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Bambarra Groundnut

(*Voandzeia subterranea* Thouars)

Abstracts of World Literature 1900-78

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THE INTERNATIONAL GRAIN LEGUME INFORMATION CENTRE
IITA, PMB 5320, Ibadan, Nigeria



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August 1978



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INTRODUCTION

These abstracts of literature on the Bambarra groundnut have been compiled as an activity of the International Grain Legume Information Centre. The Centre is administered as a part of the Library and Documentation Centre of the International Institute of Tropical Agriculture, Ibadan and is supported by a grant from the International Development Research Centre, Ottawa, Canada.

Bambarra groundnut is a potentially important grain legume indigenous to Africa. It is cultivated in tropical and subtropical Africa from the Sahara to Natal. It features prominently in many traditional farming systems in Africa as an intercrop of cereals and root crops. It is also cultivated in parts of Southeast Asia and in Brazil. The seeds contain about 6% oil, 60% carbohydrates and 18% protein and are highly nutritious.

Bambarra groundnut was described by Linnaeus in 1763 and given the name *Glycine subterra*. Du Petit Thouars in 1806 changed it to *Voandzeia subterranea*. Bambarra is the name of a district on the Upper Niger near Timbuktu in Mali while *Voandzeia* is believed to have been formed from the deformation of a Malagasy term "Voandjo" ("Voa" means seed and "anjo" means that which satisfies well). While the African origin of the crop is established, there is no agreement on the exact location; suggested locations include Mali, Madagascar and Angola.

The vernacular names of the crop include: Earth Nut, Ground Bean, Nyimo or Ndhlubu in Rhodesia, Njugo Bean in the Republic of South Africa, Epi roro, Okpa ibi and Guijiya by the Yoruba, Ibo and Hausa of Nigeria respectively, Nzama or Njama in Malawi, Kachang Menila, Kachang poi and Nela-Kadalai in Malaya, Kachang bogor in Java, Guerte or gertere in Arabic, Haricot pistache, Pois arachide, Madagascar groundnut, and Stone groundnut.

This bibliography collates available information on the crop, mostly published and a few unpublished reports. It covers the period 1900-1978.

Collection of Materials: Requests were made to individuals and institutions working on this crop to supply literature. Manual searches of abstracting and indexing journals, bibliographies, were augmented by commissioned computer searches. The major bibliographical sources consulted are listed hereunder. Abstracts have been provided to documents available in the Centre. Some publications which could not be located were however included to make the bibliography as complete as possible. We are continuing to record new literature and we request persons working on Bambarra groundnuts to send us reprints and any available information for inclusion in future supplements.

Availability of Publication: Except those listed hereunder the publications in this bibliography are in the collection of the International Grain Legume Information Centre. Photocopying facilities are available; the current rate is 10 cents a page. Photocopies of a limited number of papers may be provided free of charge to active agricultural workers in developing countries. The following were not available at the Centre at the time of going to press: 015, 023, 038, 045, 054, 055, 065, 075, 089, 100, 102, 106, 111, 114, 117-119, 122, 123, 125, 136, 142, 146, 147, 162-165, 180, 182, 195, 203, 223, 229, 234, 240, 241-260.

Arrangement: Entries are grouped by broad subject categories, and within each category are arranged alphabetically by author. The 260 entries in this bibliography are numbered in one sequence (to facilitate user access). An Author Index, and a Subject Index are provided.

Major bibliographical sources consulted

Abstracts of Tropical Agriculture, Vols. 4(4), 1975-1978
Agrindex Vols. 1-4(5), 1975-1978.
Bibliography of Agriculture, Vols. 1-41(10), 1942-1977.
Biological Abstracts, Vols. 1-65(4), 1926-1978.
Bioresearch Index, Vols. 1-14(4), 1965-1978.
Bulletin Signaletique Section 370; Biologie et Physiologie Vegetales, Vols. 32-39(1), 1967-1978.
Chemical Abstracts, Vols. 1-84, 1907-1976.
Dissertation Abstracts, Vols. 12-38, 1952-1978.
Experiment Station Record, Vols. 12-95, 1900-1946.
Field Crop Abstracts, Vols. 1-31(7), 1948-1978.
Food Science and Technology Abstracts, Vols. 1-10(6), 1969-1978.
Helminthological Abstracts, Vols. 1-47, 1932-1978.
Nutrition Abstracts and Reviews, Vols. 1-46(6), 1931-1978.
Plant Breeding Abstracts, Vols. 1-48(7), 1930-1978.
Review of Applied Entomology, Vols. 1-66, 1913-1978.
Review of Applied Entomology/Review of Plant Pathology, Vols. 1-57(6), 1922-1978.
Soils and Fertilizers, Vols. 1-41(7), 1938-1978.
Tropical Abstracts (continued in 1975 as Abstracts on Tropical Agriculture), Vols. 1-29, 1946-1974.

Language Note: The original language of publication is indicated if it is not English.

Authorship: This bibliography is the joint effort of all the staff, temporary and permanent, of the International Grain Legume Information Centre. Mr. B.O. Adenaike was responsible for the final collation, editing and indexing.

A00 GENERAL

- 001 BURKHILL, I.H. 1906. Bambarra groundnut (*Voandzeia subterranea*, Thou). Bulletin of Miscellaneous Information of the Royal Botanic Gardens Kew, 20: 68-70.

Bambarra groundnut takes its name from a district on the Upper Niger near Timbuctoo. The plant is undoubtedly native to Africa, growing wild on the Upper Nile, both wild and cultivated in Senegambia, and cultivated from the Sahara to Natal. Although it has been introduced to India, Malaya, Brazil and Northern Australia where it gave a large yield, it is not cultivated on a large scale anywhere. The different forms, plant and seed characters, habit and uses are described. *Voandzeia* seeds have a very low oil content (4.53-6.0%). As the seeds mature only underground, earthing up is practised in the Transvaal with the object of burying the flowers which at times are all aerially borne. Differences between *Voandzeia* and *Arachis* seeds are discussed.

- 002 BURKILL, I.H. 1966. *Voandzeia* Thouars. In: A dictionary of the economic products of the Malay peninsula. Vol. 2. Kuala Lumpur, Malaysia. Ministry of Agriculture and Cooperatives. p. 2291-2292.

Voandzeia subterranea is a food plant of African origin which buries its pods underground like those of *Arachis*. Its cultivation in Africa is widespread and its distribution extends to Brazil, Madagascar and Malaysia. There are a number of races of the plant differing in shape of leaf, size, hardness and color of the seeds. The seeds are not oily but about half of their weight is starch and 20% is nitrogenous. There is no demand for them in Europe and no indication they would sell except as a substitute for split peas, but during World War, a substitute for coffee was made of them.

