Minor cereals in Niger
—Focusing on Pearl millet and Sorghum—

JAICAF
Japan Association for
International Collaboration of
Agriculture and Forestry

March, 2009
Cover Page: Threshing and winnowing by women (Photograph by Nobuyuki KURAUCHI).
Preface

Many developing countries are situated in the tropics or the subtropics, and they are exposed to severe natural, social and economic environments, so the level of crop production in these areas is generally low and unstable.

Under these circumstances, these counties are faced with the challenge of increasing food production while struggling against population problem and poverty, etc.

In an effort to address these issues, the technologies developed in advanced nations located in the temperate zone mostly cannot be adopted without modifications.

Therefore, it is necessary to conduct an investigation on the technologies which are applicable to these regions and also to fully understand the peculiarity of the terrain and social conditions of these areas. These activities are needed and are also often requested when it comes to agricultural cooperation in developing countries. As part of our studies and research project, this Association has been conducting investigations on tropical agricultural technologies and has published on two volumes of “Tropical Agriculture Series” and “Tropical Crops Handbook”.

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 Niger (hereinafter referred to as “Niger”) in order to examine the potential of new subsistence crops. Although Major food crops in Africa are tubers (cassava, yam), grains (pearl millet, sorghum, maize and rice), plantain and bananas, etc, people in Niger mostly rely on grains such as pearl millet and sorghum. As these crops are so important in Niger, we took up this country to survey.

In the preparation of this Report, a study team was dispatched to Niger in order to obtain more accurate, up-to-date information. At the same time, the Japanese Technical
Committee established within the Association (chaired by Dr. Osamu ITO) examined the context from a technical point of view. This committee also took the lead writing this report. Once again, I would like to express my gratitude to the members of the Technical Committee for their valuable contribution.

In addition, we drew up “Agricultural and forestry projects in Niger “in installments dissertating by containing wider information of agricultural and forestry projects in Niger. Please refer to this number as well.

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

March, 2009

Hisao AZUMA, President
Japan Association for International Collaboration of Agriculture and Forestry
“Study on Subsistence Crops”
of the Basic Data Improvement Project for Supporting Developing Countries

Members of the Technical Committee

Chukichi KANEDA (Dr)\textsuperscript{1,2}
Technical Adviser, Japan Association for International Collaboration of Agriculture and Forestry (JAICAF).

Kenji HIMENO\textsuperscript{2}
Deputy General Manager, Grain Dept., Marubeni, Co. LTD.

Kimio OSUGA
Principal Engineer, Rural Development Planning Division, Japan International Research Center for Agricultural Sciences (JIRCAS).

Koichi SASADATE
Deputy Director General, Secretariat of Japan Overseas Cooperation Volunteers (JOCV), Japan International Cooperation Agency (JICA).

Naoto INOUE (Dr)\textsuperscript{1,2}
Professor, Department of Agriculture, Shinshu University.

Nobuyuki KURAUCHI (Dr)\textsuperscript{1,2}
Associate Professor, College of Bioresources sciences, Nihon University.

Nozomi UI
Program Officer, Rural Development Department, JICA.

Osamu ITO (Dr.)\textsuperscript{2}
Director, Crop Production & Environment Division, JIRCAS.

Yoshiaki NiSHIKAWA (Dr.)\textsuperscript{2}
Professor, Graduate School of International Development, Nagoya University.

Yuichi SEKIYA (Dr)\textsuperscript{1}
Associate Professor, Aoyama Gakuin Women’s Junior College.

Note: Order of the alphabets
Chairperson indicated by ○
\textsuperscript{1} Dispatched mission members
\textsuperscript{2} Authors
Field Survey Team in Niger

Chukichi KANEDA (Dr)
Katsuyuki YAMAMOTO
  Assistant Director of 2nd Operations Department, JAICAF
Naoto INOUE (Dr)
Nobuyuki KURAUCHI (Dr)
Tetsu KURAOKA
  Vegetable Growing Expert, Ex-JOCV Volunteers
Yuichi SEKIYA (Dr)
Yuzo KOBAYASHI
  Assistant Director of 2nd Operations Department, JAICAF

Introduction of Authors

Kenji HIMENO
Field: International Farm Products Circulation / Trade Trend
Part: Chapter VI

Naoto INOUE (Dr)
Field: Agronomy, Maize Breeding
Part: Chapter III and IV (Edible grass weeds)

Nobuyuki KURAUCHI (Dr)
Field: Crop science, Plant breeding
Part: Chapter II and IV (Fonio)

Osamu ITO (Dr.)
Field: Plant nutrition / Physiology
Part: Preface

Yoshiaki NISHIKAWA (Dr.)
Field: Development Administration and Rural Development
Part: Chapter V

Yuzo KOBAYASHI
Part: Chapter I
Photo 1: Grains sold in market (Niamey).

Photo 2: Pearl millet and sorghum treated by retailer in wayside (Niamey).

Photo 3: Warehouse (Sadoré).

Photo 4: Pearl millet in farmer’s field (Kollo).

Photo 5: Youngman showing wild Fonio (Kollo).

Photo 6: Women threshing pearl millet.
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Introduction

This book is published as a report based on studies and research targeting Niger, as a part of basic information gathering project, “Research on Crops for Self-sufficiency” for developing countries. According to the Agroecological zone report by FAO, many of the regions under agricultural activity in Niger are situated in the semi-arid tropics and its possible cropping period is 75-120 days, and the average monthly temperature is over 18°C throughout the year. From a worldwide view, 55 countries are categorized as semi-arid tropics, and accommodate 1.4 billion people. 40% of them are the poor who earn less than 1 dollar per day and 70% of them dwell in rural areas. The mean annual rainfall in this area is 500-700 mm which is very low and it may be no exaggeration to classify this is a marginal area to practice agriculture directly depending upon rain water. Besides, yearly change of rainfall is very large and the region is prone to drought. Cereal crops such as drought-resistant pearl millet and sorghum are widely cultivated as staple diet. However, for many cases, its level of crop yield stays low (less than 1t/ha) because of its forced condition of the cultivating system with few agricultural input on low-fertile sandy soil widely distributed. The need for agricultural development and extension in this area should not only focus on increasing yield, but also target the stabilization of yield.

The Niger government considers rural development as a main means of reducing poverty, thus has formulated Strategy for Rural Development (SDR) as an acting program for achieving this objective. It was adopted on November 14, 2003. The objective of SDR is to reduce poverty in the various regions from 66% to 52% by the year 2015 through the promotion of sustainable natural resource management, food safety and security, and socio-economic development. SDR aims at integrated rural development through the “expansion of products”, “maintenance of self-sufficiency in food production”, “risk reduction”, “improvement in the organizational efficiency of
producers” and “the supply of public materials”, etc. Among these, more emphasis is to be placed on the direction of rural development based on producer organizations and not the current Government-driven approach. There are various authorities related to rural development to be gradually transferred to regional or producer’s level. Decision making related to natural resource management like land and water is conducted nearer to production site and indicates a direction modified to be able to act promptly which answers the needs. Against this background, international organizations have initiated a move with suggestions and verifications of systems aimed at increasing yield by applying fertilizer by temporarily keeping the harvest in a simple storage facility and making profit by selling the product when prices are high (warantage), and use the money to purchase fertilizer, and a technology to make a biggest efficiency from the least (micro doze).

From the above, although agriculture in Niger inevitably takes place under harsh environmental conditions, a medium to long–term development strategy has been formulated, and measures based on this strategy are in the implement stage. However, there is the need for continuous assistance from developed nations in order for Niger to develop in the future. There is a suggestion on how aid programs should be implemented by following a national strategy at the end of this Report, which could serve as a reference as well. This will be helpful in understanding the future direction of agricultural development in Niger based on pearl millet and sorghum as staple food crops.
Chapter I  Agriculture overview of Niger and demand trends of cereals

1. Agriculture overview of Niger

1-1  Topography

The Republic of Niger (hereinafter referred to as “Niger”) has a total land area of roughly 1,267,000 km² (about 3.4 times the size of Japan). It is a large landlocked country and lies between longitude 0° to 16° E and latitude 11° to 24° N. It shares borders with Chad, to the east, Libya and Algeria to the north, Mali to the west and Burkina Faso, Nigeria and Benin to the south. Overall, it is relatively flat and has a peneplain (elevation 200 m - 300 m) stretching from the western region which has the Sahara desert (covering two thirds of the country) to the Chad basin. However, the elevation reaches as high as 1,000 m in the north eastern region bordering on Chad and Libya.

The main topography has been classified as follows (Fig.I.1)

① Liptako region

It is located on the right bank of Niger River and it is a rocky low plateau. The northern area is covered by sand dunes while the south is surrounded by rock debris.

② Zarmaganda region

It is a plateau with an elevation at 250 - 300 m on the left bank of the Niger River, and traversed by gigantic and fertile fossil valleys like Bosso, Maouri, etc.

③ Ader Doutchi and Majia region

It lies to the east of Zarmaganda region, consisting of a fairly high rocky plateau with an elevation from 400 to 600 m traversed by several large wadis1 like Majia.

④ Goulbi

It lies to the east of Ader Doutchi, consisting of a vast plain of sand dunes, is fertile

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1 Wadi: a valley found in arid climate where water flows only during the rainy season (valley with a dry watercourse), derived from an Arabic word “wadi”.

and traversed by shallow wadis.

⑤ Eastern hilly region

It lies to the east of Goulbi region, scattered with many isolated hills with an elevation at around 500 m such as Damagaram, Mounio and Koutous, all covered with sand.

⑥ Talak, Azawak and Tegama region

A vast plateau of rock debris with an elevation at 400 - 500 m, lying to the north of above-mentioned regions ③ - ⑤, mostly covered with sand. In the region, there are the Ighazer plateau of clayey soil and several escarpments like Tighijid. The region is traversed by a gigantic fossil valley of Azawak extending from the massif of Aïr.

⑦ Massif of Aïr

An extension of the Ahggard mountain land of Algeria, branching out to the south from it, stretching for 400 km north and south and 250 km east and west with the total area of 80,000 km². There are many high mountain peaks with an elevation exceeding 1,500 m, including Idoukâl-en-Taghès (the highest mountain in Nijer with an altitude of 2,030 m) in the mountain range of Bagzane, interspersed with several oases such as Iferouâne and Timia.

⑧ Manga region

A vast sandy area to the east of Damagaram which has the lake Chad, but the sand dunes are fixed with vegetation, and the whole area is dotted with lowlands with clayey soil. Lake Chad is a shallow lake in the basin formed by tectonic bending, and its size is rapidly shrinking recently due to such factors as large scale-irrigation projects in the surrounding countries, the demographic migration from Nigeria and the geographic situation making it a frontline area of desertification as well as owing to the problem of overgrazing.

⑨ Ténéré

A large area of moving sand dunes stretching to the east of the Massif of Aïr, dotted with several oases including Bilma, Fachi and Termit, all lying at the foot of isolated
escarpments and salt is produced in Bilma and Fachi.

Djado, Manguéni and Tchigaï region

This region consists of a rocky plateau with an elevation of 800 to 1,000 m, having steep escarpments. An oasis is found in Djado.

Fig.I.1  Topography in Niger
Source: ATLAS DE L’AFRIQUE, 2000
1-2 Water availability

The Niger River (total length of 4,180 km) which is the 13th longest watercourse in the world and the third in Africa, traverses Niger and passes along its south-western side in the direction of south-east for the distance about 550 km, running from Mali, on the border with Benin and then to Nigeria. It is for Niger the only river which does not run dry throughout the year. Incidentally, the water source of the Niger River mostly originates from the rainfalls during the rainy season in the Guinea highlands and those in Mali in the middle courses.

Although tributaries on the right bank of the Niger River like Sirba as well the Komadougou Yobé River which flows into Lake Chad dry up only for several months in the year, the wadis, including Ighazer originating from the Massif of Aïr and Goulbin Maradi flowing into the Sokoto River, see water flow only for a few days after rainfall, and in the extreme cases of Dallol Bosso and Dallol Maouri, they are called fossil valleys where nowadays no water is seen flowing at all.

In the 1960s, the aforementioned Lake Chad used to have the surface area of 26,000 km² (the 12th largest in the world at that time) and the water depth of 7 m, already a shallow lake then, but it lost by the 1990s 45 % of its surface area Two times in the past, 1908 and 1984, it dried up completely and the current average depth is 1.5 m. As a result of these droughts, all the lake surface area within the territory of Niger has been lost, and therefore it is no more a lake on which Niger can depend for the supply of water. Incidentally, a certain number of marshes which are permanently present or more or less remain after rains, including Madarounfa and Keita, are benefiting humans and animals as the open water sources.

For Niger the ground water provides a valuable and rich water source. People exploit either the water which originates from the rains in recent years and has been confined in the aquifer of impermeable strata at a relatively shallow depth or the fossil water which, having been accumulated in the aquifer of relatively deep impermeable strata, is abundant but cannot be recharged, by means of artesian wells (self flowing wells) or
wells of bored holes. While in the wadis located in the eastern regions and the north-western regions including Manga and Agadez, a number of artesian wells are found, the depth of wells varies greatly depending on locations and in certain cases it goes as deep as 1,000 m.

1-3 Geology

While the crystalline basement rock is distributed in the wide valley of the Niger River flowing in the south-western part of Niger, the regions lying to the east of it incline gently and are overlaid with sandstone deposited for a long period of time. The Aïr Massif in the northern part of the central Niger is principally composed of the Precambrian gneiss and granite, accompanied by the lava, tuff, and volcanic ash of the Cenozoic era. Moreover, the Massif is a very old anticline zone with the axis running north and south and dividing several basins one of which is the Oulliminden Basin that adjoins the crystalline schist of the Precambrian era of the Aïr Massif in the east and the crystalline massif of Hoggar in the north and the west. Furthermore, to the east of the Aïr Massif the present day sand covers Cenozoic sediments, and the Djad highlands in the extreme northeast of the country are composed of the terrestrial sedimentary rock strata of the Carboniferous, the Triassic, and the early Cretaceous.

Incidentally, volcanic activities took place in the periods from the Devonian to the Jurassic and the tuff materials were accumulated simultaneously with other deposits. Among such deposits, certain carbonaceous materials like lime are found, and the circumstances are favorable to endow Niger with the deposits of uranium ore. In fact, the mineralization of uranium has been found in the Carboniferous sandstone and in the reddish strata of the Permian and the Cretaceous.
1-4 Climate and vegetation

Niger lies to the south of the tropic of Cancer, belonging to the zone where the boundary line of the tropical climate passes, and can be cited as one of the hottest areas on earth. While the northern Niger is an extremely dry desert zone (about two thirds of the country) with the annual rainfall approaching as low as 0 mm, the precipitation amounts to as much as 800 mm in the southwestern part. According to the rainfall situation like this, the climate zones of Niger can be classified roughly into the
following categories (Fig. I.3).

![Climatic zone in Niger](image)

**Fig. I.3  Climatic zone in Niger**  
*Source: National Adaptation Programme of Action, 2006*

① Sahel and Sudan zone  
This is an area with the annual rainfall ranging from 600 to 800 mm, constituting about 1% of the country, having savanna vegetation, presenting the relatively rich environment, and can be said to be the most suitable area for agriculture.

② Sahel zone  
This is an area with the annual rainfall ranging from 300 to 600 mm, constituting
about 10% of the country, presenting the environment relatively suitable for agriculture, with a high concentration of human population.

③ Sahel and Sahara zone

This is an area with the annual rainfall ranging from 150 to 300 mm, constituting about 12% of the country, covered with the vegetation of herbaceous species of the steppes, suited for pastoral activities.

④ Sahara zone

This is an extremely arid area with the annual rainfall less than 150 mm, constituting about 77% of the country, where the vegetation can be found only at limited places like valleys and oases.

