removed or broken the fire extinguished.

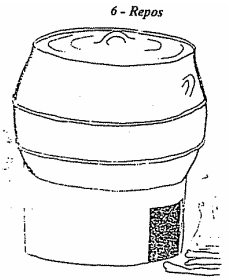

Fig. 6 For easily removal of skins, boiled seeds is placed on an oven for 4 to 8 hours.

Fig. 7 Seeds are removed from boiling water and transferred to a bowl for pealing.

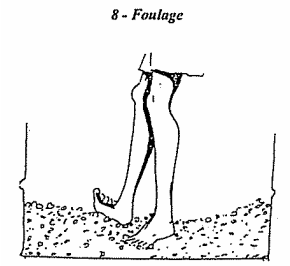

Fig. 8 Seeds are stepped on until threshed and skins are removed.

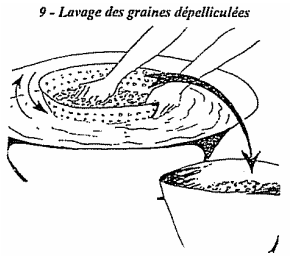

Fig. 9 Pealed-skin seeds are washed with water in a basket. Grains are transferred to a net.

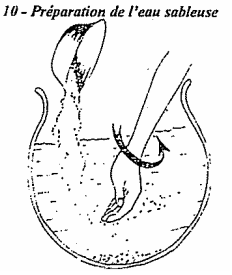

Fig. 10 Fine 500g sand is paced in a pot to boil the seeds. Water is filled to 2/3 of the pot.

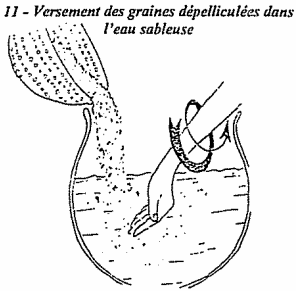

Fig. 11 Skin-stripped seeds are poured into sandy water and stirred in one direction. Any skins or uncooked seeds appearing on the bottom should be removed.

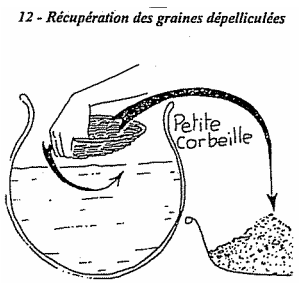

Fig. 12 Seeds that float to the surface are collected with a basket.

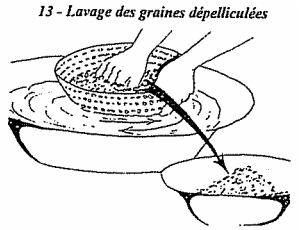

Fig. 13 Seed are washed in water to remove the sand.

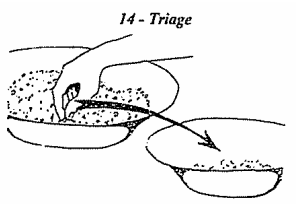

Fig. 14 Irregular seeds such as seeds with skins or seed skins are removed.

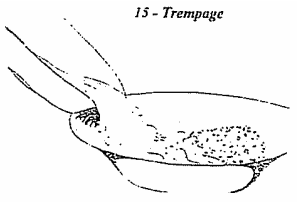

Fig. 15 Washed seeds are soaked in water for about 1 hour.

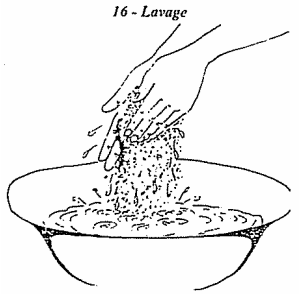

Fig. 16 Seed are washed in water to remove moss-like slime that forms when soaking in water.

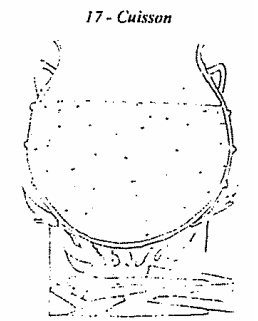

Fig. 17 Seeds are boiled in water covered for 30 minutes.

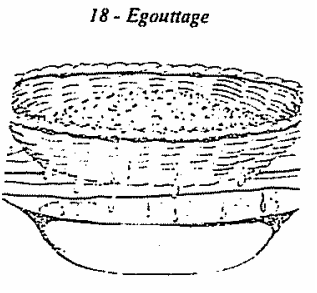

Fig. 18 Boiled seeds are transferred to a basket to strain the water.