- 003 CHEVALIER, A. 1933. [Bambarra groundnut]. Revue Botanique Appliquee et d'Agriculture Tropicale, 13: 697-705. French.

The botany, geographical distribution, yield, uses and chemical composition of Bambarra groundnuts (*Voandzeia subterranea* Thouars) are discussed.

- 004 COBLEY, L.S. 1956. Bambarra groundnut, earth nut-*Voandzeia subterranea*. In: An introduction to the botany of tropical crops. London, UK. Longmans, Greens & Co. p. 162-163.

Central Africa is suggested as the probable centre of origin of Bambarra groundnut (*V. subterranea*) though found throughout Africa, in Madagascar and parts of tropical central America. The plant is a bunched herbaceous annual with subterranean habit. The morphology of the plant is discussed. The seeds contain 4-6% oil, considerably more protein than this and a starch content of 50-60%. The seeds are used as a pulse either when mature or in the young state.

- 005 DALZIEL, J.M. 1937. *Voandzeia* Thouars. In: Useful plants of West Tropical Africa. London, UK. Crown Agents for the colonies. p. 269-271.

Bambarra groundnut was found growing wild in northern Nigeria. The albuminoid, oil and starch contents are from 16-12%, 4.5-6.5% and 49-59%, respectively. It is eaten extensively in Nigeria. The foliage is not used for fodder, but the seeds when soaked are suitable

for horses.

- 006 DUFURNET, R. 1957. Note sur le voanjobory (*Voandzeia subterranea* Dup. Thouars) cultivate a Madagascar. [Note on Bambarra groundnut (*V. subterranea*) grown in Madagascar]. Riz et Riziculture et Culture Vivrieres Tropicales, (France) 3(4): 169-172. French, English & Spanish summary. 11 Ref.

Observations on climatic and soil requirements, agronomy, productivity and chemical composition of the seed are reported for seven types of Bambarra groundnut, grown at the Lake Alaotra Agronomic Station. At Vohimena, yields of 1300-1500 kg/ha of nuts were obtained.

- 007 FOOD AND AGRICULTURE ORGANISATION (FAO). 1959. Tabulated information on tropical and sub-tropical grain legumes. Italy, Rome. FAO. p. 349-362.

Information is given on morphology and habit; culture; resistance to adverse factors such as high temperatures, frost, shade, drought, water-logging and saline soils; uses; yield and quality of grain legumes including *Arachis hypogaea*, *Cajanus cajan*, *Canavalia* spp., *Cicer arietinum*, *Glycine max*, *Lablab niger* [= *Lablab purpureus*], *Phaseolus lunatus*, *Vigna* spp. and *Voandzeia subterranea*. The variety name, local names, the station submitting the information and the country, are listed for each entry.

- 008 HEPPER, F.N. 1970. Bambarra groundnut (*Voandzeia subterranea*). Review article. Field Crop Abstracts, 23(1): 1-6. 56 Ref.

Reviews the literature on the botany, origin and nomenclature, wild and cultivated forms, cytology, chemical composition, environmental requirements, cultivation, diseases and pests, and uses of the Bambarra groundnut.

- 009 HERKLOT, G.A.C. 1972. Bambarra groundnut. In: Vegetables in South-East Asia. London, UK George Allen and Unwin. p. 268-270.

Gives information on the origin, distribution, common names, morphology, cultivation, chemical composition and ways of cooking Bambarra groundnut.

- 010 HOLM, J.M. and MARLOTH, B.W. 1940. The Bambarra groundnut or Njugo bean. Farming in South Africa, 15: 195-198, 200. 14 Ref. Illus. [Reprinted as Union of South Africa Department of Agriculture and Forestry, Pamphlet No. 215, 10p].

The leguminous Njugo bean (*Voandzeia subterranea*), is a source of edible or industrial oil. In cultivation, the plant requires heat, a frost-free period of 3½ months and a loose sandy loam soil with a fair amount of lime and organic matter. Earthing up at flowering time is essential. Harvesting is done by loosening the soil and pulling up the plant or by using a single furrow plough. Dehused Njugo bean contains 10.3% water, 15.0% protein, 7.4% fat, 5.1% fibre, 59.1% carbohydrate, 3.1% ash, 0.6% P₂O₅, 1.1% K₂O and 0.9% CaO. Collected analyses of the nuts, shells and leaves and of maize, wheat, groundnut kernels, cassava meat, and Indian polished rice are given. History, distribution and description of the bean are also reviewed.

- 011 HOONG FONG, C. 1969. Agricultural and horticultural seeds in Malavsia. Malaya College of Agriculture. p. 33, 89. Illus.

Bambarra groundnut, *Voandzeia subterranea* is illustrated on page 33 of the book. The seeds are 9.6 mm in diameter, and colour ranges from creamy to black, smooth and shiny.

A special characteristic of the seeds is the white hilum.

- 012 IRVINE, F.R. 1969. Bambarra groundnut (*Voandzeia subterranea*). In: West African crops. Vol. 2. London, UK. Oxford University Press. p. 209-210.

It is a small herb growing to 1 ft in height, with compound leaves of three leaflets. The flowers are underground, with pods usually containing one or two seeds, although one variety has three. The fruits are about 1" in diameter, rounded and wrinkled when dry. The seeds are about $\frac{1}{2}$ " in diameter, almost spherical, smooth and hard, and varying greatly in colour, being brown, black, white, yellow, red or variously mottled. It is ready for harvesting 4-5 months after planting. The seeds must be cooked before eating. They contain much less oil than the groundnut but they are a well-balanced food. Cakes fried in palm oil, with pepper and salt, keep better than boiled cakes.

- 013 JACQUES-FELIX, H. 1950. Pour une enquete sur le Voandzou (*Voandzeia subterranea* Thou.). [For an enquiry on Bambarra groundnuts, *V. subterranea* Thou.]. L'Agronomie Tropicale (Paris), 5(1-2): 62-73. French. 45 Ref. Illus.

The author places the centre of origin of *Voandzeia* in the Sudan, where the greatest variability is seen in the cultivated forms and where a spreading type differing from the cultivated bunch types can be found growing wild, spontaneously or in cultivation. The state of knowledge on the geographical distribution, cytology of the plant and the morphology, anatomy, chemical composition and nutritive value of the seed is discussed.

- 014 MUNDY, H.C. 1914. The groundnut or monkey nut. Rhodesia Agricultural Journal, 11: 867-884. Illus.

On p. 869, mention is made of the similarity between the ground-bean or Bambarra groundnut a crop much cultivated by the natives of tropical and sub-tropical Africa, and the groundnut or monkey nut.

- 015 PIOVANO, G. 1964. [Notes on some leguminosae of Mozambique]. Giornale Botanico Italiano, 70(5-6): 643-649. Italian, English summ.