Incidentally, the average annual rainfall over the country is about 180 mm, with the rainy season lasting approximately from June to September and other months remaining extremely arid. For information, the monthly precipitation in the rainy seasons from 1999/2000 to 2006/07 is shown below (Fig. I.4).
As another climatic factor, the principal seasonal winds in Niger are “harmattan” and monsoon (Fig. I.5). The former harmattan is a strong, hot and dry northeasterly blowing from the Sahara desert from October to May, and said to be the wind caused by the morning solar radiation disturbing the air mass which has been cooled off due to nocturnal radiation in the inland environment. The latter monsoon (rain wind) is a southwesterly blowing in the southern part from June to October which brings in the moist air mass providing quiet rains when the tropical front lingers for a few weeks in August to the north of the latitude 18° N.

Furthermore, the continental trade wind may blow several times for a few days from December to February. In the Sahara climate zone sand storms occur from June to August, causing dry fogs due to floating dust over wide areas.
1-5 Soil

Niger soils are classified roughly into the following types.

① Coarse mineral soils

The soils of this type are generated under the conditions of desert climate with irregular rainfalls of annual precipitation at less than 200 mm, and with a large diurnal temperature variation. They are distributed over more than half of the entire country. They are further subdivided into the lithosols which are weakly weathered and shallow with a depth of less than 10 cm, the abraded soils which have light yellowish A horizon, and the transported soils which contribute to the formation of sand dunes through the action of weathering.

② Undeveloped soils

This type of soil deficient in organic matters are classified into the “climatic soils” which occur in areas surrounding the great sand dune region of Ténéré and the “non-climatic soils” occurring in Liptako region, where the latter like the former contain...
gravels in mother materials with the surface having been eroded by rains, and hence are unsuited for agricultural purposes.

③ Semi-arid soils

The soils of this type are sandy soils generated under the climatic conditions of the steppes with the annual precipitation of 200 to 350 mm, having a well developed A horizon, occurring widely over the belt-shaped area extending from the border with Mali to the Lake Chad. This type of soils include also the “reddish brown soil” which looks red due to ferric oxide and occurs most widely, the “brown soils” generated on clay and sandstone, and the clayey soils which are found around the Lake Chad and cause readily hydromorphism and salinization.

④ Tropical ferric soils

The soils of this type are reddish brown soils which develop a B horizon of accumulated clay under the semi-moist climatic conditions as well as are rich with ferric oxide, occurring widely on the sandstone-natured plateau in the southern part of Niger. Because their physical properties permit easy cultural operations, they are suited for growing pearl millet, sorghum and groundnut, but the sandy property makes them vulnerable to erosion. Moreover, there occur occasionally the gravelly soils which have been extremely degenerated due to leaching action and contain aggregates of bleached nodules and the soils which have been subjected to hydromorphism and salinization.

⑤ Hydromorphy (aqueous sedimentary soils)

These soils are characterized by the presence of mottled horizons like gleyified ones under the influence of ground water, occurring on the alluvial terrains along rivers in the south and suited for rice cultivation.

⑥ Vertisols

These are dark colored heavy clayey soils occurring principally in Diffa area of the Lake Chad. They are rich with the clay minerals similar to montmorillonite, and have the composition of fine particles which have been affected little by leaching. The
The absorption of water makes them expand and the desiccation makes them shrink and solidify. They are relatively fertile but extremely poorly drained, presenting the problem of salinization in the dry season.

**Fig. I.6 Soils in Niger**
Incidentally, Niger farmers classify the soils occurring in their fields according to colors and textures, and employ the terms of that classification to express the level of fertility. According to Hayashi (2004), the principal soils are roughly classified into 3 types, Labu-tjirey (red sand), Labu-kwarey (white sand), and Labu-bi (black sand), and these represent the concepts shared in common by farmers to recognize the differences in soil fertility. These terms are of Zarma language and since it has been confirmed by “Field survey in the study of subsistence crops as a part of the Project to collect the basic information for the assistance of developing countries (September 2008)” that similar classification concepts are found also in other languages like Hausa and Fulani, the Table I.1 below shows the designations of fertility level by each of languages that are recognized by local farmers.

Table I.1  The soil classification which the local peasant recognizes

<table>
<thead>
<tr>
<th>Zarma*</th>
<th>Hausa**</th>
<th>Fulani***</th>
<th>Characteristics</th>
<th>Distributions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labu Kwarey</td>
<td>Jigawa</td>
<td>Laidi-renehô</td>
<td>White sand, lowest fertile soil</td>
<td>Extensive In the southern part of Niger</td>
</tr>
<tr>
<td>Labu tjirey</td>
<td>Janhoko</td>
<td>Laidi-bodêdjo</td>
<td>The red sand or red argillic soil, low fertile soil</td>
<td>Extensive In the southern part of Niger</td>
</tr>
<tr>
<td>Labu bi</td>
<td>Fadama</td>
<td>Laidi-balêdjo</td>
<td>The black sand or black argillic soil, good fertile soil</td>
<td>Swamps, alluvial valley and so forth</td>
</tr>
</tbody>
</table>

**Interview from Dr. Addam Kiari Seidou, INRAN-Maradi, September 2008.  
*** Interview from Mr. Sodja Amadou, JIRCAS-ICRISAT, September 2008.
The distribution of arable land in Niger is limited to the southern regions and only about 12% of the total land area of the country is available for cultivation. The principal crops are pearl millet and sorghum that are cultivated on about two thirds of the total arable land (15 million ha). In order to meet the rate of rapid population growth exceeding 3%, the cultivated area of major food crops has been expanded and the yield also is increasing, but the agriculture is essentially that of pluvial regime and hence the production depends on the amount of precipitation. In particular in 2004 a small drought occurred and hence the cultivated area as well as the yield declined greatly (refer to Table I.2). Leguminous crops like cowpea and groundnut are mainly planted as intercrops accompanying pearl millet and sorghum. Maize and rice are cultivated in the areas where water is relatively more easily available, including the areas along the Niger River, and in the southern regions with abundant rainfall. Incidentally, the cultural calendars of major food crops are as shown in Fig. I.7 and the characteristics of production of these crops are briefly described in the following section.

① Pearl millet

This is the most important cereal in Niger, generally planted in the beginning of the rainy season (June) and harvested in October. As the cultural mode, it is rarely planted alone but normally very often accompanies other crops like cowpea and groundnut. The duration of growth cycle is about 70 to 100 days, and there are diverse plant types represented by panicle lengths ranging from 30 to 90 cm. Pearl millet is grown in the areas with annual rainfall between 250 and 650 mm, including Niamey capital district, Tillabéri region, Maradi region, Tahoua region, and Zinder region, and the areas with the annual precipitation of 200 to 250 mm are reportedly the marginal ones for cultivation. In the countries where the rainfall is limited and unstable with a great yearly variation, the early-ripening varieties which can complete the growth cycle within the period of the rainy season are preferred. As the suitable soil conditions, it is cultivated
Table I.2  Change of main crop production (2002-2007)

<table>
<thead>
<tr>
<th>Year</th>
<th>Items</th>
<th>Pearl millet</th>
<th>Sorghum</th>
<th>Cowpea</th>
<th>Maize</th>
<th>Rice</th>
<th>Groudnut</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>Area Harvested*</td>
<td>5,576,122</td>
<td>2,240,463</td>
<td>3,845,212</td>
<td>14,083</td>
<td>23,863</td>
<td>334,565</td>
</tr>
<tr>
<td></td>
<td>Yield**</td>
<td>461</td>
<td>299</td>
<td>170</td>
<td>1,200</td>
<td>3,362</td>
<td>433</td>
</tr>
<tr>
<td></td>
<td>Production***</td>
<td>2,670,401</td>
<td>669,709</td>
<td>654,232</td>
<td>16,900</td>
<td>79,949</td>
<td>153,729</td>
</tr>
<tr>
<td>2003</td>
<td>Area Harvested*</td>
<td>5,771,293</td>
<td>2,269,923</td>
<td>4,103,710</td>
<td>4,358</td>
<td>18,710</td>
<td>423,382</td>
</tr>
<tr>
<td></td>
<td>Yield**</td>
<td>476</td>
<td>334</td>
<td>134</td>
<td>508</td>
<td>3,046</td>
<td>495</td>
</tr>
<tr>
<td></td>
<td>Production***</td>
<td>2,744,906</td>
<td>757,556</td>
<td>549,035</td>
<td>2,216</td>
<td>56,980</td>
<td>203,369</td>
</tr>
<tr>
<td>2004</td>
<td>Area Harvested*</td>
<td>5,604,366</td>
<td>2,218,905</td>
<td>2,722,186</td>
<td>5,287</td>
<td>23,383</td>
<td>349,313</td>
</tr>
<tr>
<td></td>
<td>Yield**</td>
<td>364</td>
<td>270</td>
<td>125</td>
<td>751</td>
<td>3,340</td>
<td>455</td>
</tr>
<tr>
<td></td>
<td>Production***</td>
<td>2,037,714</td>
<td>599,528</td>
<td>339,499</td>
<td>3,970</td>
<td>78,099</td>
<td>159,079</td>
</tr>
<tr>
<td>2005</td>
<td>Area Harvested*</td>
<td>5,893,929</td>
<td>2,476,507</td>
<td>3,464,291</td>
<td>1,186</td>
<td>15,110</td>
<td>303,846</td>
</tr>
<tr>
<td></td>
<td>Yield**</td>
<td>450</td>
<td>381</td>
<td>169</td>
<td>802</td>
<td>3,964</td>
<td>450</td>
</tr>
<tr>
<td></td>
<td>Production***</td>
<td>2,652,391</td>
<td>943,941</td>
<td>586,078</td>
<td>951</td>
<td>69,902</td>
<td>139,035</td>
</tr>
<tr>
<td>2006</td>
<td>Area Harvested*</td>
<td>6,229,948</td>
<td>2,682,362</td>
<td>4,133,495</td>
<td>16,999</td>
<td>21,136</td>
<td>310,137</td>
</tr>
<tr>
<td></td>
<td>Yield**</td>
<td>483</td>
<td>346</td>
<td>172</td>
<td>1,123</td>
<td>3,708</td>
<td>492</td>
</tr>
<tr>
<td></td>
<td>Production***</td>
<td>3,006,584</td>
<td>929,265</td>
<td>712,031</td>
<td>19,085</td>
<td>78,377</td>
<td>152,561</td>
</tr>
<tr>
<td>2007</td>
<td>Area Harvested*</td>
<td>6,170,179</td>
<td>2,838,847</td>
<td>4,766,138</td>
<td>17,770</td>
<td>22,435</td>
<td>375,318</td>
</tr>
<tr>
<td></td>
<td>Yield**</td>
<td>451</td>
<td>344</td>
<td>210</td>
<td>1,087</td>
<td>3,120</td>
<td>393</td>
</tr>
<tr>
<td></td>
<td>Production***</td>
<td>2,781,928</td>
<td>975,223</td>
<td>1,001,139</td>
<td>19,324</td>
<td>70,000</td>
<td>147,676</td>
</tr>
</tbody>
</table>


Fig. I.7  Cultivation calendar of main crop in Niger

Source: Référentiel commenté des prix des produits agricoles du Niger, Août 1999
even on soils of relatively poor fertility, and suited especially for the cultivation on sandy to sandy loam soils. In the areas of pearl millet cultivation, the weed *striga* is often observed, but pearl millet is reportedly more resistant to it than sorghum. The average yield in Niger at the level of farmers’ fields is very low, coming to only 0.4 to 0.45 t/ha, out of the comparison with the yield level of 2.5 t/ha realizable in research institutions. After harvest, the grains are pounded with a mallet and mortar, or ground with a flour mill, and the kernels or flour are generally cooked to prepare gruel-like stuff which is cooled and formed to make the food of a type of pudding called “patte” or “toou” for human consumption. The husks are used as chicken feeds and the stalks are utilized as building materials for houses (roof and wall) or as forage for animals. Further details will be given in Chapter 2.

② Sorghum

Similarly as pearl millet, sorghum is sown in the beginning of the rainy season (June) and harvested in October. It is cultivated in the areas where the annual rainfall ranges between 600 and 1,000 mm or higher than that, namely, Niamey, Dosso region and Maradi region, requiring a higher level of soil moisture and fertility status than that for pearl millet. The length of growth cycle ranges between 80 and 100 days and the stalk length reaches about 150 to 200 cm. The average yield in Niger at the level of farmers’ fields is 0.2 to 0.4 t/ha, little different from that of pearl millet, while the yield level realized in research institutions is much higher, ranging from 2.5 to 3.5 t/ha. Since sorghum has a longer length of growth cycle than pearl millet, it is more liable to suffer from the damage due to *striga*, and the measures for evading the damage by means of the adoption of resistant varieties and by planting early-maturing varieties are being recommended. Further details are as described in Chapter 3.

③ Cowpea

Cowpea is a well known leguminous crop also in Japan which originated indeed from West Africa. In Niger it is grown widely as an intercrop accompanying pearl millet and sorghum, where the seeds are consumed as a grain food and the leaves as a
vegetable. Furthermore, it is not only used as a cover crop to prevent soil erosion or as green manure but also its stem and leaves after harvest are used as animal forages. While the length of growth cycle varies greatly ranging from 55 to 150 days, it is normally planted in late June, bearing pods in August, and can be harvested before the harvest of pearl millet and sorghum in October. The average yield in Niger at the level of farmers’ fields is about 200 kg/ha, but the research institutions realize the yield of as high as 3 t/ha. Incidentally, concerning the leguminous crops in West Africa, please refer to the detailed descriptions in the current series of “Tropical Crops Handbook” - Production, Processing and Marketing of Pulses crops in West Africa -, JAICAF (March 2007).

4 Maize

Maize is widely grown in those areas where the annual rainfall exceeds 1,000 mm (areas with soil of relatively high moisture status like river basins and the vicinities of wadis in Dosso and Maradi regions), planted in May to June and harvested in September to October. The length of growth cycle ranges from 80 to 140 days. Similarly as pearl millet and sorghum, maize is processed and prepared generally to make foods looking like pudding called “patte” or “toou” for consumption.

5 Rice

Rice is grown by exploiting the water from rivers or reservoirs, and although the planted area is very small as shown in Table I.2 and the production varies greatly from year to year, the consumption in Niger is increasing by degrees as one of staple foods. In the irrigated rice cultivation in paddy fields developed along the Niger River, it is grown twice a year, from October to January, and from March to June. In the traditional irrigated cultivation practiced on flood plains, it is grown once from July to November. In the former case, the first crop starts by the preparation of nurseries early in August to the early part of September, followed by the preparation of production fields early in September to the early part of October, then by transplanting (mostly planting in regular lines) in mid-October, and is harvested in January. The second crop starts by the
preparation of nurseries in February, followed by the preparation of production fields in March, then by transplanting late in March, and is harvested late in June to July. In the latter case, the preparation of nurseries takes place late in May to the end of June, the preparation of the production fields in the end of June to mid-July, the transplanting in the end of July, and the crop is harvested late in October to the beginning of December.

The length of growth cycle of varieties grown in Niger ranges from 120 to 160 days. While the average yield in farmers’ fields is low, with the level of 3 t/ha in the developed paddy fields and the level ranging between 0.7 and 1.2 t/ha in the traditional cultivation, many of the disseminated varieties are improved ones of IR lines with which research institutions reportedly can realize the yield level of 5 to 6 t/ha. For detailed information, please refer to the separate volume “Agriculture and Forestry in Niger”.

6 Groundnut

Groundnut which used to be a representative cash crop is essentially pressed and consumed as edible oil, rather than being taken as a food in the form of grains as they are. The length of growth cycle ranges from 90 to 130 days. It is planted in June to July, and harvested in October. While groundnut is cultivated in soils which range from those of a high clay content to even sandy soils with good water percolation, in the fields of pearl millet in Tahoua region where the reddish brown soils often occur, it is cultivated as a preferred intercrop plant rather than cowpea. The average yield in farmers’ fields ranges from 0.4 to 0.7 t/ha, but the research institutions can realize the yield level of 3 t/ha. The main growing areas are Maradi, Zinder, and Dosso regions, but as mentioned above, it is cultivated in Tahoua region as well.