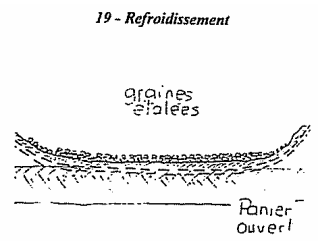

Fig. 19 Boiled seeds are spread onto a jute bag on an open basket.

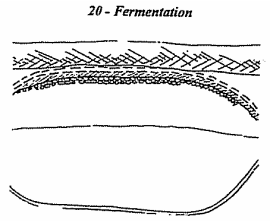

Fig. 20 Seeds are placed into a wash tub and covered with a jute bag or cloth for fermentation for about 12 hours.

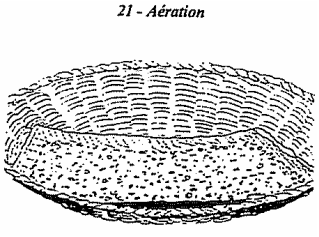

Fig. 21 Fermented products are air-dried for 4 to 8 hours. This operation improves the flavor.

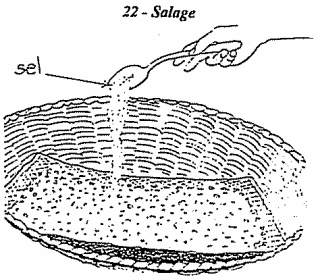

Fig. 22 250g salt is added to promote a good consistency.

Fig. 23 The fermented product is milled in a stationary miller and the dough is called *Afitin*.

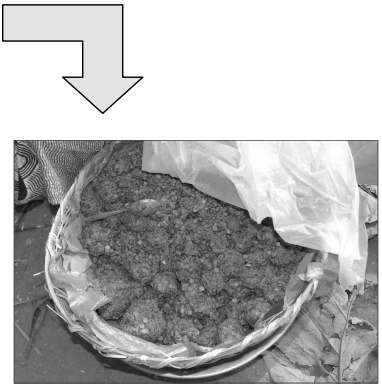

Photo. *Afitin* at a market in Benin.

Source: D.J. HOUNHOUIGAN, M.C.NAGO, J.MONHOUANOU, M.EGOUNLETY, LA TRANSFORMATION ALIMENTAIRE TRADITIONELLE DES LEGUMINEUSES ET OLEAGINEUX AU BENIN, Les Publications du CERNA, 1998.

3. List of Collected Materials

Materials collected in a field survey implemented in Benin in December 2006 are listed as follows. (Non-bound materials such as copies are omitted)

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11) GUIDE PRATIQUE D'ELEVAGE, Aulacodes, CENTRE SONGHAI, 2000.
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13) GUIDE PRATIQUE D'ELEVAGE, ESCARGOTS, CENTRE SONGHAI, 2001.
14) GUIDE PRATIQUE, JARDINAGE BIOLOGIQUE, CENTRE SONGHAI, 2001.
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16) GUIDE PRATIQUE D'ELEVAGE, OIES ET CANARDS, CENTRE SONGHAI, 2001.
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18) GUIDE PRATIQUE D'ELEVAGE, PINTADES, CENTRE SONGHAI, 2001.
19) GUIDE PRATIQUE, PHARMACOPEE VETERINAIRE, CENTRE SONGHAI, 2002.
20) GUIDE PRATIQUE D'ELEVAGE, PISCICULTURE, CENTRE SONGHAI, 2001.
21) GUIDE PRATIQUE D'ELEVAGE, PORCS, CENTRE SONGHAI, 2000.
22) GUIDE PRATIQUE D'ELEVAGE, POULETS DE CHAIR, CENTRE SONGHAI,

2002.
23) GUIDE PRATIQUE D'ELEVAGE, POULES PONDEUSES, CENTRE SONGHAI, 2002.
24) Alex G. ZOFFOUN et Col., Manuel d'aviculture à l'usage des pisciculteurs pour des élevages associés (cas des poules pondeuses), CARDER-MONO, Ministère de l'Agriculre, de l'Elevage et de la Pêche, REPUBLIQUE DU BENIN, 2003.
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