Describes 18 legume species including *Cajanus cajan*, *Dolichos niger* [= *Lablab purpureus*], *Mucuna pruriens utilis*, *Voandzeia subterranea* and *Vigna*.

- 016 PURSEGLOVE, J.W. 1974. *Voandzeia subterranea*. In: Tropical Crops. Dicotyledons, 1. London, UK. Longman. p. 329-332. Illus.

Describes the habit, origin, distribution, morphology, chemical composition, cultivation, pests and diseases of Bambarra groundnut.

- 017 QUIN, P.J. 1959. Foods and feeding habits of the Pedi with special reference to identification, classification, preparation and nutritive value of the respective foods. Ph.D thesis, University of the Witwatersrand, Johannesburg, South Africa. p. 44-47.

Some of the more common concepts on the origin and distribution of Bambarra groundnuts are discussed. The botany, chemical composition and agronomy of the plant, including cultivation, harvesting, threshing, storage, yield and usage are also discussed.

- 018 RABECHAULT, H. 1960. Recueil iconographique des especes comestibles de legumineuses Africaines. [Collection of illustrations of species of edible African legumes]. Riz et Riziculture et culture Vivrieres Tropicales (France), 6(1): 38-44. French. illus.

The importance of grain legumes in human nutrition is stressed. *Voandzeia subterranea* and other legumes, including *Arachis hypogaea*, *Cicer arietinum*, *Glycine max*, *Sphenostylis stenocarpa* etc. are illustrated along with notes on popular names and botanical characteristics.

- 019 RACHIE, K.O. (ed). 1974. Secondary food legumes. In: Litzenberger S.C. (ed). Guide for field crops in the tropics and the subtropics. Washington, D.C., Technical Assistance Bureau, Agency for International Development. p. 162-169.

Bambarra groundnut is a small, bunched annual herb with erect long-stalked, trifoliate leaves. It is widely found in Africa, especially in the semi-arid to subhumid southern fringes of the Sahara, in Eastern Africa from Sudan to Rhodesia, and in the Malagasy Republic. It grows in dry, poor soils and is drought-resistant. It has very low pest and disease susceptibility. Maximum yields of dry seed are about 2,600 kg/ha and average about 750 kg. Unripe seeds are eaten fresh, ripe seeds are used as pulse. It is high in protein, but unlike ordinary groundnuts, contain very little oil. Other legumes discussed include Kersting's groundnut, *Phaseolus* sp., lablab, *Parkia* sp., *Vigna* sp., winged bean, jack bean, African yam bean, Mexican yam bean and *Mucuna* sp.

- 020 RACHIE, K.O. and ROBERTS, L.M. 1974. Grain legumes of the lowland tropics. Advances in Agronomy, 26: 132p. 494 Ref.

Bambarra groundnut is a most extensively cultivated crop in Africa with Nigeria being one of the major producers (100,000 t). The ripe seeds contain 20% protein, 4-7% fat and 50-60% carbohydrate. It may be intercropped with pearl millet or sorghum. It has few diseases and pests, and a chromosome number $2n=22$. It is indigenous to Africa with a broad range of variation occurring in West Africa or East Africa and Madagascar. Other crops reviewed include cowpea, pigeon pea, peanuts, winged bean, lima beans, mung beans, African yam bean, velvet beans etc.

- 021 RACHIE, K.O. and SILVESTRE, P. 1977. Grain legumes. In: C.L.A. Leakey and J.B. Wills. (eds). Food crops of the lowland tropics. London, UK. Oxford University Press. p. 41-44.

Bambarra groundnut, together with Kersting's groundnut, is the third most important legume after groundnuts and cowpeas. It is confined to the hot drier regions between the desert and sub-humid savannah forest land on the southern fringe of the Sahara and in scattered areas in East Africa. Production of seeds in the lowland tropics is from 300-450 thousand t of which Niger alone produces 30,000 t on 40,750 ha and Nigeria 100,000 t. The botany and probable trend of evolution of the plant are also discussed. Seeds take up to 15 days to germinate in the cultivated forms and in the wild relative (var. *spontanea*) it is 31 days. Protein, fat and carbohydrate contents are 16-21, 4.5-6.5 and 50-60%, respectively. It may be planted as a mixed crop with cereals at spacings of 100-200 cm and as a sole crop at 15 x 30, 25 x 30, 20 x 50 or 40 x 40 cm. Superphosphate at 60 kg/ha at planting and ammonium sulphate at 40 kg/ha are economical. Stem and foliage rots are caused by *Sclerotium rolfsii*, *Pythium* sp. and *Rhizoctonia solani*; root rot by *Phytophthora manihoti* and foliage diseases by *Sphaerotheca voandzeia*, *Cercospora canescens* and *Aschochyta phaseolorum*.

- 022 RASSEL, A. 1960. Le voandzou (*Voandzeia subterranea* Thouars) et sa culture au Kwango. [The cultivation of Bambarra groundnut, *Voandzeia subterranea* Thouars in the Kwango]. Bulletin Agricole du Congo Belge, 51(1): 1-26. French, German summ. 8 Ref. Illus.

Voandzeia subterranea grew wild in the Sudan before the introduction of the groundnut (*Arachis hypogaea*). The morphology, selection and cultivation of the plant are described. The seeds have 19.31% crude protein, 7.48% crude fat, 4.74% cellulose, 3.88% minerals, 4.52% sugars and 44.58% starch. The chemical composition is compared with that of groundnut. In Kwango, whole seeds are used by man as food in small quantities either immature or mature, and in other parts of Africa they are made into flour. Their possible use as a feed for livestock, poultry and fish is being studied.

- 023 REPUBLIQUE FRANCAISE. MINISTERE DE LA COOPERATION. 1974. *Voandzou*. [Bambarra groundnut]. In: Memento de l'agronome. Republique Francaise, Ministere de la cooperation. p. 689, 905. French.

Bambarra groundnut is an annual which resembles *Arachis hypogaea* both in cultivation and habit. It is widespread in tropical Africa and Madagascar. It is used mainly for human consumption. Chemical analyses shows it contains: 89.7% dry matter, 19.1% crude protein, 5.8% cellulose, 5.1% fat, 7.9% mineral matter, 0.15% Ca and 0.43% P.

- 024 ROME. INTERNATIONAL INSTITUTE OF AGRICULTURE. 1936. *Voandzeia subterranea* Thouars. In: Use of leguminous plants in tropical countries as green manure, as cover and as shade. Rome, Villa Umberto I. p. 254.

It is a small plant of African origin and subterranean habit. There are a number of varieties of the plant differing in shape of leaf, size, hardness and colour of seeds. The seeds are very nutritious, about half their weight is starch and 20% nitrogenous. There is no demand for the Bambarra groundnut seeds in Europe, and in Nyasaland it is grown as a mixed or sole crop.