2 Irrigated agriculture

Since irrigated agriculture is able to assure stable food production, a great deal of expectation has been shown for it since long ago. The irrigable land area in Niger is about 270,000 ha, composed of 140,000 ha in the basin of the Niger River, 20,000 ha in
the upper basin of the Sokoto River, 50,000 ha in the vicinities of the Komadougou River and the Lake Chad, and 60,000 ha in the basins of wadis and small rivers. However, the areas which have been developed for irrigated agriculture and are actually cultivated are distributed only along the Niger River and in the upper basin of the Sokoto River, and the quantity of water resources for other irrigable areas still remains unknown.

Many farmers practice the vegetable production on a small scale area of 0.25 to 0.5 ha in the dry season. As traditional means for lifting water for irrigation, there are puistte (manual lifting by using gourds), shadouf (well sweep method, see Fig. I.8), and dallou (lifting by animal power, Fig. I.9), and in certain areas lifting facilities by small scale pumps are found. In particular, there are 8,000 ha of rice fields in the zones of irrigation development where two crops per year can be cultivated, and intensive cultural methods are practiced to realize an average reported yield of 4 to 5 t/ha. 88 % of such fields are concentrated in Tillabéri area, 7.7 % are found in Niamey, and remaining 4.3 % in Dosso, all distributed in the basin of the Niger River in the southwestern part of the country (Kaneda, 2009).

![Fig. I.8  shadouf](image1)

![Fig. I.9  dallou](image2)

Source: Study report of the food production increase development in African region -Niger-, March 1991, AICAF.
(3) Farming activities

The farming activities generally take the form of family farm which practices traditional agriculture. Since the cultivation is carried out by manual means, the labor productivity is relatively low. As mentioned before, agriculture is practiced mostly under the rain-fed conditions, the average area of cultivated land per farm is 5 ha, and the average number of working persons is six per farm. The amount of fertilizer application is limited, and the reduction of the duration of fallow as well as the clearing of land of low fertile lead to soil erosion, reducing extremely the land productivity.

(4) Stock farming

The stock farming of Niger accounts for 10 % of the GDP in a stable manner, greatly contributing to the financial as well as economic wellbeing of the country. In reality, while the numbers of animals are on the increase in recent years, it is a well known fact that small animals like goat and sheep are cited as the causes to accelerate desertification, and here arises the problem of conflict of purposes between the promotion of farming and food security and the restoration and preservation of the environment (see Fig. I.10).

Incidentally, the characteristics of animal husbandry are essentially classified as follows:
① Seasonally moving type

In the rainy season, animals are taken away far from crop fields for pasturing in grazing grounds. Animals pastured there from June to October return to the agricultural land in November after the end of harvest of cultivated crops, and during the dry season they are fed with the residues of crops (stalks of pearl millet and sorghum, or stems and leaves of cowpea, etc.) or let graze on crop fields after harvest or on the land in fallow.
② Nomadic type

This type of animal rearing is practiced by exclusively nomadic pastoralist people (ethnic groups of Fulani people including Touareg and Peul), by leading animals
regardless of specific seasons and places.

③ Settled type

This type of animal rearing is practiced in agricultural zones by settled pastoralist people as well as by farmers rearing only small numbers of animals. Animals are raised on rotational pastures, the land in fallow, crop fields or the idle land unsuited to cultivation around villages, etc.

Fig.I.10 Change of the domestic animal feeding heads in Niger
Source: Country Profile 2008, EIU

Since the number of animals represents the power of pastoralist people, they try to increase the number rather than to make a profit by selling them. Moreover, agriculturists also aim at building up reserves by stock instead of doing it by cash, if they have money to spare. The recent increase of the numbers of domestic animals has created difficulties for the access to pastures for grazing and is causing the competition for forage among pastoralists or a conflict between pastoralists and agriculturalists.
1-7 Policy on food and agriculture

(1) Policies on agriculture

National policy of Niger has been formulated according to the Poverty Reduction Strategy Paper (PRSP) which describes as the primary objective the reduction of the poverty level from 66% presently (2002) to less than 50% by 2015. PRSP has defined four areas as strategic axes: ① Macro-economic and financial stability as a prerequisite for sustainable growth, ② Development of productive sector development, especially in rural areas, ③ Improvement in the access for the poor to the quality social services, ④ Strengthening of institutional and individual capacity, within and outside government, at the central and local levels. The rural development objective included in PRSP has been adopted (2003) as SDR (Rural Development Strategy).

In the SDR the issues affecting rural sector have been identified as follows among which those described as “the production of agriculture, livestock and forestry falls short of the demand and the status of food supply is unstable”, and “the increase of major cereals cannot catch up with the population growth” are indeed the questions directly related to the present study.

[I Issues affecting rural sector identified by SDR]

- The production of agriculture, livestock and forestry falls short of the demand and the status of food supply is unstable.
- The competition for the exploitation of natural resources is causing social conflicts.
- The mining development is causing environmental degradation.
- The increase of major cereals cannot catch up with demographic growth.
- The underdevelopment of market makes prevents the principle of competition from working.
- The economic environment is unstable.
- Professional organizations are not fully functional in their roles.
The strategic objectives are classified into the following three strategies with all of which the present study is concerned.

1st strategy: Encouraging rural populations’ access to economic opportunities in order to create the conditions for a sustainable economic growth in rural areas (strengthening of relevant organizations, improvement of access to financial services, etc);

2nd strategy: Preventing risks, improving food security and managing efficiently the natural resources in order to secure the living conditions of the populations (water resources development for diversification of production, etc);

3rd strategy: Building the capacities of public institutions and rural organizations in order to improve the rural sector management (enhancement of capabilities of rural organizations, strengthening of information systems in agricultural and forestry sectors, enhancement of administrative capabilities, etc).

Accordingly, in order to implement these strategies, the structural programs and the priority programs for the sector have been formulated as enumerated below. The former are not the kind of programs which aim directly at raising the productivity and the rate of self-sufficiency of food, but they intend to provide institutional support for promoting the private initiatives and to induce the improvement of respective actors in rural development. The latter are the approaches to implement resolutely specific policies in order to produce immediate results.

[1] Structural programs
   ① Program for local and community development (commune-oriented program)
   ② Program for local management of natural resources (application of Agricultural
Land Act, establishment of land committee)  
③ Program for organization of professional groups and establishment of distribution (fund for distribution development, establishment and support of cooperatives, etc.)  
④ Program for rural infrastructure (transportation infrastructure, information infrastructure, electrification)  
⑤ Program for rural financing systems (legal adjustments, support for rural financing institutions, access for the poorest, etc.)  
⑥ Program for research, human resource development, and extension (research and extension for technologies in high demand)  
⑦ Program for enhancement of public institutions in rural sector (building of capacities of respective administrative organs and officials)  
⑧ Program for drinking water and sewerage systems (construction and rehabilitation of water-supplying facilities, participatory management of facilities)  
⑨ Program for reducing family vulnerability (grains bank, public hygiene, assistance for the poorest, etc.)  
⑩ Program for environmental conservation (prevention of soil erosion, biodiversity, activities for concern over environment, etc)  

[2] Priority programs for the sector  
① Program for irrigation (rehabilitation of existing irrigation facilities, construction of new ones)  
② Program for development of grazing areas and for stabilization of livestock rearing systems (development of watering facilities, etc.)  
③ Program for rehabilitation of land and reforestation (activities by beneficiaries for conservation of land and water, assistance by local governments, etc.)  
④ Program for restoration and development of ecosystems in Niger River basin (irrigation development)
(2) Agricultural administration

In aforementioned SDR, in order to apply and run the strategy, the administrative approaches by linking horizontally the relevant government agencies and ministries are being taken. However, the principal active authorities in the approaches are 4 ministries, namely, Ministry of Development of Territory and Communities, Ministry of Agricultural Development, Ministry of Hydraulic Affairs, Environment and Prevention of Desertification, and Ministry of Animal Resources. Among them, regarding the production of minor cereals, subject of the present study, the Ministry of Agricultural Development possesses the ultimate authority to decide the policies.

While the present Ministry of Agricultural Development was organized in 2005, actually the government authority responsible for agricultural affairs has undergone several stages of reorganization and renaming since the national independence in 1960. The Ministry has now the authority over the formulation and monitoring of national policies on agricultural development. The organizational structure of the Ministry is shown in Fig.I.11.

![Organigram of Ministry of Agricultural Development](image-url)

Source: Décret No .2002-109/PNR/MDA du 7 mai 2002
(3) Research and experiments

INRAN (National Institute of Agricultural Research of Niger)

INRAN (Institute National de Recherches Agronomiques du Niger) was established on January 7, 1975 by regrouping several French research institutions having existed until then, including IRAT (Research Institute of Tropical Crops), IEMVT (Research Institute of Tropical Veterinary Medicine and Animal Husbandry), IRHO (Research Institute of Oil Crops), IFRA (Research Institute of Fruits), CFDT (Research Institute of Fiber and Textile), CTET (Center of Tropical Forestry), and its administrative headquarters are situated in Niamey.

Disciplinary research units of INRAN consist of six divisions, namely those of agriculture, veterinary medicine, forestry, rural economy, information and statistics, and ecology. INRAN disposes the agricultural research center in Maradi, and experimental farms in Kollo, Bengou, Tillabéri, N’Dounga, and Agadez. In particular, the institution in Maradi is an agricultural research center with a reputed history established by IRAT of France in 1928, which is the oldest one in West Africa. It has a campus with a land area of 270 ha, containing 5 research divisions (those of management of natural resources, food crops, etc), staffed with 19 scientists, and about 80 field technicians (including temporary employees). Although it consists of several laboratories including that of the soil science, carrying out the selection of cultivars and the production of seeds of pearl millet, sorghum, cowpea, and groundnut, there is no facility for cold storage of seeds. In this regard, only ICRISAT located in Sadoré (see below) is equipped with facilities to maintain a gene bank. In Maradi area, important commodities are pearl millet, sorghum, groundnut, cowpea, bambara groundnut, tiger nut, sesame, etc.

Incidentally, among the principal commodities which constitute the objective of research activities of INRAN, for the food crops (pearl millet, sorghum, groundnut,
cowpea, maize, and rice) and vegetable crops (onion, tomato, bissap\(^2\), etc.), the selection and improvement of varieties and cultural methods, and the production of seeds are carried out, and for the fruit trees, the experiments on cultural methods for date palm, mango, citruses, guava, etc are carried out. In addition to these activities, the experiments on the control of diseases and insect pests in these crops are also conducted.

Moreover, experiments and technical processes are carried out in different domains on respective subjects as follows: in the domain of animal husbandry, experiments on varieties and cultural methods of forage crops, the reproduction and the feeding of sheep and cattle, and the prevention of animal diseases; in the domain of forestry, experiments on the nursery practices for seedlings, and techniques of planting trees and forestation, etc.; in the domain of soil science, soil survey, cartography, experiments on fertilizers, chemical analysis, etc.

\(^2\) Bissap: *Hibiscus sabdariffa* L. (Eng. Roselle). Annual herb looking like an arboreal bush, reportedly originated in West Africa. Its calyces are succulent, taste sour, are extensively used for eating fresh, syrup, drinks, and for processing. In French speaking West African countries including Niger, it is called Bissap.
② ICRISAT-WCA (regional hub of West and Central Africa)

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) located in India carries out research programs pertaining to pearl millet, sorghum, groundnut, pigeon pea, and chick pea, and in order to promote the cultivation of these crops in west Africa, has established its Sahelian Center in Niger and 2 branch centers in Burkina Faso and Mali, conducting researches on breeding, cultural practices, and resources management concerning the production of pearl millet, sorghum and groundnut.

In Niger, ICRISAT has established WCA in Sadoré situated 45 km away to the southwest of Niamey and is implementing programs on breeding, cropping systems, improvement of fertilizer application, and management of diseases and insect pests of pearl millet, sorghum, and groundnut, and also on improvement of varieties of fruit trees.

Lately WCA has been carrying out research programs in collaboration with JIRCAS: Japan International Research Center for Agricultural Sciences. Since 2003, the partnership activities are aiming at developing technology for the enhancement of soil fertility and the elevation of crop productivity, by means of the effective utilization of organic matters.

Specifically speaking, the collaborative program has intended to reassess scientifically the traditional techniques of soil fertility management that have evolved and been accumulated over the years as farmers’ hereditary knowledge (retaining herded animals in fields at night to return dung and urine to the field soils, or keeping fields in fallow for several years). As extension of the context, the program has verified the effects of combination of organic matters and non-organic fertilizers, selected those high yielding strains of cowpea that are adapted to the Sahelian environment and also usable as animal forage, and further proposed the adoption of plant resources that have not been exploited so far, and a new cropping system that establishes patches of fallow within a cultivated field.
2. Trend of supply and demand of minor cereals in Niger

2-1 Historical background

Around the 7th century A.D., Songhaï Empire emerged in the region in the vicinity of present day Gao in Mali. It ruled the present day western part of Niger around the 12th century, but the eastern part was ruled by Bornou Kingdom. Later in the 17th and the 18th centuries, the Tuareg exercised great influence, and in the 19th and the 20th centuries, France expanded its influence over the entire West Africa, and Niger became its colony in 1922. In 1946 Niger became one of its overseas territories, but similarly as other French speaking countries in West Africa, Niger established the independence from the colonial rule of France in 1960 (it still uses French as official language). West African countries including Niger were divided as a consequence of the Congress of Berlin in 1878 held to decide the outcome of the Russo-Turkish War, without the understanding by the parties involved, and therefore the national borders do not correspond to the demarcations between different spheres of tribal languages, since hitherto diverse ethnic groups (language groups) of people have been moving around and making interchange.
with each other. For instance, the nomadic Fulani people\(^3\) are distributed widely over West Africa and lead a traditional way of life moving from the north to the south during the rainy season, then from the south to the north in the dry season, in pursuit of water and pastures, but recently certain groups of them have settled at fixed places and practice cultivation. As another example, Hausa who practice commerce are distributed in several countries, and their language groups are found in Nigeria and Niger.

While it is generally believed that the agriculture in West Africa was developed based on the “Savannah agricultural culture” which, originating from the upper Niger River regions, had domesticated such crops as cowpea, pearl millet, bottle gourd, sesame, African rice (\textit{Oryza Glaberrima} Steud.) (Yoneyama, 1998), the Meroë civilization which prospered from the 6\(^{th}\) to the 4\(^{th}\) century, B.C., in Sudan already possessed the technology to melt iron. It may be assumed that the agricultural culture in this region rapidly extended when the steel making technology began to spread into the interior regions of Africa along with the migration of cultivating people of Sudan. Moreover, as cattle, sheep and goat constitute the main elements of animal husbandry in this region, there used to be certain people who had specialized in rearing animals for their occupation like the aforementioned Hausa.

The number of crops which can be cultivated is limited in such a country as Niger lying close to the Sahara, where the half of the national territory has been turned into the state of desert. It can be easily imagined that pearl millet, indigenous species to West Africa, and sorghum which does not require much of soil moisture and nutrients have become staple foods. In addition to them, the rice cultivation has developed in certain places thanks to the water provided by the great river of Niger, and fonio which requires little skill for cultivation and matures early with a short growing period also has become a valuable staple food cereal for nomadic people unfamiliar with the practices of

\(^3\) Fulani are nomadic tribal people distributed in many countries in West Africa, from Mauritania in the northwest to Cameroon in the east, practicing mainly nomadic animal husbandry as an occupation.
2-2 Trend of supply and demand

Presently, an overview of the production of minor cereals in Africa, particularly of millet\(^4\) and sorghum, is given anew. It can be seen from the Fig. I-12 that Nigeria leads absolutely in the production of millet among countries of both East and West Africa but that Niger follows it and is the second largest producer of the crop.

![Fig.I.12 Millet’s production of major producing countries in Africa](source)

However, regarding sorghum, Niger does not necessarily grow it much in comparison with other countries, as Fig. I-13 shows. Nevertheless it is grown relatively abundantly in West Africa. The difference in relative importance between the two crops does not signify the preference in taste of the Niger people but should be attributed to the difference in rainfall that has been mentioned before. Because even in Niger, those areas which are lying along rivers and with the access to irrigation water or those in the

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\(^4\) The millet cultivated in West Africa is pearl millet (*Perineum glaucum*), but that in East Africa is principally finger millet (*Eleusine coracana*).
southern part that are favored with rainfall, those crops that are both productive and cashable like rice and maize are also grown. In the past, since it was not thinkable in Niger to produce enough quantity of rice or maize that could meet the domestic need, maize was imported from neighboring countries and rice from the Southeast Asian countries like Thailand and Vietnam.