- 025 SANDS, W.N. 1931. The Bambarra groundnut in Kedah. The Malayan Agricultural Journal, 19(7): 339-340.

Bambarra groundnut is an annual bearing numerous erect long-petioled trifoliate leaves which are produced from small short creeping stems, whilst the small yellowish coloured flowers are borne on these stems quite close to the ground. A well-drained, sandy loam soil is most appropriate for cultivation with a spacing of 2 ft to 2½ ft square. Two seeds are sown in each hole and the plants mature their small round single-seeded pods in 3-4 months from time of sowing. Yield of dried unshelled nuts is about 800-1000 lb/ac under suitable conditions and two or more crops can be obtained/annum. The usual local method of preparing the nuts for food is to boil them until they become soft and shell the beans afterwards. Uses of the plant include the employment of the nut for food, both for human consumption and for stock and leaves for fodder and green manure.

- 026 SELLSCHOP, J.P.F. 1962. Cowpeas, *Vigna unguiculata* (L) Walp. Field Crop Abstracts, 15(4): 259-266. 85 Ref.

Mentions briefly that in Africa, Bambarra groundnut (*Voandzeia subterranea*) ranks next to cowpeas both in production and as a human food.

- 027 SILVESTRE, P. 1958. Note sur la production des legumineuses a graines alimentaires, dans les territoires Francais d'Outre-mer et leur commerce avec la metropole. [Note on the production of pulses in the French overseas territories and their trade with metropolitan France]. Riz et Riziculture Vivrieres Tropicales (France), 4(2-3): 97-104. French, English & Spanish summ.

The principal pulses grown in tropical countries are *Vigna sinensis*, *Dolichos lablab* [= *Lablob purpureus*], *Phaseolus lunatus* and *Voandzeia subterranea*, but with the exception of *P. vulgaris* and *P. lunatus*, both grown in Madagascar, trade in these legumes with metropolitan France is small. Production statistics and various market prices, export standards, selection and breeding standards achieved to date, are reviewed.

- 028 SMYTH, K.J.F. 1968. Bambarra groundnut or Nguju Mawe (*Voandzeia subterranea*) Ukiriguru Research Notes No. 12.

A one page note on the origin, composition and agronomy, as well as varietal trial of Bambarra groundnut.

- 029 STANTON, W.R.; DOUGHTY, J.; ORRACA-TETTEH, R. and STEELE, W. 1966. *Voandzeia subterranea* Thouars. In: Grain legumes in Africa. Rome, Italy. Food and Agriculture Organisation. p. 128-133. English and French.

Bambarra groundnut is described under the following headings: origin, morphology, pest and diseases, extent of cultivation, place in rotational cropping, time of planting, type of culture, planting distance and depth, rhizobia, cultivars, fertilizers, yields, storage and future prospects.

- 030 THOMS, H. 1899. Afrikanische erderbse *Voandzeia subterranea* (p. 169-170). Mitteilung aus dem pharmaceutisch chemischen laboratorium der Universitat Berlin. Der Tropenpflanzer, 3: 170. German.

A description of bambarra groundnuts, including an illustration, is given on page 169-170. Bambarra groundnut contains 10.2% moisture, 4.53% fat, 5.13% ash, 0.8% phosphorus, 19.20% nitrogenous substances and 49.91% starch.

- 031 THONNER, F. 1915. *Voandzeia* Thouars. In: The flowering plants of Africa. An analytical key to the genera of African phanerogams. London, UK. Dulau & Co. Ltd., p. 227.

The fruit of *V. subterranea* is sub-globular, 1-2 seeded and ripens underground. The fruits are edible and oily.

- 032 VAUGHAN, J.G. 1970. Bambarra groundnut (*Voandzeia subterranea* Thouars.). In: The structure and utilization of oil seeds. London, UK. Champman & Hall Ltd., p. 138-139.

Voandzeia is one of the most important of the local African pulse crops and is found throughout Africa, Madagascar and parts of tropical America. The seed contains 4-6% oil, about 18% protein and 50-60% starch. The subterranean pod has a wrinkled surface and normally contains one, occasionally two, oval or almost spherical seed about 10 mm long. Colour variation of the testa is very marked, being white, red or black. Microscopic details of the testa and embryo are given.

- 033 ZAGORODSKY, M. 1911. Die erderbse (*Voandzeia subterranea* Thou.) und ihre verwertung als futtermittel. [The groundnut (*V. subterranea* Thou.) and its value as feeding stuff.]. Der Tropenpflanzer, 15(8): 413-436. German.

Describes the history and cultivation of the groundnut sometimes called the Madagascar peanut. The coefficients of digestibility were protein 84.2, fat 100.0, nitrogen-free extract 84.3, and fibre 25.6%. Analysis of the unshelled nut was water 15.0, protein 17.9, fat 3.9, nitrogen-free extract 49.1, fibre 10.7 and ash 3.4%.

A01 DOCUMENTATION

- 034 EBONG, U.U. 1971. The Nigerian Grain Legume Gene Bank. Samaru Agricultural Newsletter, 13(2): 21-24. Paper presented at the Ford Foundation/IITA/IRAT Grain Legume Seminar, Ibadan, Nigeria. 1970. 8p.

Gives the history of the Nigerian Grain Legume Gene Bank and describes the species maintained as of 1970. These include *Vigna sinensis*, *Cyamopsis psoraloides*, *Glycine max*, *Phaseolus radiatus* (= *Vigna radiata*), *P. lunatus*, *P. vulgaris*, *P. mungo* (= *Vigna mungo*), *Voandzeia subterranea*, *Dolichos lablab* (= *Lablab purpureus*), *Sphenostylis stenocarpa* and *Canavalia* spp.

- 035 LAWANI, S.M. and RACHIE, K.O. 1975. Announcing pulse cultivars and germplasms for the hultrops. Tropical Grain Legume Bulletin, No. 1, p. 12.

Information is given on the scope of the Tropical Grain Legume Bulletin, a newsletter which contains research notes by scientists or grain legume workers, a space for announcing and describing unique and useful grain legume germplasms and cultivars, and abstracts of current literature on tropical grain legumes, including cowpeas, Bambarra groundnuts, lima beans, pigeon peas, winged bean, etc.

- 036 RAWAL, K.M. 1973. Systematic germplasm collection of grain legumes in West Africa. Proceedings of the First IITA Grain Legume Improvement Workshop 29th Oct.- 2nd Nov. 1973. Ibadan, Nigeria. International Institute of Tropical Agriculture. p. 15-16.

Describes the beginning of what is intended to be a systematic field collection of cultivated and wild grain legumes throughout the lowland humid tropics. In Nigeria collections of *Vigna unguiculata* included 394 cultivated and 49 wild and weedy forms. Other species collected during 1972 were *Sphenostylis stenocarpa* (42), *Voandzeia subterranea* (22), *Phaseolus lunatus* (16), *Cajanus cajan* (5), *Mucuna sloanei* (5), *Canavalia ensiformis* (3), *Kerstingiella geocarpa* (2), and *Lablab niger* (= *Lablab purpureus*) (1).

B00 AGRONOMY

- 037 AUCHINLECK, G. 1910. [Experiments with field crops]. Improvement Reports of the Department of Agriculture West Indies. Reports of Botanical Stations, Grenada, 1910-1911. p. 4-6.

In experimental sowings of *Crotalaria rotusa*, indigo, Bambarra groundnuts, *Tephrosia candida* and sword bean (*Canavalia gladiata*), only the last named germinated well under a cacao shade.

- 038 BONAME, P. 1909. [Cultivation and composition of ordinary groundnuts and the Bambarra groundnut]. Bulletin de la Station d'Agronomie l'île Maurice, 21: 25-31.

Bambarra groundnut belongs to the Leguminosae and is thus capable of using atmospheric nitrogen. Though similar to ordinary groundnuts, its development of leaves is less abundant giving a smaller amount of vegetable matter after harvest. It produces a bunch of upright leaves, and the leaves are developed close around the stem, at a very small depth in the soil. It is a good cover crop and its cultivation is the same as that of the ordinary groundnut. In sowing, 3-4 seeds are put into each pocket, at a depth of 1 in. Yields are usually better than those of groundnuts. It keeps well when nuts are dry and is not attacked by insects. Bambarra groundnut contains a little less phosphoric acid but a greater amount of potash than the ordinary groundnut which also has a greater N content. Uses include nut as food for man and stock, use of leaves for fodder, and as green manure.

- 039 DART, P.J. and KRANTZ, B.A. 1977. Legumes in the semi-arid tropics. In: Proceedings of a Workshop on Exploiting the Legume-Rhizobium Symbiosis in Tropical Agriculture, held at Kahului, Maui, Hawaii. 23-28 August, 1976. p. 119-154.

Though it is also grown in East Africa, Bambarra groundnut (*Voandzeia subterranea* (L) Thou.) is most extensively cultivated in Africa with Nigeria (100,000 tonnes), Niger (30,000 t) and Ghana (20,000 t) estimated to be the main producers. The crop grows on very poor, sandy soils which are marginal for other pulses, as a mixed crop with millet or sorghum, or in pure stands, maturing in about four months. The fruits are developed in the soil, which is often earthed up to help the process.

- 040 DE SCHLIPPE, P. 1956. Shifting cultivation in Africa. The Zande system of Agriculture. London, UK, Routledge and Kegan Paul. 304p. Illus.

Earthnut or Bambarra groundnut is a close relation of the groundnut possessing the same physical characteristics including the subterranean habit. Neither pests nor diseases have been found on the Bambarra groundnut so far and its storage in the form of unshelled pods is easy. It contains 20.8% proteins and 5.8% fat. Calorific, nicotinic and aneurine values are also given.

- 041 DOKU, E.V. 1977. Grain legume production in Ghana. In: Proceedings of the University of Ghana - Council for Scientific and Industrial Research Symposium on Grain Legumes in Ghana, 10-11 December, 1976. Legon, Ghana. Faculty of Agriculture, University of Ghana. p. 1-6.

The cultivated grain legumes of Ghana are in a descending order of importance cowpea, groundnut, Bambarra groundnut and lima bean. Bambarra groundnut is retailed but the amount available at any one time is always less than that of cowpea. It is indigenous to West Africa, adapted to the dry areas stretching as far North as the northern fringes of the Sudan savanna and is most drought tolerant. In the south, it is usually grown in pure stands and at high densities, but in the north it is grown mixed with millets, sorghum, yam etc. It grows well on a variety of soils, especially light and sandy loams, but it also does well on heavier soils. Bambarra groundnut has very few pests and diseases, almost all of which attack under high rain fall conditions.

- 042 DOKU, E.V. and KARIKARI, S.K. 1971. Bambarra groundnut. Economic Botany, 25(3): 255-262. 25 Ref.

In Ghana, Bambarra groundnut ranks second only to cowpeas in production and consumption as it is tolerant of poor soils and drought. It has been cultivated since ancient times, but interest in the crop is very recent. The present state of knowledge regarding the past and present cultivation of Bambarra groundnut is reviewed.

- 043 DUKE, J.A. 1978. Ecosystematic data on economic plants. Beltsville, Maryland, USA. Medicinal Plant Resources Laboratory. Mimeo. 12p.

Mean annual rainfall, temperature and pH values for Bambarra groundnuts (*Voandzeia subterranea*) were 13.8 dm, 22.7°C, and 7.3, respectively. Values were also reported for *Cajanus cajan*, *Canavalia ensiformis*, *Dolichos lablab* [= *Lablab purpureus*], *Glycine* sp., *Phaseolus* sp., *Psophocarpus tetragonolobus* and *Vigna* sp.

- 044 FARRINGTON, P. 1974. Grain legume crops: their role on the world scene and in Australian agriculture. Journal of the Australian Institute of Agricultural Sciences, 40(2): 99-108.

Bambarra groundnut (*Voandzeia subterranea*), a tropical-subtropical legume sensitive to frost and drought, grows best in a temperature range of from 15-30°C. Protein and oil content are 15 and 7%, respectively.

- 045 FREIHERR VON ROTENHAN, D. 1966. [Land use and animal husbandry in Sukumaland, Tanzania. The organization of land management on African peasant farms]. Afrika-Studien II, IFO-Institut Wirtschaftsforsch, Munchen. 131p. German.

The principal crops grown include groundnuts, Bambarra groundnuts, cowpeas, mung beans, chickpeas and some cereals, all of which are grown as pure stands on 65% of the area. Maize, sorghum and legumes are also often grown in mixture in two of the three areas studied.

- 046 JOHNSON, D.T. 1968. The Bambarra groundnut: a review. Rhodesia Agricultural Journal, 65(1): 1-4.

Discusses briefly the botany, agronomy, soils and utilisation of *Voandzeia subterranea*. Low yield of this highly nutritious pulse is attributed to low population and late planting.

With good management, yields are comparatively high. The crop appears singularly free of disease but is attacked by *Meloidogyne javanica* and by *Piezotrachelus (Apton) varium* and *Callosobruchus rhodesianus* in storage.

- 047 KARIKARI, S.K. 1971. Economic importance of Bambarra groundnut. World Crops, 23(4): 195-196. 20 Ref.