However, the recent years in Niger (1996 to 2005) with statistics as for import of the principal cereals which excludes sorghum there is a decrease tendency (Fig.I-14). In fact, the appraisal final returns report of the cropping season of 2007/2008 which is announced in February, 2008 (by Economical Statistical Bureau, Ministry of Agricultural Development) Niger citizen of 13,845,000 cereals required quantity which needs was estimated at 3,198,201 t, but pearl millet, sorghum and maize with the rainwater agriculture such as fonio 3,778,312 t, the wheat, 78,500 t, total 3,856,812 t there is a production volume roughly with the irrigated agriculture such as the rice, the available grain quantity after the post harvesting has become 3,211,566 t. Due to the
fact that the surplus of 13,365 t is born from this, as a supply quantity of the grain it means with to be supplied, but as appeared even in the upper figure, in Niger which many depends on rainwater agriculture when years of some drought and few rain do not limit come also. Promotion of irrigated agriculture utilizing the rainfall which is limited collectively effectively how without wastefulness, whether it ties to crop production, because you can call the important key, it probably won't be?
Fig. I-14-3 Import and export of maize in Niger

Fig. I-14-4 Import and export of rice in Niger

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(7) http://vf-tropi.com/

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Chapter II  Pearl millet

1. Overview

The section of cereals in FAO’s Statistical yearbook (FAO 2008) gives the figures for rice, wheat, maize, barley, sorghum, millet, rye, and oat. Among them, the millet is the common denomination for minor crops of Gramineae family, representing different plants other than those cited above, including barnyard millet (*Echinochloa esculenta*), common millet (*Panicum miliaceum*), foxtail millet (*Setaria italica*), finger millet (*Eleusine coracana*) and pearl millet. Pearl millet (*Penisetum glaucum* (L.) R. Br.) is an annual species belonging to the genus *Pennisetum*, Paniceae tribe, Panicoideae subfamily, Poaceae family, and one of minor cereals. Since it exposes at maturity glossy grains which glitter like pearls, the plant is called pearl millet in English. Those regions which grow pearl millet as a food crop are mainly in India and West Africa. In Japanese papers and documents dealing with West Africa, writers often cite crops under Japanese terms representing common millet (*Panicum miliaceum*) or barnyard millet (*Echinochloa esculenta*). Their usage of those common names in translation is wrong, and they actually almost always refer to pearl millet. Because like in such cases the term millet (*mil* in French) includes many cereals of Gramineae species, it is frequently translated inaccurately.

In Africa barnyard millet and foxtail millet are rarely cultivated. The tem millet represents pearl millet in West Africa, and pearl millet as well as finger millet in East Africa. In fact in West Africa there are a considerable number of regions where pearl millet is taken as a regular ingredient of meals. Pearl millet constitutes the mainstay crop rather than a minor one in savannah regions in West Africa. West African countries where France used to be the suzerain power nowadays use the common currency of CFA franc and the coin of 250 FCFA is sculptured with a design of pearl millet, a fact testifying the important place given to this crop in this region (Miura 2001).

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1  Exchange rate of CFA franc is fixed at 1 Euro = 655.957 FrCFA.  1 yen = about 5.54 FrCFA (as of March 2009).
2. Origin

The origin of pearl millet is estimated to be located in the central part of the Sahara Desert in West Africa. Archeological evidence for it is the discovery of a large number of seeds of pearl millet in the ruins of Villini in northern Ghana. The result of dating by radioisotope carbon has enabled the estimation that the plant may have been cultivated in this region about 2500 to 3500 BP (D’Andra and Casey 2001). Moreover, in view of the diversity of morphological differentiation, isozyme analysis, and the verification on the level of rDNA, it could be reasonably concluded that pearl millet as a crop originated in West Africa about 4000 BP. Pearl millet domesticated in West Africa was disseminated rapidly. It reached India 3000 BP and differentiated diverse cultivars there, and hence India has become the secondary center of diversification. Pearl millet as a food crop is mostly cultivated in Africa and India, while it is grown more frequently instead as a forage crop in American continents. In African continent, it is distributed widely in the countries on the southern border of the Sahara Desert stretching from Senegal to Somalia.

3. Types of pearl millet

(1) Wild type

Wild ancestral species of pearl millet is estimated to be *Pennisetum subsp. violaceum (monodii)*. This species has small panicles, small caryopsis and the spikelets that fall at maturity, all of which distinguish it greatly from cultivated types. It is distributed in the regions lying along the southern border of the Sahara Desert from Senegal to Central Sudan and reportedly also in the highlands right in the middle of the Desert. It is able to cross readily with cultivated species to produce a fertile hybrid (Sakamoto, 1988).

(2) Weedy type

In the fields of pearl millet, one often finds a weedy type of pearl millet with morphological characteristics that are intermediate between those of the wild type and those of the domesticated one. This species is *Pennisetum glaucum subsp.*
*Stenostachyum*. It resembles very closely to the cultivated types and is difficult to distinguish from cultivated types until heading stage but it shatters readily upon maturity, and therefore, it is called *shibras* in Sahel. However the naming may differ depending on tribes.

(3) Cultivated types

4 principal types of cultivated pearl millet are known to be distinguished according to the morphological differences in caryopsis. The most widely disseminated type among them is the *typhoides* with obovate caryopsis that is distributed in the zone spreading from Senegal to Ethiopia and further to South Africa. The dimensions of caryopsis are 2.5 - 5.5 mm in length, 1.5 - 3 mm in width, and 1.2 - 2.4 in thickness, with the greatest range of variation among 4 types. The type *nigritarum* has obovate caryopsis with angularities and is distributed from Western Sudan to Northern Nigeria. The dimensions of caryopsis are 3 - 5 mm in length, 1.7 - 2.5 mm in width, and 1.5 - 2.2 in thickness, The type *globosum* has spherical caryopsis about 2.4 mm in diameter. This type spreads from the middle of Burkina Faso to West Sudan, and abounds particularly in Northern Nigeria, Niger, Ghana, Togo, and Benin. The type *leonis* has oblanleolate caryopsis, is distributed from Northern Senegal to Southern Mauritania, but it is supposed to have originated from Sierra Leone. It is presumed that the caryopsis has elongated in order to adapt also to high rainfall environment in Sierra Leone.

4. Agronomic characteristics

Most of the areas where pearl millet is grown have the environment in which rainfall is unstable and limited, temperatures are high and the soil fertility is low, like the areas lying from the climatic zone of Sahel to that of Sudan. These factors and the low level of improvement of cultivars lead to the low yield level (0.5 - 0.6 t/ha). In such an environment, not to speak of rice, other cereals like maize are not able to realize economic yield, and even their existence is difficult. In such climatic zones, pearl millet is the only cereal that can be grown, and therefore it serves as the essential source of
energy for the rural areas in poverty. Pearl millet is an annual C\textsubscript{4} plant. Generally C\textsubscript{4} plants are more resistant to drought and require less water, compared to C\textsubscript{3} plants like rice and wheat. Pearl millet is the most resistant to drought among C\textsubscript{4} plants, and the characteristic makes it possible to grow it in the Sahel climatic zone where the annual rainfall is around 250 mm.

It develops a deep root system reaching as deep as 180 cm. Plant height is 1 - 3 m, with leaf blades 20 cm - 1 m long, and the appearance of plant resembles that of maize or sorghum (Photo II.1). Panicle forms a cylindrical raceme resembling the head of cattail with a length from 20 cm to 150 cm for the longest (Photo II.2). The diameter is 2 - 4 cm. The rachis bears a large number of short rachis-branch, each of which bears a pair of spikelets or in certain varieties up to 5 spikelets (Appa and de Wet 1999). The number of spikelets reaches 800 - 3000. A distinctive feature is the presence of the thick growth of long bristles in dark brownish color at the base of spikelet, and the botanical name of genus derives from this, namely, penni (plume) and setum (bristle) (Shigeta 2003).
Each spikelet has 2 florets, out of which the lower one has only stamens and is sterile and the upper one is bisexual and complete flower and fertile. There are 3 stamens, no lodicule is present, and the style extends long. Pearl millet is a proterogenous plant. Styles begin to extend 2 to 3 days after heading. Styles start the extrusion in the inflorescence at the upper middle portion of the panicle, and later the extrusion progresses upward and downward. The stigma of the bisexual floret emerges earlier than anthers, and therefore the stigma is pollinated by pollens from other plants. For the complete emergence of stigma, it takes 2 - 3 days. Immediately after the complete extrusion of a style, it divides into two parts. The style maintains the ability of pollination for 2 - 3 days after extrusion. Therefore, it is pollinated by cross fertilization but certain inflorescence may sometimes be self-fertilized, and the rate of self-fertilization varies depending on cultivars. The temperatures during the flowering period also are considered to influence pollination, and those below 25 °C. affect the fertility of seeds (Mori et Kurauchi, 2003). Seeds mature in 30 - 40 days after pollination, and harvesting is carried out by reaping only panicles starting from the main culm and then progressively for those of tillers.

5. Production and yield

Although pearl millet is only one of those minor cereals, it is placed at the 6th position among the most important cereals in the world, following rice, wheat, maize, barley and sorghum. However, the statistics treating exclusively pearl millet is not provided even by FAO, and as mentioned before the organization presents only the figures representing the combined statistics for plural kinds of cereals under the general term of millets which include at the same time common millet and barnyard millet (Table II.1). According to estimated figures, the millets are cultivated on the land area of over 10 million ha in Africa and Asia respectively, with annual production of more than 10 million tons each, and they constitute the staple food for at least 500 million people (National Research Council 1996). The millets cultivated in Africa include pearl millet,
Among them, pearl millet is grown in almost all countries around the south of Sahara, finger millet in East Africa including Kenya and Tanzania, fonio in areas lying along the southern border of Sahara extending from Senegal to Chad, and teff in Ethiopia. Among these countries, those which cultivate them on a large area with large production are Niger and Nigeria in West Africa. The cultivated area is almost the same for both

Table II.1 Principal Food crops of the world (2007)

<table>
<thead>
<tr>
<th>Principal crops</th>
<th>Area harvested (1 million ha)</th>
<th>Production (1 million t)</th>
<th>Yield ( t/ha )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals total</td>
<td>700</td>
<td>2,342</td>
<td>3.35</td>
</tr>
<tr>
<td>Wheat</td>
<td>217</td>
<td>607</td>
<td>2.79</td>
</tr>
<tr>
<td>Maize</td>
<td>158</td>
<td>785</td>
<td>4.97</td>
</tr>
<tr>
<td>Rice</td>
<td>157</td>
<td>652</td>
<td>4.15</td>
</tr>
<tr>
<td>Barley</td>
<td>57</td>
<td>136</td>
<td>2.4</td>
</tr>
<tr>
<td>Sorghum</td>
<td>44</td>
<td>65</td>
<td>1.47</td>
</tr>
<tr>
<td>Millet</td>
<td>36</td>
<td>32</td>
<td>0.89</td>
</tr>
<tr>
<td>Oat</td>
<td>12</td>
<td>26</td>
<td>2.17</td>
</tr>
<tr>
<td>Rye</td>
<td>7</td>
<td>16</td>
<td>2.28</td>
</tr>
<tr>
<td>Other</td>
<td>12</td>
<td>23</td>
<td>1.92</td>
</tr>
<tr>
<td>Crop other than cereals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td>95</td>
<td>216</td>
<td>2.27</td>
</tr>
<tr>
<td>Potato</td>
<td>19</td>
<td>322</td>
<td>16.6</td>
</tr>
<tr>
<td>Cassava</td>
<td>19</td>
<td>228</td>
<td>12.2</td>
</tr>
<tr>
<td>Sweet potato</td>
<td>9</td>
<td>126</td>
<td>13.9</td>
</tr>
</tbody>
</table>

Note: As for millet are minor cereals such as barnyard millet, common millet, pearl millet, finger millet, other than sorghum.

Source: FAOSTAT 2008
countries, but the volume of production in Nigeria is about 3 times as large as that in Niger (Table II.2). The reason for the difference is that in yield per unit area. The reason that causes the difference between two neighboring countries could be accounted for by the difference in ecological factors there. The volume and period of rainfall differ greatly between two countries, because Nigeria lies in areas ranging from Sudan climatic zones to Guinea climatic zone and further to equatorial forest climatic zone, while Niger lies in the area ranging from Sahel climatic zone to Sudan climatic zone.

<table>
<thead>
<tr>
<th>countries</th>
<th>Area harvested 10,000 ha</th>
<th>Production 10,000 t</th>
<th>Yield kg/10a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niger</td>
<td>494</td>
<td>189</td>
<td>38.2</td>
</tr>
<tr>
<td>Nigeria</td>
<td>501</td>
<td>632</td>
<td>126.1</td>
</tr>
<tr>
<td>Mali</td>
<td>128</td>
<td>91</td>
<td>71.1</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>128</td>
<td>97</td>
<td>75.8</td>
</tr>
<tr>
<td>Senegal</td>
<td>82</td>
<td>52</td>
<td>63.4</td>
</tr>
<tr>
<td>Guinea</td>
<td>19</td>
<td>17</td>
<td>89.5</td>
</tr>
<tr>
<td>Cote d’Ivoire</td>
<td>6</td>
<td>4</td>
<td>66.7</td>
</tr>
<tr>
<td>Benin</td>
<td>4</td>
<td>3</td>
<td>75.0</td>
</tr>
</tbody>
</table>

**Table II.2**  The comparison data of pearl millet in Niger and neighbor countries

According to the criteria of classification of climatic zones by FAO, the length of growing period (LGP) in Niger falls in the class of arid (74 $\leq$ LGP $\leq$ 1) to semi-arid (119 $\leq$ LGP $\leq$ 75), while that of Nigeria extends from dry-sub-humid (179 $\leq$ LGP $\leq$ 120) to moist-sub-humid (269 $\leq$ LGP $\leq$ 180) and further to moist (LGP $\geq$ 270), revealing clearly the severity of growing environment in Niger. The state of pearl millet production indicates that it is subject to climatic conditions of respective Regions. In the
Region of Agadez where the desert climatic zone and the Sahel climatic zone predominate, the cultivated area is small and the production volume is small but the yield is relatively high (Table II.3, Fig. II.1, 2, 3). This situation is due to the fact that the agriculture in Agadez is not that by rain-fed cultivation but that practiced by irrigation using the subterranean water in oasis. Moreover, in the Region of Diffa on the border with Chad, the area of cultivation is small and the production volume is also small, because the rainfall is low compared with other Regions. In Diffa, because not only the rainfall is low but also the number of days with rainfall is small, an early cultivar called Boudouma is mainly cultivated (Table II.4). In the Regions including Diffa to start with where the rainfall is low, early varieties are cultivated and the area of such cultivars is on the increase year after year (Fig II.4).