The value of Bambarra groundnut (*Voandzeia subterranea*) production in Africa is reviewed. The crop is drought-resistant, comparatively free from pests and diseases and well adapted to poor soils. It is important as a source of protein for human consumption and animal feed and can be sown in sand as a means of erosion control.

- 048 MASEFIELD, G.B. 1970. Bambarra groundnut *Voandzeia subterranea*. In: A handbook of tropical agriculture. Oxford, UK. At the Clarendon Press. 6th edition. p. 35.

It grows much the same way as the bunch type of groundnut and their cultivation methods are the same. It cannot be eaten raw, contains 6% oil and a high content of carbohydrates and proteins. It is grown for domestic consumption in some parts of Africa, the seed rate being about 25 lb., and yield up to 800 lb./ac. of unshelled nuts after 4-5 months.

- 049 NIGERIA. INSTITUTE FOR AGRICULTURAL RESEARCH. 1969. Other legumes: Bambarra groundnuts. In: Annual report of the Institute for Agricultural Research and Special Services, Ahmadu Bello University, Samaru, Zaria, Nigeria. 1967-1968. p. 26, 29.

Bambarra groundnuts were shown to be second in importance only to cowpeas as cultivated grain legumes in Northern Nigeria. Accessions 1862 and 1972 which were resistant to an unidentified virus disease of this crop were recommended for extension, choice of seed color being determined by local preference.

- 050 NYASALAND PROTECTORATE. DEPARTMENT OF AGRICULTURE. 1961. Bambarra groundnuts. In: Annual Report of the Department of Agriculture for 1959-1960. Part 2. p. 41, 205.

Of four stations used for Bambarra groundnut varietal trials, the highest yield of 2340 lb shelled nuts/ac was recorded at Chitedze. Time of sowing had a critical effect on yield thus 14 Dec. 2040, 11 Jan. 430 and 8 Feb. 30 lb shelled nuts/ac. New records of diseases include leaf spot caused by *Cercospora canescens* and *Pseudoplea trifolii*, and wilt caused by *Sclerotium rolfsii* [= *Corticium rolfsii*].

- 051 SAVILE, A.H. and WRIGHT, W.A. 1958. Notes on Kenya agriculture. 3. Oil seeds, pulses, legumes and root crops. The East African Agricultural Journal, 24(1): 1-9.

Notes are given on climatic and soil requirements, cultivation and harvesting methods, and main uses of groundnut (*Arachis hypogaea*), bonavist bean (*Dolichos lablab* [= *Lablab purpureus*]), lima bean, sword bean (*Canavalia ensiformis*), jack bean (*C. gladiata*), chickpea cowpea (*Vigna catjang*), pigeon pea, green gram (*Vigna radiata*), black gram (*V. mungo*), Bambarra groundnut, etc. Spacings, sowing rates, yields/ac. and time to maturity are tabulated for each crop.

- 052 VAN DEN ABEELE, M. and VANDENPUT, R. 1956. Le voandzou (*Voandzeia subterranea* Thou). In: Les principales cultures du Congo Belge [=Zaire]. 3rd edition. Bruxelles, Direction de l'Agriculture, des Forêts et de l'Élevage. p. 864. French.

A description of the botany, cultivation and the results of yield trials of Bambarra groundnut is given.

B01 PLANTING DATE, PLANTING METHOD AND SPACING

- 053 NABOS, J. 1970. [Grain legumes in Niger: present state of research]. Paper presented at the Ford Foundation/IITA/IRAT Grain Legume Seminar, 22-26 June 1970, Ibadan, Nigeria. 18p. French, English translation.

Almost 85% voandzou cultivation is concentrated in the Dosso department, Dogon Douchi sector and 75% of the harvests are exported to coastal countries. Density trials set up in Tarna and Kala Pate during 1965-1967 gave a high density of 0.30x0.15m (222,000 plants/ha). Varietal work in 1964-1967 showed the varieties TV21, TV12, TV37, TV7 and TV83 to be the highest yielders. Groundnuts and cowpeas are also discussed.

- 054 TANGANYIKA AGRICULTURAL CORPORATION. 1956. Reports and accounts for the period 1 April to 30 September, 1955. Dar-Es-Salaam. 83p.

Bambarra groundnut (*Voandzeia subterranea*) did well in the area, but a wide spacing of 36 x 6 in. was unsatisfactory.

- 055 VAN DER WOLK, P.C. 1915. Hilling of *Voandzeia subterranea*. Cultura, 27(328): 405-417.

Common and individual characteristics of groundnut (*Arachis hypogaea*) and Bambarra groundnut (*V. subterranea*) are discussed. Considerable attention is given to the phenomenon of subterranean fruit production common to both plants. In an experiment on the effect of hilling as practised with groundnut, *Voandzeia* plants all died. The author states that hilling creates conditions which favour disease attack.

B02 CROPPING SYSTEMS: INTERCROPPING AND ROTATIONAL CROPPING

- 056 DOKU, E.V. 1967. Are there any alternatives to the traditional bush fallow system of maintaining fertility? Ghana Farmer, 11(1): 27-30, 38. 9 Ref.

In most parts of Ghana, Bambarra groundnut is a prominent intercrop legume. It is mostly intercropped with cereals and groundnuts.

- 057 ISRAELY, E. 1965. La culture des légumineuses alimentaires en Haute-Volta. [The cultivation of food legumes in Upper Volta]. Paper presented at the First FAO Technical Meeting on Improvement of Vegetable and Grain Legume Production in Africa, Dakar, Senegal, 18-24 January, 1965. 8p. French.

The most important legumes in Upper Volta (apart from the groundnut *Arachis hypogaea*) are cowpeas (*Vigna sinensis*), Bambarra groundnut (*Voandzeia subterranea*) and to a lesser extent *Parkia biglobosa* and the haricot kissi (*Phaseolus spp.*). Rotation is recommended for the promotion of legume cultivation.

- 058 OKIGBO, B.N. 1973. Grain legumes in the farming systems of the humid lowland tropics. Proceedings of the first IITA Grain Legume Improvement Workshop, 29 Oct-2 Nov 1973. Ibadan, Nigeria. International Institute of Tropical Agriculture. p. 211-223. 12 Ref.

Bambarra groundnut (*Voandzeia subterranea*) is one of the important food legumes of Nigeria predominantly grown in the more sandy soils of the northern fringes of the humid tropics in the derived savannah zone. It may be grown as a sole crop in rotation with maize, cowpeas, cassava or yam. As one moves northwards, the area of sole cropping increases.

- 059 OKIGBO, B.N. 1978. Cropping systems and related research in Africa. Ibadan, Nigeria. International Institute of Tropical Agriculture. Special Issue on the Occasion of the 10th Anniversary of the Association for the Advancement of Agricultural Sciences in Africa (AAASA). Occasional Publications in Africa OT-1. 81p. 106 Ref. Illus.

The traditional and transitional cropping systems of Africa were discussed. The use of Bambarra groundnuts and other legumes, such as beans, cowpeas, groundnuts, pigeon peas, soybeans, lima beans and *Sphenostylis sp.* were also discussed.

- 060 SINNADURAI, S. 1973. Crop rotation to control nematodes in tomatoes. Ghana Journal of Agricultural Science, 6(2): 137-139. French summ. 5 Ref.

In an experiment conducted over two years, tomato following a clear fallow gave the best yield followed by tomato after cowpea, tomato after Bambarra nut, and tomato after groundnut. Tomato after tomato had the highest number of nematodes followed by tomato after cowpea, tomato after Bambarra nut, tomato after fallow and tomato after groundnut.

- 061 WRIGLEY, G. 1969. Crop rotation. In: Tropical Agriculture: The development of production. London, UK. Faber & Faber. p. 106.

The Magadi crop rotation system of Nyasaland is a 5-10 year rotation based on maize-beans-maize-groundnuts. The maize is often spaced 5ft and the groundnuts interplanted on mounds. The maize and bean crop that follows may be interplanted with cowpeas or Bambarra groundnuts.

B03 CULTIVATION PRACTICES: WEED CONTROL AND HARVESTING

- 062 DE SCHLIPPE, P. 1948. Sous-station d'essais de l'I.N.E.A.C. a Kurukwata. (Extraits du premier rapport annuel). [Test Report of I.N.E.A.C. station. Extracts from the first annual report]. Bulletin Agricole du Congo Belge, 39: 361-402. French. Illus.

The crops grown in this region are groundnuts, cowpeas, maize, sorghum, rice, eleusine, sesame, pigeon peas, Bambarra groundnuts, and Kidney beans. Results show that very high yields are obtained with non-selected varieties and primitive cultural methods.

- 063 HOLLAND, J.H. 1937. Overseas plant products. London, UK. John Bale, Sons & Curnow Ltd. p. 237.

Voandzou or Bambarra groundnut is a tropical and south African pulse crop of great importance in Nigeria. It is grown like groundnut.

- 064 JACQUES-FELIX, H. 1940. L'agriculture des noirs au Cameroun. Enquete sur les plantes cultivees, sur les outils agricoles et sur les greniers. [Agriculture among the negroes of Cameroon. Survey of cultivated plants, agricultural tools and granaries]. Revue Botanique Appliquee et d'Agriculture Tropicale, 20: 815-838. French.

Crops grown by various ethnic groups in the Cameroun include Bambarra groundnuts, cowpeas and groundnuts. Amongst the various tribes, there is varying emphasis on the crop grown.

- 065 LUNAN, M. 1950. Mound cultivation in Ufipa, Tanganyika. East African Agricultural Journal, 16(2): 88-89.

Maize can be interplanted with groundnuts, beans or Bambarra nuts on ridges or occasionally alone with groundnuts on flat surfaces.

- 066 MIRACLE, M.P. 1967. Agriculture in the Congo Basin. Tradition and change in African rural economies. Madison, USA. The University of Wisconsin Press. 355p. Illus.

Cultivation systems of the various tribes of the Congo Basin are described. Among the crops discussed is the Bambarra groundnut, a crop which looks very much like the peanut and has the same subterranean habit of seed development. But differs in having only one seed/pod.

- 067 MUSISI, Y.K. 1970. Bambarra groundnut -*Voandzeia subterranea* (L) Thou. In: J.D. Jameson (ed). Agriculture in Uganda. 2nd Edition, London, UK. Oxford University Press. p. 240.

Although this crop is still grown regularly, very few plots are now cultivated as it has been largely replaced by groundnuts (*Arachis hypogaea*) with which it has similar methods of cultivation. The nuts are only consumed in appreciable amounts in south Buganda and Busoga and are either boiled or roasted. Two groups of cultivars are identified by color of the kernels: the plain brown or black kernel type and the mottled type with brown as the dominant color.

- 068 NIGERIA. FEDERAL MINISTRY OF AGRICULTURE & NATURAL RESOURCES. JOINT PLANNING COMMITTEE. 1974. Chapter 6. Primary Production-Crops. In: Agricultural development in Nigeria, 1973-1985. Lagos, Nigeria. Federal MANR Joint Planning Committee. p, 84, 96.

Historical series on cultivated areas are unreliable, particularly on a breakdown of cultivated areas by component states of the Federation for crops such as locust bean, pigeon pea, Bambarra nut, oil bean, yam bean, sword bean, lima bean and chickpea, which are grown and consumed in some parts of Nigeria.

- 069 PRIESTLEY, M.J.S.W. and GREENING, P. 1956. Ngoni land utilization survey. Lusaka, Zambia. Government Printer. p. 21.

In the Eastern Province of Zambia, yields of Bambarra groundnuts (*Voandzeia subterranea*) probably average only 50-100 lb/ac. Under traditional farming systems, Bambarra nuts are grown in combination with other crops.

- 070 RUTHENBERG, H. 1976. Farming systems in the tropics. Oxford, UK. Clarendon Press. 2nd edition. p. 77, 147.

In Sukumaland, Tanzania, phased planting is practiced for Bambarra groundnuts because of the uncertainty of constant rainfall.

- 071 SILVESTRE, P. 1970. [Irat work on various food grain legumes]. Paper presented at the Ford Foundation/IITA/IRAT Grain Legume Seminar, 22-26 June 1970, Ibadan, Nigeria. 5p. French. English translation.

Bambarra groundnut *Voandzeia subterranea* is cultivated in many regions of Africa and Madagascar though on a small scale. Several varieties have a high yield potential. Other legumes discussed include *Lablab niger* (= *Lablab purpureus*), tepary beans, lima beans, pigeon peas and *Vigna* sp.

- 072 UGANDA PROTECTORATE. DEPARTMENT OF AGRICULTURE. 1953. Bambarra groundnut (*Voandzeia subterranea*). In: Notes on the Principal Annual Food Crops. Uganda, Government Printer. p. 35.

Although Bambarra groundnut is an indigenous and traditional crop of Uganda, it is now not extensively grown. Small quantities are grown on the highly leached soils of Busoga: it has a low oil content and little information is available on its methods of cultivation.

B04 FERTILIZERS, MINERAL NUTRITION, NODULATION AND NITROGEN FIXATION

- 073 DENARIE, J.; ANDRIAMANANTENA, S. and RAMONJY, J. 1968. L'inoculation des legumineuses a Madagascar. Resultats de l' experimentation. [Legume inoculation in Madagascar. Results of trials in 1966-71]. L'Agronomie Tropicale (Paris), 23(9): 925-966. French. English & Spanish summ. 26 Ref.