### Table II.3 Production of pearl millet by state in Niger

<table>
<thead>
<tr>
<th>Regions</th>
<th>Area harvested (ha)</th>
<th>Production (t)</th>
<th>Yield (kg/10a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agadez</td>
<td>195</td>
<td>166</td>
<td>61.2</td>
</tr>
<tr>
<td>Diffa</td>
<td>140,374</td>
<td>61,404</td>
<td>43.7</td>
</tr>
<tr>
<td>Dosso</td>
<td>1,015,821</td>
<td>540,270</td>
<td>53.1</td>
</tr>
<tr>
<td>Maradi</td>
<td>1,292,504</td>
<td>614,817</td>
<td>47.4</td>
</tr>
<tr>
<td>Tahoua</td>
<td>1,137,530</td>
<td>566,609</td>
<td>49.7</td>
</tr>
<tr>
<td>Tillabery</td>
<td>1,345,395</td>
<td>586,724</td>
<td>43.6</td>
</tr>
<tr>
<td>Zinder</td>
<td>1,148,979</td>
<td>465,987</td>
<td>40.6</td>
</tr>
<tr>
<td>C.U.N.</td>
<td>11,948</td>
<td>9,600</td>
<td>54.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6,098,019</strong></td>
<td><strong>2,845,522</strong></td>
<td><strong>46.7</strong></td>
</tr>
</tbody>
</table>

Source: Campagne agricole 2005-2007

Note: As for C.U.N meaning of Niamey (capital)
Fig. II.1 Cultivated area of pearl millet by state in Niger

Fig. II.2 Production of pearl millet by state in Niger
Source: ditto
Fig. II.3 Yield of pearl millet by state in Niger  

Table II. 4 Characters of main local varieties of pearl millet

<table>
<thead>
<tr>
<th>variety</th>
<th>growing period</th>
<th>ear length (cm)</th>
<th>ear type</th>
<th>grain color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haini-Kiré</td>
<td>85-110</td>
<td>90-110</td>
<td>Cylindrical</td>
<td>yellow</td>
</tr>
<tr>
<td>Guerguera</td>
<td>85-95</td>
<td>55-65</td>
<td>Cone</td>
<td>yellow</td>
</tr>
<tr>
<td>Ba Angoure</td>
<td>80-90</td>
<td>40-45</td>
<td>Cylindrical</td>
<td>gray or blue gray</td>
</tr>
<tr>
<td>Boudouma</td>
<td>55-60</td>
<td>15-25</td>
<td>Cylindrical</td>
<td>gray or yellow gray</td>
</tr>
<tr>
<td>Maiwa</td>
<td>120-140</td>
<td>80-90</td>
<td>Cylindrical</td>
<td>gray or blue gray</td>
</tr>
<tr>
<td>Zongo</td>
<td>100-110</td>
<td>180</td>
<td>Cone</td>
<td>yellow</td>
</tr>
<tr>
<td>Tamangaji</td>
<td>80-90</td>
<td>&lt; 50</td>
<td>Cone</td>
<td>gray or yellow gray</td>
</tr>
<tr>
<td>Ankoutess</td>
<td>85-90</td>
<td>&lt; 35</td>
<td>Cone</td>
<td>yellow</td>
</tr>
<tr>
<td>Moro</td>
<td>75-85</td>
<td>60-70</td>
<td>Cylindrical</td>
<td>gray</td>
</tr>
</tbody>
</table>

6. Cropping system and cultivation method

Pearl millet can realize a yield level going up to higher than 5 t/ha, if a sufficient amount of irrigation water and fertilizers is provided. However, in Niger where people consume it as staple food, a yield level of only 0.4 - 0.5 t/ha is being achieved. The cultivation of pearl millet in Sahel climatic zone and Sudan climatic zone of Niger is carried out entirely by the moisture regime of rainfall. The agriculture that is carried out under the moisture regime entirely by rainfall, namely very limited rainfall, is called dry-farming (Ouchi, 1997). In the dry-farming of pearl millet, the growing period of
cultivation naturally is determined by the seasonal distribution of rainfall. Consequently, in Niger where the rainfall is concentrated in the season equivalent to Japanese summer, the cultivation of pearl millet is an event of dry-farming of summer rain type occurring during the growing season of summer. The first stage of cultivation is breaking up of soil and seedbed preparation (Photo II.3).

However, in these climatic zones, there are often cases where no operation of breaking up of soil and seedbed preparation takes place. Around in June when the rainy season starts, manual hoes called “daba” are used for making pockets for sawing seeds and 10 - 20 seeds per pocket are dropped there by hand and covered with soil moved by foot (Photo II.4). If the seedlings die off due to lack of sufficient rainfall, seeds are sown again. The selection of appropriate time of seeding is difficult. Moreover, only 20 % of area for growing pearl millet is used for single crop culture and the remaining 80 % is used for mixed culture with other crops. As the crops for mixed culture, cowpea is most frequently selected and accounts for about 55 % of cases (Table II.5). In mixed culture, the seeds of two crops are planted either in the same pocket or in different pockets. More frequently fertilizers are not applied at all. As fertilizers available in Niger, there are only three products, namely, 15 - 15 - 15 (N: P: K = 15: 15: 15), Urée (urea), and
DAP (N: P: K = 16: 48: 0), among which 15 - 15 - 15 is disseminated and used widely.

Table II.5  Pearl millet based combination of mixed cropping

<table>
<thead>
<tr>
<th>Combination of mixed cropping</th>
<th>Area (ha)</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ cowpea</td>
<td>1,491,509</td>
<td>55.04</td>
</tr>
<tr>
<td>+ sorghum+ cowpea</td>
<td>851,601</td>
<td>31.42</td>
</tr>
<tr>
<td>+ sorghum</td>
<td>145,711</td>
<td>5.38</td>
</tr>
<tr>
<td>+ other crops</td>
<td>92,296</td>
<td>3.41</td>
</tr>
<tr>
<td>+ cowpea+ bissap</td>
<td>84,653</td>
<td>3.12</td>
</tr>
<tr>
<td>+ cowpea+ groundnut</td>
<td>22,385</td>
<td>0.83</td>
</tr>
<tr>
<td>+ sorghum+ groundnut</td>
<td>8,446</td>
<td>0.31</td>
</tr>
<tr>
<td>+ groundnut</td>
<td>7,648</td>
<td>0.28</td>
</tr>
<tr>
<td>+ bissap</td>
<td>4,517</td>
<td>0.17</td>
</tr>
<tr>
<td>+ cowpea+ sesame</td>
<td>844</td>
<td>0.03</td>
</tr>
<tr>
<td>+ cowpea+ bambara groundnut</td>
<td>416</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2,710,029</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: Productive des exploitations agricoles 2008

Niger farmers acquire fertilizers as much as they can afford to purchase with the money at hand at the moment and apply them, without any definite plan based on calculation of the need according to the area of cultivation. DAP is a compound fertilizer with the formulation best suited to the agricultural lands of the country, but its availability is limited and it is difficult to acquire it, and hence the dissemination is limited to only a small part of the country. Consequently fertilizers are rarely applied but certain farmers apply frequently the manure of animal dung and litter. Some farmers, in off seasons, ask nomadic cattle herders to rear animals on crop fields after harvest for fees paid in proportion to the area grazed, to return the excrement and urine discharged
there during the period as an organic fertilizer (parquage = animal parking). Moreover certain farmers owning carts transport litter and wastes of animals reared on premises and husks of pearl millet to farm lands. Although farmers are aware of the effect of application of animal wastes and other organic matters, for the reason that very few farmers own animals or carts, or for other reasons, the farmers who practice the method belong to a small minority. Intertillage and weeding are carried out by using hand hoes or hoes with a long handle called “hilaire”. Harvesting starts around 90 days after seeding for early cultivars and 150 days for late ones (Kurauchi et al., 2004). In most cases, panicles only are reaped by using a knife or bare hands. In cases of tall plants, panicles are reaped after stalks are brought down by pushing with feet. Harvested panicles are stored in granaries as they are or after drying them for about a week (Photo II.5). Panicles are taken out according to needs and threshed with a stick or a pestle (Photo II.6, 7). The series of farm work from seedbed preparation to threshing may vary depending on particular ethnic groups or on the state of wealth of farmers, and
there are certain cases where they employ animal power or machinery.

7. Future perspectives and other matters

7-1 Future perspectives

Pearl millet can be cultivated in arid and semi-arid areas with the annual precipitation of 200 - 800 mm where it is difficult to grow other cereals, and hence it is important as the food resource under poor environments. Pearl millet has differentiated into many ecotypes owing to diverse kinds of environmental isolation or to various cropping systems (Kurauchi et al., 2000). On the other hand, traditional varieties are diminishing gradually as a consequence of the dissemination of high yielding cultivars, the emergence of more profitable alternative crops, droughts in recent years, and the spread of urbanization. The collection and conservation of traditional varieties with diverse genetic variations is essential not only for the present task of varietal improvement but also for that purpose in the future. The germ-plasm preservation and the varietal improvement of pearl millet are mainly carried out by ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) situated in India. So far 21,191 specimens from 49 countries have been preserved. In Niger, the varietal improvement is carried out by using those specimens of germ-plasm, and the production is increasing, even though it augments only at a low rate. But the growth of human population surpasses that of production. In the future as well, further development is hoped for in the research for varietal improvement and for improvement of cultural techniques (Fig.II.5).

Although pearl millet is a crop of which even the existence is not known in industrialized countries including Japan, one should never forget the fact that there are people who consume it as the only staple food. Now that the global warming continues its process and expands the arid lands, the importance of pearl millet will become higher and higher.
7-2 How to use pearl millet

The flour of pearl millet processed by pounding with pestle or by mill is consumed as the staple food or as side dishes. As the staple food, it is prepared into a kind of dough called in various terms like *to*, *pat*, or *kurupa kurupa*, which resembles *ugari* or *sima* prepared from maize flour in East Africa (Photo II. 8, 9). *To* is prepared by firstly boiling water dissolving a small amount of flour. More flour is added to it and the mixture is kneaded elaborately by a wooden dipper. The soft paste is poured into a container resembling a washing basin for cooling and settling to finish the process. The dough is torn off to make mouthful balls which are immersed in soup and eaten. The soup is prepared from plants which produce sticky substances like okra, leaves of baobab, sumbara (condiment processed by fermentation of seeds of *Parkia biglobosa* “Néré”), leaves of wild Mulukhiyah (mallow). As side dishes, there are *donu*, a drink
which is prepared by dissolving blanched dumplings of pearl millet flour in milk or yoghurt, and *koko*, a kind of thin porridge like rice water (Photo II.10, 11).

Aside from the use as food, pearl millet is an important plant resource. Leaves and stalks are important as materials for the construction of roofs and hedges, fuel, and forage for animals.
7-3 Nutritional value of pearl millet

Pearl millet which sustains the life of people inhabiting the marginal areas in West Africa has a high nutritional value (Table II.6). The kernel has no husk, nor contains any tannin. It contains 5 - 7 % of fat and a higher amount of protein in comparison with

| Table II.6 Nutritional value of pearl millet (per 100g) |
|---------------------------------|-----------------|-----------------|
| **Main Components**             | **Essential Amino Acid** |
| Moisture (g)                    | 10              | Cystine (mg)    | 1.8 |
| Food energy (Kcal)              | 353             | Isoleucine (mg) | 3.9 |
| Protein (g)                     | 11.8            | Leucine (mg)    | 9.5 |
| Carbohydrates (g)               | 70              | Lysine (mg)     | 3.2 |
| Fat (g)                         | 1.9             | Methionine (mg) | 1.8 |
| Fiber (g)                       | 1.9             | Phenylalanine (mg) | 4.1 |
| Ash (g)                         | 2.3             | Threonine (mg)  | 3.3 |
| Vitamin A (RE)                  | 22              | Tryptophan (mg) | 1.4 |
| Thiamine (mg)                   | 0.31            | Tyrosine (mg)   | 3.0 |
| Riboflavin (mg)                 | 0.19            | Valine (mg)     | 4.9 |
| Niacin (mg)                     | 2.6             |                 |     |
| Calcium (mg)                    | 37              |                 |     |
| Chloride (mg)                   | 43              |                 |     |
| Copper (mg)                     | 0.5             |                 |     |
| Iron (mg)                       | 9.8             |                 |     |
| Magnesium (mg)                  | 114             |                 |     |
| Manganese (mg)                  | 0.8             |                 |     |
| Molybdenum (mg)                 | 190             |                 |     |
| Phosphorus (mg)                 | 339             |                 |     |
| Potassium (mg)                  | 418             |                 |     |
| Sodium (mg)                     | 15              |                 |     |
| Zinc (mg)                       | 2               |                 |     |

Source: Lost Crops of Africa (1996)
maize and sorghum. Regarding the composition of fatty acids, it contains as unsaturated ones, oleic acid (21 - 31 %), linoleic acid (40 - 52 %) and linolenic acid (2 - 5 %), and as saturated ones, palmitic acid (18 - 25 %) and stearic acid (2 - 8 %). Pearl millet which sustains the human life is an important crop also as animal food, and the nutritional value of not only the grains but also that of stalks and leaves are not to be neglected. All living things inhabiting Sahel carry on with their life there by depending on pearl millet.

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Chapter III  Sorghum

1. Overview

Sorghum (*Sorghum bicolor* (*L.* Moench)) is one of minor cereals which is cultivated widely all over the world, and in Japan has been called by various names like *takakibi*, *morokoshi*, and *koliang*, and has become familiar as a traditional crop. The important feature of this species is the fact that it possesses diverse morphological variations suited to many purposes of utilization. It has also a distinctive characteristic among minor cereals in the aspect that it has the capacity of being able to adapt to a wide range of environment. It is considered that it has become cultivated all over the world because it possesses these characteristics.

As examples of adaptability to many utilization purposes, the following cases can be cited.

For example, broom sorghum is a variant which has developed long rachis-branches on the panicle (raceme). Since panicles can be made into brooms after threshing, it is used in many places in the world. There are also a great range of variations in the plant height including the type with a short plant height of about 100 cm suited for grain production, namely the grain sorghum, the one with a height of 200 - 400 cm which can be used for making whole crop silage as well as for producing grains, namely the dual-purpose sorghum, the one with a height of 200 - 400 cm, namely the sorghum of sorgo-type, and the sorghum of Sudan type, a line created by hybridization with Sudan grass, capable of regeneration, with the statue of grass having fine stalks, and used as a forage crop. The type with long stalks is useful also as materials for construction of houses. Sorghum grains can be consumed by cooking whole grains like rice as well as by the preparation of flour. In Africa it is generally taken in the latter form, by preparing flour gruels.

Moreover there are also glutinous varieties which enable the preparation of diverse foods. An alcoholic beverage obtained by using such grains is the traditional Chinese
baijiu with the characteristics of unique flavor which is prepared by distilling the steam passing through the fermented steamed grains stored in an underground pit. Furthermore, while the reddish pigment contained in stalks and panicles is considered to be the repellant substances acquired by plant to evade the ravage by birds or insects, it is also used for coloring festive red rice and tableware. There is also a type called sweet sorghum. This is a variant which stores sugar in the stem, characteristic that is not found in maize. The sugar can be utilized either by chewing the stem as it is or by pressing it to extract the juice to make a sweetener or for processing alcohol. Lately bioethanol is attracting much interest, and the research on the use of this genetic resource has been initiated.

Table III.1 Classification and characteristics of sorghum

<table>
<thead>
<tr>
<th>crop species</th>
<th>morphological character of inflorescence</th>
<th>geographical distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>wild type</td>
<td>Small and the meagerness, it does not spread out. It does not quite branching near the base.</td>
<td>The savanna and the drier field in West Africa. Coast guinea, and the damp tropical forest and field in Congo. It is far-reaching distributed to the savanna and the roadsides.</td>
</tr>
<tr>
<td></td>
<td>It does branching and large near the base.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Width of the head is narrow, and the rachis-branch stands (Leaf width 2cm).</td>
<td>It seems on desert such as Sudan, along the waterfront of Nile riverfront.</td>
</tr>
<tr>
<td>cultivation type</td>
<td>bicolor</td>
<td>Goose neck type is many with dense inflorescence.</td>
</tr>
<tr>
<td></td>
<td>dura</td>
<td>Meagerness, and wide oval canopy is thick ephelitic. It is dense and narrow umbrella type, as for the surface of the mature canopy is smooth and back becomes pointed apex roundly.</td>
</tr>
<tr>
<td></td>
<td>leuca</td>
<td>The inflorescence spreads out sparsely.</td>
</tr>
<tr>
<td></td>
<td>caudatum</td>
<td>The inflorescence spreads out sparsely and rachis-branch hangs down. When it matures, the plumes opening largely, the flat canopy exposes.</td>
</tr>
<tr>
<td></td>
<td>bicolor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>guinea</td>
<td></td>
</tr>
<tr>
<td>weedy type</td>
<td>drummonalis</td>
<td>(The cross between weedy type and cultivation type, such as a companion weed)</td>
</tr>
</tbody>
</table>

Source: Author made out on the basis of the “Roads traveled by minor cereals”, by Sakamoto.
The range of morphological variation of sorghum is great, and the reason for it is deeply associated with the fact that the distribution and the variation of closely related wild species are also extremely wide and great. By a report by J. D. Snowden (1936), the number of related species used to be deemed to amount to a total of 52, comprising 17 wild species, 28 cultivated species, 7 hybrids between wild races and cultivated ones (Sadao Sakamoto, 1988). Later, through the studies by J. R. Harlan (1975) and others, it has been established that sorghum and related species can be classified into three species, namely, *Sorghum bicolor* [chromosome number: 2n = 20], perennial *Sorghum halepense* [2n = 20, 2n = 40], and perennial *Sorghum propinquium* [2n = 20], out of which *Sorghum bicolor* and *Sorghum propinquium* can cross-fertilize each other and therefore are considered to be related to the evolution of cultivated species. *Sorghum bicolor* is classified into three subspecies (Table III.1).

2. Origin

Since wild species of sorghum are distributed only in Africa, the place of origin of cultivated sorghum can be supposed to be Africa. The race of *arundinaceum* is distributed in tropical rainforests and the *virgatum* is in deserts like those in Sudan and does not grow in savannah. Therefore, it is supposed that *aethiopicum* and *verticilliflorum* are the ancestral wild types of cultivated sorghum. It is presumed that the primitive type of *bicolor* was born through the domestication of wild types of sorghum across the savannah belt from eastern Chad to eastern Ethiopia (Sadao Sakamoto, 1988). From archeological evidences, it is presumed that sorghum was domesticated more than 4000 BP, and firstly the *bicolor* race spread from Oman peninsula to West Africa and then the guinea race differentiated more than 3000 BP (Harlan, 1976). On the other hand, since the special race of *durra* is found in India, it is presumed that *durra* there evolved out of races that had arrived from the place of origin around 4000 years ago. However, since *durra* is also distributed mainly in Sudan and Ethiopia, the probability of its simultaneous evolution in northeastern Africa in parallel
with that in India is also conjectured. Moreover, it is supposed that the race of *kafir* which is specifically distributed in Africa differentiated after its ancestral race had spread from the place of origin of *bicolor* to southern Africa. Since in southern Africa the wild type of sorghum, *verticilliflorum*, is also being used as food and for brewing, researchers consider also the probability of evolution of *kafir* race through independent differentiation from *verticilliflorum*. The path of evolution and dispersal of guinea race started from West Africa, spreading to East Africa then to South Africa, where it crossed with *kafir* race, deriving many intermediate races. The *caudatum* race is considered to have differentiated from *bicolor* race in and around the place of origin. Since the distribution of *caudatum* is limited to a narrow area including eastern Nigeria, Chad and Sudan, its differentiation is considered to have taken place relatively recently. As seen from the routes of dispersal described above, it is presumed that sorghum as a crop which had originated in zones in Africa where the rainy season occurs in summer was not able to be grown in Middle East where the dry season occurs in summer or in the desert zones in Sahel which are permanently dry, was hence disseminated to the savannah zones in Africa with relatively abundant rainfall and to India which had traded with such parts of Africa, and differentiated diverse races.

3. Production and yield

In Niger sorghum is produced in the marginal cultivation areas of Sahel / Sudan zone where the annual precipitation exceeds 350 mm, in Sudan savannah zone (600 - 800 mm), and in Guinea savannah zone (more than 800 mm). Niger produces the fifth to sixth largest volume of sorghum in Africa, and it is on the increase (see the figure shown previously, I.13).

The production quantity of sorghum in Niger accounts for one quarter of that for principal cereals (Fig. III.1), and in certain areas, it surpasses pearl millet in the rank of importance as staple food. The area of cultivation is about one half of that of pearl millet, accounting for about one third of the total area of cereals (Fig. III.2). Yield per unit area
is about 0.35 t/ha, about one third of that of maize and slightly lower than that of pearl millet (Fig. III.3). Although simple comparison is not possible because of great variation in distribution and growing environment, the level of productivity per unit area could be regarded as being roughly similar to cases of other minor cereals.

From the statistics of sorghum production by Regions in Niger (Fig III.4), it can be seen that area and harvested quantity are large in southern Regions predominated by Maradi and Zinder, and that the yield per unit area has nothing to do with it. It is also known that the yield in the southern Region of Dosso is high and that the yield in Guinea savannah zone in the South exceeds that of pearl millet. Thus it is evidently shown that the distribution of rainfall determines the distribution and the yield of minor cereals.

![Fig. III.1 Comparison of production quantity of sorghum and other cereals (t)](source: Resultats Provisoires 2007, Synthèse Nationale, Direction de la Statistique, Ministère du Développement Agricole, Niger.)
Fig. III.2 Comparison of cultivation area of sorghum and other cereals (ha)
Source: ditto

Fig. III.3 Yield of sorghum and other cereals (kg/ha)
Source: ditto
3-1 Principal varieties

Cultivars of sorghum in Niger are mostly traditional varieties. The major production areas are situated in Guinea savannah in the South where the rainfall is relatively
abundant. In Sudan savannah with rainfall of 600 - 800 mm the principal crop is pearl millet but sorghum is also often cultivated. There, among durra varieties, those of gooseneck type in which the neck of panicle droops during the ripening period are often cultivated (Photo III.1). Cultivars of this type tend to be less tolerant to humidity and are rarely cultivated in Japan. The cultivation of varieties of gooseneck type was not observed in southern Niger. In the survey conducted in suburban villages of Tillabéri Department of Tillabéri Region, it was revealed that farmers purchased the seeds of traditional varieties from markets or NGOs, and they did not grow and conserve them on their own. The reason for such a circumstance is because they consume the harvest as much as possible, and there seemed to be no custom for farmers to reserve the seeds of varieties of their own according to a systematic scheme.

Photo III.1 Durra lines of the bicolor subspecies of Sorghum bicolor (gooseneck type in which the neck of panicle droops during the ripening period are many).

Gaya of southern Niger near the border with Benin belongs to a Guinea savannah zone with annual rainfall exceeding 800 mm, and hence the plant height of bush trees is relatively tall. Many Hausa people inhabit the area and some villages cultivate sorghum as the principal crop. Cultivars of sorghum there are more frequently late maturing ones.
At the end of the rainy season, namely the early part of September, crops are harvested generally in the order beginning from maize, pearl millet and then sorghum.

Cultivars which are currently being disseminated are F1 varieties developed by INRAN, namely, SEPON, NAD, and SSD. SEPON is a short-stalked variety with a plant height of around 150 - 170 cm and grains in a light yellow color (Photo III.2). Since the yield in the year of droughts was superior to that of traditional varieties, the appreciation is getting higher recently.

![Photo III.2 SEPON is one of the Sorghum F1 varieties (at southwest of Gaya).](image)

We have come across with the cultivation of a variety of extremely long stalks (variety called the sorghum of sorgo-type in Japan) in the flood plains of the Niger River on the border with Benin. The stature is huge with the plant height exceeding 5 m, with large panicles of about 40 cm in length with white grains. This is a traditional variety cultivated by Hausa people. The plant is considered to represent the kind of varieties resulting from the selection which favors the production of larger quantity of
biomass by the maximum utilization of the growing period during the season of relatively abundant rainfall; presumably with the trait showing a high sensitivity to photoperiod. This is one of the varieties with the longest stem length in the world (Photo III.3).

Photo III.3 Indigenous variety of long stalk type which is presumed the bicolor lines of *Sorghum bicolor* (the dry riverbed of the Benin border).

<table>
<thead>
<tr>
<th>name</th>
<th>local variety name</th>
<th>maturity characteristics</th>
<th>morphological characteristics</th>
<th>other characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>dawa</td>
<td>fara-fara</td>
<td>To mature in 4 months, extremely early maturing</td>
<td>The white grain, long stalk type, and the costa is white</td>
<td>lodging resistance</td>
</tr>
<tr>
<td>babandara</td>
<td></td>
<td>To mature in 5 months, early maturing</td>
<td>Red white mixed color, long stalk type, and the costa is red</td>
<td>There is a little sweet taste, and best eating quality. It is many yield, occupies 70% of the cultivation area of the farmer.</td>
</tr>
<tr>
<td>keuobag</td>
<td></td>
<td>To mature in 4 months, extremely early maturing</td>
<td>The head black, the leaf blade is red, and plant length is low (150cm).</td>
<td>It is good to the sickness such as the sunstroke, the variety where vigor comes out, and the woman gets fat.</td>
</tr>
<tr>
<td>mahile</td>
<td></td>
<td>To mature in 4 months, extremely early maturing</td>
<td>Red, and plant length is low (150cm).</td>
<td>red color</td>
</tr>
</tbody>
</table>

*note. From survey in Beng Village, Gaya Department, Dosso Region.*

*Each indigenous variety are long stalk type, those are above 350cm.*
A survey in Beng Village, Gaya Department, Dosso Region, has revealed that the local varieties there are classified according to grain colors and maturity property (Table III.2). There sorghum is cultivated under organic conditions, and people prefer to grow sorghum rather than pearl millet, because the taste is better. *Fara-fara* is normally cultivated in the mixed culture of pearl millet and sorghum but *Banbandawa* is cultivated alone. This is because the latter is strong in competition in mixed vegetation, predominates other plants, and pearl millet cannot catch up with it. It is also tall, and with the growth period extending as long as 5 months, it is the variety which attains the largest size.

The variety which the research and development institution has developed and is promoting aggressively recently is the one called IRAT-204. This is a variety with grains in light yellow color that has been selected from the race of *caudatum*. It is adapted to the areas where the annual rainfall ranges from 500 mm to 700 mm, and it is considered to be preferable to have irrigation facilities. The maturity property is of very early type and matures in 90 days. Plant height is 110 cm and belongs to grain-sorgo type. It has characteristics of high resistance to diseases. Grains contain no tannin, taste good and are considered to be a good source of vitamin A because they contain carotenoid. However, owing to the limited size of biomass it produces, it is conjectured that high yield would not be attained unless a management system of high level of accuracy is adopted. The variety is considered to be unsuitable for the objective to make the best use of the rainy season climate. The documents of INRAN indicate that the yield level of the variety is at 0.4 t/ha under ordinary management and at 0.7 t/ha with irrigation.

As another local variety of excellent traits, there is one called *Mota Maradi*. It is an extremely early maturing variety with a plant height of 2.5 m, and matures in 80 days. It has high levels of resistance against various diseases and insect pests including viruses, and is said to be able to yield 1 - 2 t/ha under favorable conditions.
3-2 Major constraints

Sorghum is attacked by an insect named “paknoda” (*Poophilus costalis*) which constitutes the most serious constraint in sorghum production. The presence of a parasitic weed species of *Scrophulariaceae* called striga (*Striga hermonthica*), is considered to be an important problem in sorghum cultivation. Striga is a small herbaceous plant with a height of about 40 cm, the parasitic infestation by which weakens the host plant and reduces the crop yield. It is reportedly different from the species living on pearl millet.

4. Cropping system and yield

In farming activities during the rainy season, men engage themselves in the cultivation of major cereals like pearl millet, sorghum, maize and rice, and leguminous crops like niébé (cowpea) and groundnut. There are many farmlands where the intercropping of pearl millet or sorghum with a leguminous crop like niébé or groundnut is practiced. On the other hand, many women exploit the spare lands which men do not cultivate, for growing such crops as okra, sesame, niébé, groundnut, hibiscus (bissap) under rain-fed conditions. The farming operations during the dry season concern mainly weeding, intertillage and fertilizer application.

The sowing in the sorghum cultivation in the Tillabéri Department, Tillabéri Region, located to the north of Niamey, takes place in June to August, and is carried out after receiving 2 to 3 times of rain following the field preparation. Transplanting is also practiced rather frequently. The planting density is
maintained by keeping the distance between plants at about 1 m. Cropping is carried out either by intercropping with other crop or by single crop culture. This level of planting density deviates hardly from that for pearl millet. Those farmers who own a large tract of farmland practice both intercropping and single crop culture, but those hold only a small area of farmland always practice intercropping. Intercropped species are niébé and sesame, and the spaces between plants are rather wide. Fertilizers are rarely applied. In the case where compound fertilizers are applied, those with formula of 15 - 15 - 15 are utilized. For weeding, a special tool called “Hilaire” is used to agitate the soil surface in an appropriate manner. In the case of pearl millet, weeding operations are carried out frequently. For intercropping, sesame and niébé are frequently grown (Photo III.4).

5. Storage and marketing

In addition to the consumption by household, products are sold also in markets. It seems that there is no designation of distinct line names, and even the seeds that farmers use for cultivation are purchased in markets. Apparently, the notion that farmers should conserve lines as valuable assets does not exist at all.

6. Future perspectives

In comparison with pearl millet, sorghum is less important in Niger and not much of results of research at INRAN have been identified. Because of the scarcity of budget for research since the 1990s, the research has hardly progressed. On the other hand, the research programs at the Western and Central Africa regional hub Center of ICRISAT include at most the field tests of tolerance of sorghum to drought stress, and the major research efforts on varietal improvement are going on in India. In order to develop varieties adapted to the Sahelian environment, the collection of germplasm and fundamental research on physiology and ecology in the local environment would be needed in the future.
In such context, the germplasm of sorghum in Niger still retains a potential that provides hopes for the future. Since there are not many cases of introduction of hybrid varieties as the products of modern plant breeding, and those of the new varieties from India, Niger still preserves quite a few traditional varieties in store. Since those traditional late varieties with huge biomass can be utilized not only as food but also for fuel, fertilizer and forage, we are able to anticipate the utility of manifold effect about which the application of criteria based solely on grain yield is irrelevant in evaluation. These varieties would receive only a low rating in the breeding system the objective of which is focused on grain production. However, they are supposed to be valuable in the agricultural system of low inputs.

Moreover, we have come across a number of forms of sorghum that are not found in other areas. For example, the long-stalked traditional variety shown in Photo III.3 was cultivated on the marshy ground. The sorghum shown in Photo III.5 was found with many coronal roots (aerial roots). These agronomic or morphological features are such ones as not to be found elsewhere. They forebode the existence of resources holding unknown genetic traits of resistance to high humidity or drought stress. We may be able to have promising perspective with respect to such unknown resources.

Moreover, from the viewpoint of the nutrient components shown in Table III.3, sorghum is superior to milled rice, and it is hence an important nutrient resource in Niger. We may have to take note of the fact that there are many colored races which possess the functionality that cannot be represented by such tables of ingredients.

![Photo III.5 The crown root which occurs from roots of sorghum local variety (aerial root, in western Tillabéri prefecture).](image-url)
Table III.3 The nutrition component of the minor cereals in Niger (per 100g)

<table>
<thead>
<tr>
<th>Crop Name</th>
<th>Energy (kcal)</th>
<th>Crude Protein (g)</th>
<th>Crude Fat (g)</th>
<th>Ca (mg)</th>
<th>Fe (mg)</th>
<th>Vitamin A (ug)</th>
<th>Vitamin B1 (mg)</th>
<th>Vitamin C (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pear millet</td>
<td>haim</td>
<td>256</td>
<td>7.2</td>
<td>3.6</td>
<td>20.0</td>
<td>6.0</td>
<td>0.21</td>
<td>0</td>
</tr>
<tr>
<td>Sorghum</td>
<td>hame</td>
<td>360</td>
<td>7.8</td>
<td>2.5</td>
<td>32.0</td>
<td>8.6</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Foenic</td>
<td>gansi</td>
<td>332</td>
<td>7.1</td>
<td>3.0</td>
<td>41.0</td>
<td>8.5</td>
<td>0</td>
<td>0.24</td>
</tr>
<tr>
<td>Maize</td>
<td>lokotli</td>
<td>350</td>
<td>9.3</td>
<td>3.8</td>
<td>17.0</td>
<td>4.2</td>
<td>4</td>
<td>0.30</td>
</tr>
<tr>
<td>Rice (milled)</td>
<td>masara</td>
<td>354</td>
<td>7.0</td>
<td>6.5</td>
<td>5.0</td>
<td>1.0</td>
<td>0</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Note: From the data of INRAN as for copying, and rice data is reference value.

References

(3) Snowden, J. D. The Cultivated Races of Sorghum. Adlard & Son, 1935
Chapter IV  Other minor cereals

1. Fonio

Fonio (hungry rice) is an annual crop species of genus *Digitaria* of gramineae family (Photo IV.1.1, 2). Its place of origin is considered to be in the regions extending from the headwaters area of the Niger River to the area around the central delta of Mali. As species of fonio, fonio, *Digitalia exlis*, and black fonio, *Digitaria iburua*, are known. They belong to different species, but they are treated as a single commodity of fonio without distinction in the crop statistics.

Fonio is called *acha* in Hausa, and black fonio, *iburu*. In Zarma spoken in western Niger, fonio is called *gansi*. While fonio is grown widely over the area stretching from Senegal to Lake Chad, black fonio is grown in limited areas in Hausa region in northern Nigeria and in a locality in the mountain of Atacora spanning Togo and Benin. In Hausa region black fonio is used as ingredient for making couscous called *wusu-wusu*, and the black fonio grown in Togo is raised by Lamba tribe, and used as raw material to brew a wine called *tchapalo*. Fonio is considered to be the oldest cereal in Africa. In the past when West Africa was more humid than the present time, fonio was presumably grown widely in Niger also, but nowadays it is grown only on a small scale in Regions of
Dosso and Maradi on the border with Nigeria. The cultivated area is 4000 - 5000 ha and the production is around 2000 t (Table IV.1.1).

### Table IV.1.1 The comparison of cultivation area and production on fonio in Niger and neighbor countries

<table>
<thead>
<tr>
<th>Countries</th>
<th>10,000ha</th>
<th>10,000t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niger</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Nigeria</td>
<td>15.8</td>
<td>8.0</td>
</tr>
<tr>
<td>Mali</td>
<td>3.6</td>
<td>2.2</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>1.5</td>
<td>1.1</td>
</tr>
<tr>
<td>Senegal</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Guinea</td>
<td>16.4</td>
<td>17.5</td>
</tr>
<tr>
<td>Cote d'Ivoire</td>
<td>2.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Benin</td>
<td>0.3</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Sources: On the basis of statistical data by each country's agricultural authorities.
Note: Senegal is cultivated equality to Guinea, but data unobtainable.

In West Africa as a whole, it is cultivated on an area of over 300,000 ha, and large areas of cultivation are found in Guinea and Nigeria. In cultivation, seeds are broadcast over the prepared fields at a rate of 1 - 2 kg/are. Seeds germinate in 3 - 4 days after sowing. A sufficient level of yield cannot be expected, unless weeding is practiced at least twice, 2 weeks and 1 month after sowing. Plant height reaches about 35 - 75 cm, and a panicle divides into 2 - 4 rachis-branches of about 15 cm in length. Grains are 1 mm in length, turn yellow at maturity, and shatter easily. Crop can be harvested in 2 - 3 months after
sowing. Entire straws are mowed at the base with a sickle and threshed (Photo IV.1.3). The yield level in Niger is 40 - 50 kg/10 a. For utilization, threshed fonio grains are pounded in a mortar firstly to remove bran and then ground to make fine flour which is prepared into gruel for eating. Whole grains are also steamed and mixed with other ingredients like palm oil, butter and milk, to be prepared into couscous for consumption. Grains are very small in size but highly nutritious (Table IV.1.2). Despite the considerable labor required for processing and preparation because of the extremely small size of grains, since it possesses and provides various advantages including excellent taste, short growth period, and relatively stable yield even in the years when pearl millet and sorghum produce only poor harvest due to the insufficient rainfall, it will continue to be cultivated and utilized in the future as well.

<table>
<thead>
<tr>
<th>Table IV.1.2 Nutritional value of fonio (per 100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Components</strong></td>
</tr>
<tr>
<td>Moisture</td>
</tr>
<tr>
<td>Food energy (Kc)</td>
</tr>
<tr>
<td>Protein (g)</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
</tr>
<tr>
<td>Fat (g)</td>
</tr>
<tr>
<td>Fiber (g)</td>
</tr>
<tr>
<td>Ash (g)</td>
</tr>
<tr>
<td>Thiamin (mg)</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
</tr>
<tr>
<td>Iron (mg)</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
</tr>
</tbody>
</table>

Source: Lost Crops of Africa (1996)
2. Edible gramineae weeds

2-1 Overview

It is known that in African continent many plant species belonging to the genera *Panicum* and *Brachiaria* are distributed abundantly and being used as food even at present. It has been discovered by R. Porters, French ethnobotanist, that animal fonio exists as a cultivated form of *Brachiaria*. Moreover its wild forms are widely distributed in savannahs stretching from Senegal to South Africa, used as wild cereals, the history of which has been indicated to go back at least as old as 6000 years (Sadao Sakamoto, 1988). Furthermore, the wild forms of animal fonio are believed to have become weeds in flooded rice fields and invaded into upland fields of fonio as weeds. Since the cultivated forms are limited to Fouta Djallon highlands spanning Mali, Guinea and Senegal, it is conjectured that the origin of cultivated forms is recent.

### Table IV.2.1 Useful marsh weed of Zaruma*

<table>
<thead>
<tr>
<th>common name</th>
<th>Morphological character</th>
<th>Utilization method</th>
<th>Scientific name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gansi</td>
<td>Head which is similar to <em>P. bisulcatum</em> Thunb. Spotted glume flower adherence, and as for stalk hollow.</td>
<td>Scooping the seed to collect, for food. Processing the stalk, it makes the whistle, just like toy.</td>
<td><em>Panicum laetum</em> Kunth. (It presumes from Zarma language***)</td>
</tr>
<tr>
<td>Ganki</td>
<td>Head which is similar to <em>P. oryzycola</em>, and as for tiller it is many a little.</td>
<td>Scooping the seed to collect, for food.</td>
<td><em>Brachiaria</em>** (It presumes from head form)</td>
</tr>
<tr>
<td>Garuji</td>
<td>The glume flower red brown (wild rice).</td>
<td>Scooping the seed to collect, for food(Food crush).</td>
<td><em>Oryza genus</em>, wild rice.</td>
</tr>
</tbody>
</table>

*: The marsh weed (Bangu-sub) collects the women scooping mainly. Scooping work called "sabe".


***: Hausa calls "garaji" some kinds *Brachiaria*. 
It is estimated that the farming culture of savannah has its origin in the human attempt to obtain food by collecting the grains of wild gramineae plants that had grown during the rainy season of summer monsoon. In the savannahs with abundant rainfall, there are many hydromorphic gramineae plants, among which the rice that has been developed uniquely in West Africa is *Oryza glaberrima*. *Oryza glaberrima* is also one of those plants that have been collected and utilized by humans like other wild gramineae plant species, and it is “a minor cereal that grows in marshy lands” and in that sense it is one of minor cereals. Consequently, in order to fully understand the minor cereals in Niger, it is necessary to take note of also the collection and the utilization of wild gramineae plants that are the cultural elements making up the base of the farming culture incorporating minor cereals.

2-2 Utilization

Zarma people collect and consume as food wild rice (*Oryza glaberrima*) and marshland gramineae weeds (Bong-sub) in the marshes (Bong) and the vicinity of rice fields where wild rice grows found in the suburban area of Kollo, Tillabéri Region in Niger (Photo IV.2.3, 5). Similarly as the case with wild rice, the weeds also are collected by scooping up and utilized as food or toys (Photo IV.2.4). One is a plant called *Gansi* in Zarma, resembling *Panicum scoparium* (Photo IV.2.1). According to Lexique des plantes du Niger, B. Peyre de Fabregues (1979), *Gansi* is *Panicum laetum Kunth*. The literature describes it with the term “le grain = fonio” which shows that it is used as a cereal.
Since the name “Gansi” is the only Zarma word for it, in the Zarma area fonio is not grown, and fonio signifies “processed cereal”, the description, “le grain = fonio”, may have been used to mean “cereal consumed like fonio”. “Crops and Man” by J. R. Harlan also records this botanical name and recognizes it as an important resource plant of minor cereals in Africa.

Moreover, in the vicinity there is found a marshy weed (Bong-sub) resembling *Echinochloa esculenta*, and we have heard that it is also collected and consumed in a
similar manner as food by scooping up (scoop up = sabé). From the morphological characteristics of panicles (Photo IV. 2.2), it has been considered to be a wild species of genus *Brachiaria*. It is estimated that it is a wild species or a related wild species of the animal fonio described by Sadao Sakamoto in his book “Roads traveled by minor cereals”. However, without the availability of animal fonio in Tillabéri Region, the comparison of this unidentified species with animal fonio was not possible. Since animal fonio is grown in Fouta Djallon highlands, the direct comparison between two plants is required. We have purchased samples of fonio in several markets in Niamey, capital city of Niger, but both sizes and colors of seeds varied one another. This shows that different species are sold in markets under the same name of fonio, and hence in the future it is needed to explore and identify the related species of grasses including fonio and animal fonio.
Chapter V  Potential for enhancement of utilization of minor cereals in Niger

1. Relative advantages of minor cereals such as pearl millet and sorghum in comparison with other food crops

The points that can be noted about minor cereals as a whole including pearl millet and sorghum are enumerated as follows by Sakamoto (1988):

① That they are strongly linked to agricultural practices, agricultural rituals and diet culture, and are playing unique roles where cultivation of major cereals such as rice and wheat is dominant.
② That there remain lots of varietal groups which retain high traditional qualities in various regions.
③ That they serve for manifold purposes (not only for eating flour but also for brewing: stalks and leaves for forage, fuel, and building materials, etc.).
④ That they are suited for long-term storage (bundled panicles can be stored in granaries, providing excellent emergency food in case of poor harvest of crops, see Photo V.1, 2).

Photo V. 1 Example of granary (Sadré)

Photo V. 2 Interior of the granary (Sadré)
Moreover, Masuda (2001) has proposed the new value of minor cereals that he has learned from the study of the minor cereals mainly in the Yaeyama region, by stating that “Five Cereals” involve no risk on human beings, who have survived innumerable food crises.

Both grains and stalks/leaves of sorghum are excellent as animal feed not only in developing countries but also industrialized ones. Because of the high resistance to drought, there is a high potential of pearl millet for agricultural development in semi-arid areas like Niger.

2. Reconfirmation of reasons for the continued cultivation of pearl millet and sorghum

Although minor cereals as subsistence crops in Niger have also another aspect of commercial crops for city dwellers, they have distinctive characteristics of relative advantages as subsistence crops at the household level of farmers compared to other cereals in above chapters.

Consequently, in addition to the effort to augment the added value of minor cereals through better processing and marketing, it is also highly necessary to reconfirm the strength of minor cereals that have actual recycling of seeds and biomass under unsteady and insufficient circumstances in external inputs within rural areas.

3. Examples and potential of processed products

There are several products of traditional processed food in Niger. In other countries in West Africa where the religious influence of Islam is limited, there are beers brewed from cereals such as pearl millet and sorghum, including the one called “chapalo” in Togo, and the one called “dolo” in Burkina Faso. They are a kind of alcoholic beverage made by natural fermentation of boiled cereal grains which have been germinated. With a low alcohol content, and not well filtered, they are rather nutritious and reportedly sometimes even taken in place of meals. These beers are not simply beverages. Such
alcoholic drinks play diverse and fundamental roles with social significance; they serve
not only as offerings to spirits in festive occasions but also as a symbol of hospitality, as
payment for labor, or as means of payment or exchange, etc. The use of those beverages
at the harvest festivals and as the offerings to ancestors is especially important. They are
also considered to constitute part of the social capital such as a step to the solution of
community problems. On the other hand, in countries like Niger where the religious
influence of Islam is strong in society, the situation is different. According to a report by
Kurauchi, among the people of Zarma Songhai living in western to central Niger, there
is a cold drink called donou (preparation procedures shown on Photos V 3 - 15, provided by Kurauchi).

As shown in Photo V.3., donou is prepared from the ingredients comprising several
types of spices, tree nuts and pearl millet. It is boiled and made into dumplings. They
are consumed for some days, during which fermentation proceeds and they taste sourer
than newly boiled ones. Some people add sugar, and others yoghurt when drinking
donou. Moreover, the stock of boiling donou dumplings is served as a drink of thin
gruel for infants.

Furthermore, according to a report by Sekiya (2008, from hearings on sites), there are
two kinds of donou, the one called labdoul for women and the other called forgousou

![Photo V. 3 Ingredients of donou](image1.jpg) ![Photo V. 4 Grains of pearl millet](image2.jpg)
Photo V. 5 Grains pounded with a pestle

Photo V. 6 Washing by water

Photo V. 7 Bare kernels washing of the bran

Photo V. 8 Flour milling
Photo V. 9 Sieving

Photo V. 10 Add hot water and pound lightly

Photo V. 11 Roll up into balls and boil

Photo V. 12 If sufficiently boiled, pound balls again
for men. Another report by Osuga (2008, from hearings on sites) describes two main reasons for taking *labdoul* by women, one of which is to enhance the lactation immediately after childbirth. The report says that mothers take it every day for that purpose, because *labdoul* is more nutritious than *forgousou*. The other reason concerns the effort of parents whose daughter has just given birth. For the birth of the first child, a woman returns to her parents’ home, where the parents give their daughter *labdoul* to gain weight after childbirth. Parents are supposed to gain better reputation if their daughter is fat when she goes back to the home of their son-in-law. After the second
child, a woman gives birth in her husband’s home, and this time the husband gives his wife take labdoul so that his parents-in-law are satisfied. Women prefer labdoul and men mainly eat Forgousou though women sometimes eat it too. It is reported that in 95 % of households it is taken by men at lunchtime. The reason why men do not take more nutritious labdoul is that men are likely to have gas at the stomach or have loose bowels when they eat it. Apparently women do not have loose bowels if they take it. It is not clear whether it is due to the physiological difference between them, or it is simply a matter of habit. They say that it is because of the difference in physical construction between man and woman. That women take labdoul while men take forgousou is common all over Niger (in all ethnic groups).

The cases of processing pearl millet into bread, porridge, fermented foods, beverages, and snack items have been confirmed. However, it is not clear which varieties are suited to respective use. Relationship between varietal characteristics and processed products has yet to be clarified.

In this context, as will be described below, it is attempted in urban areas to mix a certain amount of minor cereals in wheat flour when bread is baked. A utilization project of baking sorghum biscuits has also been reported, which is on a small experimental scale (about 50 t). In view of nutritive value, there is a high possibility of processing minor cereals on a small scale.

One of the potential exploitation of sweet varieties of pearl millet would be utilization like sweet corn. In fact, the cases of such utilization in India and Ghana have been found in a literature. Besides, it is possible to produce alcohol from varieties of high sugar content in stalks, although food production from pearl millet should be taken into account. Moreover, stalks are utilized as materials for thatching roofs, making bed mattresses, and as strings for musical instruments in Nigeria (Board on Science and Technology for International Development, 1996).
4. Situation of selling and problems

In the case study by Abele, it has been reported that, from the viewpoint of farmers, sorghum is sold in a greater proportion than pearl millet. However, the paper also reports that farmers sell it immediately after the harvest when the price is low, and buy it for high prices just before the harvest when cereals are scarce. This suggests that the selling of cereals is likely to diminish food security on the level of farmers.

Moreover, it has been reported that, in urban areas, in relation to the price fluctuation of imported wheat, when it increases, certain trials have been made to mix flour of pearl millet or sorghum with wheat flour to bake bread. As a possible destination of marketing surplus crops when the supply exceeds the local demand, the bread making sector may be taken into account (Report of IDRC). The same report mentions the possibility of introducing to West Africa as well a product like ready-mixed flour, which is being sold in Kenya as the ingredient for making ugali.

ICRISAT reports that the flour of pearl millet or sorghum can be added to wheat flour at a rate of 20 % for baking ordinary bread, or 50 % for making steamed bread (Rohrbach, year not specified).

However, regarding the marketing of minor cereals, the following points should be taken into account. The first point is the fact that the utilization of minor cereals is integrated in the daily life of local people as a component, and that the production and the consumption of minor cereals are completed within a local community. The second point concerns biological and sociological significances of minor cereals. Minor cereals, unlike major cereals, are crops which are specific to a particular locality (minor crop). Minor cereals are means for local residents of taking part in their natural environment and of making their living. In this sense, minor cereals have utility value and thus provide satisfaction and pleasure different from those provided by exchange value. For this reason, forced integration of minor cereals into the market economy may cause problems such as environmental impact, loss of biodiversity in germplasm, and disintegration of farming households. It would also be needed to take note of the linkage
between producers and consumers.

Another problem concerns the instability of minor cereals. In Niger in spite of the fact that minor cereals are established staple food, when the rainfall is unreliable, subsistence crops cannot be obtained until the following year. If farmers can afford to purchase food in the market, there is no problem, but almost all rural areas are in chronic poverty, and people are obliged to rely on aid or loan. The management of food crisis in case of such an eventuality would be the challenge to which the government is required to respond.

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Chapter VI  Toward the productivity enhancement of subsistence food crops in Niger

This book has described and discussed the current state and the issues concerning the factors in processes from production to marketing of minor cereals such as pearl millet and sorghum which local people consume as staple food. At least judging from the current state, we may have to conclude that it is necessary and indispensable to provide external assistance for the productivity enhancement of subsistence food crops in countries in West Africa including Niger. In present chapter, as conclusion of the entire volume, the present author would like to describe the external assistance and the approaches which need to be provided or taken by industrialized donor countries and international organizations.

1. Points to take into account in making decision on cooperation policies

The objective of cooperation is to realize the improvement of livelihood of people through the increase of production of food in Niger. The fact that the staple food is provided by pearl millet and sorghum, and maize production is small suggests that the food production of the country is exposed to the harsh natural condition with low rainfall. It is necessary to determine the orientation of cooperation with the country, based on, at the same time, the requirements for improvement that have been revealed through the implementation of agricultural policies, and also by taking into account the fact that the status of rice in Niger is that of cash crop for earning money income rather than that of subsistence crop which is generally considered to be the case elsewhere.

The actual state of Niger is not as simple as that it is sufficient to solve a few problems visible at present. Since the fundamental solution of problems needs to be accomplished only by going through several stages of development, this chapter also proposes stepwise solutions.

Incidentally, aid programs which provide quick remedy for problems would be
readily accepted by Niger farmers who are frequently exposed to famine risks due to
droughts occurring once every few years. However, it is feared that farmers would find
it difficult to accept such programs as those which take time to show effects. It is
needless to say that it is necessary to work out such solutions as those which will arouse
the motivation of beneficiaries even for the programs requiring enduring efforts to
achieve the goal.

2. Factors to be improved in Niger agriculture

In Niger the National Development Plan including the development of agricultural
sector was formulated for the first time in 1960. Subsequently also policies aiming at
poverty reduction were held up, but owing to the instability in politics and economy,
effective results were not achieved. Out of these circumstances, the following factors
have been identified as constraints:

① Insufficiency of the structures for technical guidance and extension for producers,
and lack of their management system and human resources
② Underdevelopment of financing services for purchasing inputs of agricultural
production
③ Insufficiency of information on market for selling products
④ Insufficiency of meteorological information for evading risks
⑤ Lack of facilities for distribution and storage of products

These 5 constraint factors cited can be said to be critical defects in a sense. However,
on the other hand, it is also a fact that by amelioration of the very constraints we surely
can expect the realization of tangible effects. Among five above cited constraints, the
first four are self-evident ones and at the same time also concern widely other external
sectors like education, economy, and communication. Therefore, I would like only to
point out their importance and leave the discussion to different occasions of study.
Regarding the fifth factor of facilities for preservation and storage, because it concerns the building of infrastructure, it may seem to be not related directly to agriculture itself. However, since the building of infrastructure is an indispensable factor for the purpose of supplying the people of the country on a year-round and stable basis with the cereals that are harvested only once a year, I will discuss it later.

3. Goal of the first stage

The improvement of productivity of pearl millet and sorghum that make up the staple food currently is the goal of the first stage. The most serious factor which checks the improvement of productivity is after all the unstable availability of water. The idea that irrigation on a large scale provides the solution would be the most obvious proposition, but to implement it, in addition to the requirement of a huge fund, it involves the question of water sources. Therefore, here I take up a point of improvement at the most familiar aspect.

In this context, I propose the implementation of a program for the effective utilization of limited water resources. Although in Japan that is endowed with relatively stable rainfall the matter may not attract much attention, the question how to make the best use of limited water available presents the biggest challenge even in the major granary belts in the U.S.A. that are major cereals producing areas in the world. The severity of natural conditions may differ in degrees, but the essential fact is similar.

To put it in more concrete terms, it concerns the improvement of seeds. One prerequisite is to develop varieties with high tolerance to drought. However, since it takes time to improve varieties, it is an appropriate strategy for the time being to import existing drought-tolerant varieties.

Regarding seeds, there is another important point to be considered. If farmers repeat the practice of using a part of food reserves as seeds for the subsequent planting for many years, the seed quality deteriorates and the yield shall be reduced as a consequence of it. Furthermore the resistance to diseases and insect pests shall also be
reduced. In order to prevent these problems, it is important to separate strictly, in both phases of production and marketing, the commodity into two portions, one for seeds and the other for general consumption. We hear that farmers eat the grains reserved for seeds in order to survive when the living gets difficult in the event of droughts. It is needless to say that a certain system has to be established so that farmers may be able to get through the situation without eating the grains to be reserved as seeds.

The next issue is the improvement of the production method itself. While in principal regions of production of cereals, the cultural methods enabling the maximum utilization of limited water resources have been developed and extended, in Niger such methods have not necessarily been extended yet. It is in the nature of things to ask for the realization of the utmost effect out of combination of the improvement of varieties and that of cultural methods.

The proposition of the first stage strategy alone would not lead to the augmentation of food production to full or nearly full self-sufficiency in Niger. However, I wish to emphasize the fact that this is an important first step toward the solution of problems.

4. Goal of the second stage

It is said that the efficiency of utilization of surface water in Niger is only less than 1 %. Regrettably we have to admit that it is rather a poor performance for the country which is confronted with the risk of droughts. If we succeed in enhancing the productivity of staple food like pearl millet and sorghum by raising the efficiency of utilization of surface water, there will be another possibility that the crops requiring more water like maize and maize will also be able to be grown in a greater quantity by developing the environment which shall enable the utilization of more of water.

Even if the quantity is small, it is wished that the rain water falling in Niger shall be used to the fullest extent. The rainfall available temporarily in the rainy season makes small otherwise dry watercourses called “wadi”, and it eventually disappears by runoff, evaporation and infiltration into the valley bottom. As the first proposition for the
second stage, I would like to suggest the promotion of effective utilization of such water.

Here one does not envisage a very grandiose scheme. Because the strategy is based on the concept to proceed by starting with what can be done. In other words, it is something like a simplified version of irrigation facilities. In addition to the primary objective of effective utilization of water, such an approach is also essential for enhancing the motivation of farmers.

As a more advanced stage, we may have to consider also full-scale irrigation facilities. It is because, in the pursuit of self-sufficiency of food, it is important to realize not only simple augmentation of production but also the stable production which will be able to resist probable climate changes.

Niger is subject to drought about once every 5 years. Moreover one drought out of 2 is a considerably severe one. While there still remain factors to be determined from now on such as the intensity of droughts or the question where to find water sources, the immediate objective should be at least to bring to a termination the current norm that the area repeats the situation to tide over the crisis of droughts once every few years by resorting to emergency relief.

By increasing the available water resources, there emerges a possibility that the cultivated crops may change. Pearl millet and sorghum will be replaced by maize, rice or root crops like cassava, with potential for higher productivity. Only, we should take note of the question whether these new crops are accepted by Niger people as staple food. If it concerns the raw material for animal feeds, we can focus only on nutritive value, but in the case of human food, we have to place importance not only on nutritive value but also on preference. In order to realize efficient food production, it is likely that the activities shall be required to propose new food to people and promote the consumption.

Incidentally, in implementing cooperation in such a project, considering the harsh natural conditions and the criteria of cost effectiveness, it would be a more practicable
approach not to insist always on the cooperation aiming at the realization of absolute self-sufficiency but rather to envisage also the eventuality of the import of food of the minimum necessity.

5. Distribution and storage of food

(1) Importance of modern systems of distribution and storage

Generally speaking there are many problems in the distribution of food in developing countries. Normally cereals can be stored under room temperature for more than one year after harvest without incurring much deterioration of quality. That is the very reason for which they can make the staple food. In developing countries however, there are considerable losses during the processes of distribution and storage due to inadequate management systems, including theft and the deterioration of quality like infestation of insects and fungi. Because the stolen commodities are sometimes used as funds for supporting activities of illegal organizations, the matter is a serious nuisance.

For the case of Niger, we have to anticipate, instead of seeking the absolute self-sufficiency, the state of importation of minimum necessity, as well as the augmentation of imports in the event of a large scale drought. And if fortunately the domestic production of cereals turns out to be a bumper crop and a surplus is created, the storage as a carry-over to succeeding years has to be considered.

In order to deal with such circumstances, the modern systems for distribution and storage have to be established, in addition to the effort to increase the production. However, it is needless to say that such systems need not to be costly installations, the likes of those found in industrialized countries, but they should be rather the ones corresponding to the existing situation in Niger.

By the way, the agricultural production is susceptible to unpredictable climate, and aid programs in Niger also aim at reducing such risks. In reality, however, the variation in harvest among different regions cannot be avoided. What is needed in meeting such a reality is the establishment of a system that enables efficient distribution of cereals at a
low cost. Although the effort would consist mainly of the development of railways, trucks, and warehouses, sufficient deliberation should be exercised from the viewpoint of effective development of infrastructure as a whole, rather than limiting the scope of vision solely to the distribution of cereals.

(2) Management of cereals

The most important matter in management of cereals in processes of distribution and storage is the prevention of losses and deterioration of quality of the commodity. In more concrete terms, the following two requirements are proposed.

The first requirement is the establishment of the system that prevents frauds in determining the quantity of commodity, in addition to the introduction of good instruments for measurement of quantity. In advanced countries, in addition to the system that the determination of quantity is carried out directly by the government or by quasi-governmental agencies, the mechanism to make the system work correctly is functioning. Simply put, a system that does not allow illegal trading of controlled commodities has been established.

Another requirement is the standardization of cereals. Nutritionally important thing is the ingredients of cereals. The maintenance of nutritional balance of staple food is desirable, but it requires funds and substantial development of facilities to control precisely the ingredients of cereals in distribution processes. Honestly speaking, the time would still not be right for Niger to introduce such a system. On the other hand, the control by much simpler standards should be carried out. Specifically, they should be controlled based on contents of moisture and foreign materials (trash and impurities). Particularly since high moisture content leads to fungi formation and rot, it should be strictly controlled. Moreover, educational effects to raise the motivation of producers and actors in distribution business in favor of the maintenance of quality and standards could be expected by introducing a discriminatory pricing system against the commodities of extremely low quality, through adoption of a measure to control bulk
density (weight of unit volume).

In the domain of assistance in agriculture, arguments often tend to focus on enhancement of productivity, but in actual circumstances, the processes of distribution also need to be equally given due attention. In particular, Japan possesses rich expertise for the management of cereals in storage and distribution through yearly operations associated with handling nearly 40 million tons of cereals, including 9 million tons of domestically produced rice and 16 million tons of imported maize. In this regard, this is a strong area for Japan and therefore the country is capable of contributing a great deal.

(3) Sale of cereals by farmers

In earlier Chapter V’s “4. Situation of selling and problems”, it was pointed out that farmers sell cereals at the time immediately after the harvest when the price is low, and buy them for high prices at the time immediately before the harvest when cereals are scarce. This situation presents an extremely inconvenient element for the improvement of livelihood of farmers. The reason for farmers to sell products immediately after harvest is considered to be the necessity for obtaining cash income. In other words, it suggests that they are fairly reduced to poverty. If the sale by farmers is concentrated around the harvest time, the market price falls much below the level corresponding to the actual supply-demand balance. As long as the harvest of the year is abundant, there would be few problems, but if the harvest is below the level of an average year, it is feared that in the following year the stock will be depleted immediately before harvest time and the market price will rise unnecessarily. Although the fluctuation of prices is a necessary phenomenon from the viewpoint of the function for regulating supply-demand balance, it is desired to prevent them if possible, since unnecessary sharp rises and falls cause a harmful influence to disturb social order. Nevertheless, it should be avoided that public power is exercised to intervene excessively in market to manipulate prices, since the function of regulating supply-demand balance shall be lost then.
The economic phenomenon that market prices fall right after the harvest time due to the concentrated selling by farmers, and that in the following year immediately before the harvest time they rise, used to be also observed in the U.S.A., which is advanced in Agriculture. In order to prevent the harmful effects of this, Chicago Board of Trade (CBOT) was established to trade in futures. This document does not touch on the fact that the trading in futures has solved the problem, since it is outside our subject matter. Thus the cases occurring in Niger used to be experienced in the U.S.A. as well, and therefore are not unique to the country at all.

The problem of seasonal price differential is recognized as an important issue in implementing aid programs as mentioned in “Introduction” without the need to point it out here. I wish to propose a concrete measure, but regrettably there is no measure being able to make a specific medicine. Trading in futures can be feasible only where the standardization of quality has been developed and a sufficient volume of dealing exists, and therefore cannot be counted on. Although it is necessary to improve the farmers’ revenue in order to eliminate the need for farmers to sell products immediately after harvest, the income security for farmers is feared to reduce their motivation for production. Even if the assistance is limited to the provision of loans, it involves many problems like the solution to eventual default, and hence the actual implementation of a specific program is not a simple matter.

While the best solution shall be the augmentation of farmers’ income through the productivity enhancement of farming activities, the productivity enhancement can be realized not only by the elements provided by external initiatives like the infrastructure development or technology improvement but also by the addition of farmers’ own efforts. In this statement, the farmers’ efforts refer not only to the spiritual aspect but also to the investment of their own monetary reserves which enable the productivity enhancement. However, the fact of matter is that the stated scenario is not feasible yet, and therefore simple proposition of a solution is likely to come to a deadlock.

Although the conclusion becomes a conventional one that the comprehensive
measures comprising not only technology transfer and income security but also the education of farmers are needed, the measures would be able to produce effects only by applying a number of different components in a harmonious way under a fine-tuned design which adapts flexibly each elements in conformity with specific needs of a particular region, rather than implementing the whole program as one covering the entire country indiscriminately.

6. Orientation of cooperation

It goes without saying and the concept itself is valid that in Niger the productivity enhancement or the augmentation of absolute production of food crops will contribute greatly to the improvement of livelihood of people. However if one takes into account the harsh climatic conditions, it is feared that the cooperation aiming at attaining full self-sufficiency will lead to excessive investment and be economically inefficient attempt. Regarding the cooperation with the country, in order to maximize also the efficiency of limited amount of financial resources available, we have to explore a realistic solution to make the country capable of earning sufficient funds for importing food, under an assumption that the food of minimum necessity is to be imported. Of course in order to maximize the effective impact of aid, those programs which enable the farmers to become self-reliant are needed. Actually, such programs are nothing but those which will be implemented with the objective to overcome five constraint factors pointed out in “2. Factors to be improved in Niger agriculture”, from the viewpoint of maintenance of consistency and from that of extent of improvement of farmers’ awareness.

While the orientation of aid should essentially conform to the “Rural Development Strategy (SDR)”, I believe that, in some cases, there could be certain approaches in which steady and concrete measures will be taken even if they may be a little bit slow to bring about results, including the step of asking Niger government to respond in a flexible manner, based on the full understanding of fundamental concepts of SDR, so
that the effective impact of aid programs may be maximized. Of course we have to take precautions not to implement imprudently such development programs as those which will inadvertently result in asking the beneficiaries to pay dearly in the future, but, on the other hand, we should equally avoid the situation that really necessary ones are not implemented simply because of the lack of flexible responses of the government.

I dare to repeat the fact that the objective of aid is the improvement of livelihood of Niger people. I would like to point it out again that, while focusing on the aid to agricultural production, aid programs for manifold purposes contributing to attaining the goal are needed, without limiting the scope of interest to production alone.

![Fig. VI Orientation of aid policies](image-url)
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Minor cereals in Niger
—Focusing on Pearl millet and Sorghum—

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