A series of field inoculation trials were carried out using local *Rhizobium* strains to determine for which legume species and on which soils the absence of specific rhizobia limited nodulation and yield. The species studied included groundnuts, Bambarra groundnuts, soybean and cowpeas.

- 074 DOKU, E.V. 1969. Host specificity among five species in the cowpea cross-inoculation group. Plant and Soil, 30(1): 126-128. 3 Ref.

In a cross-inoculation experiment using crushed nodules from groundnuts, cowpea, Bambarra groundnuts and soybeans, nodule bacteria from soybeans nodulated with all species. Groundnuts and Bambarra groundnuts nodulated with bacteria from all species except cowpeas and lima beans.

- 075 ILLINOIS AGRICULTURAL EXPERIMENT STATION. 1924. Experiments with legumes in Illinois. Illinois Station Report, 1924. 23-25, 33-37.

Many legumes including mung bean, *Phaseolus aconitifolius*, urd bean (*Vigna mungo*), *Voandzeia subterranea* etc. were found to belong to the cowpea inoculation group.

- 076 NNADI, L.A. and BALASUBRAMANIAN, V. 1978. Root nitrogen content and transformation in selected grain legumes. Tropical Agriculture, 55(1): 23-32. 15 Ref. Illus.

Bambarra groundnut roots were found to contain 3.93% total N, 2.10% total water soluble N, 0.97% Ca, 0.55% Mg, 1.52% K and 0.30% P. Net mineralization or immobilization of root N in Bambarra groundnut was 48.7% after 84 days of incubation in fallow soil. Other legumes studied included cowpeas, lima beans, pigeon peas and soybeans.

- 077 THOMPSON, E.J. and DENNIS, E.A. 1977. Studies on nodulation and nitrogen fixation by selected legumes. In: Proceedings of the University of Ghana Council for Scientific and Industrial Research Symposium on Grain Legumes in Ghana, 10-11 December, 1976. Legon, Ghana. Faculty of Agriculture, University of Ghana. p. 85-102. 16 Ref.

Bambarra groundnuts, whose pods develop underground, takes 36+5 days to flower. Its nodules are 2.81-7.5 mm in size, smooth and spherical, with a red or pinkish colour visible through the cortex. Nodule number ranges from 92-318.

B05 PRODUCTION

- 078 NYASALAND, DEPARTMENT OF AGRICULTURE. 1959. A summary of some aspects of agricultural experimental work, 1958/59. 7. Other legumes. Nyasaland Farmer and Forester, 5(1): 7.

Very good yields (up to 3000 lb/ac of shelled beans) were obtained at Chitedze from Bambarra groundnuts planted early on December 11th and allowed to grow for 146 days before wilting and harvesting. Plots in the same field planted on January 24th wilted and harvested after 118 days gave less than one-fifth of the yield of the early planted plots. Up to 65% of the beans broke from the haulm on lifting, and were left in the ground. Gleaning therefore is very important.

- 079 NYASALAND PROTECTORATE. DEPARTMENT OF AGRICULTURE. 1950 Other legumes. Ground beans (*Voandzeia subterranea*). In: Annual Report of the Department of Agriculture for 1958-1959. Zomba, Nyasaland. Government Printer. p. 35, 151.

At Chitedze very good yields of from 1,747-3,373 lb/ac shelled seed were obtained from ground beans planted 11th December, which were able to grow for 146 days before lifting. Gleaning is a very important factor if maximum yield is to be obtained. Leaf spot of the ground bean was caused by *Cercospora canescens* Ell. & Mart.

- 080 SILVESTRE, P. and SOITOUT, M. 1965. Compte rendu. Premiere reunion technique sur l'amelioration et la production des legumes et des legumineuses a grains en Afrique, Dakar, 18-28 janvier 1965. [Proceedings of the first technical meeting on the improvement of vegetables and grain legumes in Africa, Dakar. 18-28 January, 1965]. L'Agronomie Tropicale, 20(8): 747-768. French.

This is a report of the first technical meeting on improvement of production of vegetables and grain legumes including Bambarra groundnuts, cowpeas, groundnuts, soybeans, lima beans and pigeon peas, in Africa.

- 081 SMARTT, J. 1959. Some factors limiting the production of edible legumes in Northern Rhodesia. Proceedings 4th Annual Conference of Professional Officers, Department of Research and Specialist Services. Salisbury, Government Printer. p. 13.

Ground bean or Bambarra groundnut, one of the commonest legumes grown in Africa, possesses subterranean fruits which can be boiled and eaten. Its use in rotational cropping is doubtful and apart from a small local market, the crop is of little economic value.

C00 PHYSIOLOGY, GROWTH AND DEVELOPMENT

- 082 AMUTI, K.S. and POLLARD, C.J. 1977. The metabolism of galactose and the raffinose oligosaccharides by germinating Bambarra groundnut seeds. Phytochemistry, 16(5): 533-537. 18 Ref. Illus.

Stachyose was present in the highest amount in the soluble sugar fraction of dry Bambarra groundnut cotyledons, followed in descending order by raffinose, sucrose and verbascose. During germination in the dark, the stachyose and raffinose content decreased rapidly, but there was little change in the relatively small amount of verbascose present. The sucrose content increased rapidly during the first two weeks and decreased thereafter. Free glucose and fructose were present in the cotyledons after the 7th day and gradually increased in amount with time of germination. Free galactose and other galactose-containing oligosaccharides were not detected in either the dry or germinated Bambarra seeds. During germination, galactose was the only identifiable sugar, aside from traces of sucrose, glucose and fructose, in the extracted soluble sugar fraction in the embryonic axes of all ages when the tissue was incubated with D-[1⁴C] galactose. With the cotyledons, however, most of the radioactivity was in glucose and fructose during the early period of germination and in sucrose later. A small fraction of radioactivity was lost as CO₂.

- 083 BOND, G. 1935. The endodermis in light-grown and etiolated shoots of the leguminosae: a contribution to the causal study of differentiation in the plant. Transactions of the Royal Society of Edinburgh, 58(2): 409-425. 10 Ref.

The distribution of the endodermis in etiolated and light-grown shoots was compared in *Pisum sativum*, *P. jomardi*, *Vicia faba*, *Lathyrus odoratus*, *L. latifolius*, *Lens esculenta*, *Phaseolus multiflorus*, *P. caracalla*, *P. vulgaris*, *Glycine soja*, *Voandzeia subterranea*, *Arachis hypogaea* and *Acacia* sp.

- 084 DOKU, E.V. 1968. Flowering, pollination and pod formation in Bambarra groundnut (*Voandzeia subterranea*) in Ghana. Experimental Agriculture, 4: 41-48. 5 Ref. Illus.

Self and cross pollination, both brought about by ants, occur to varying extents depending on the variety or strain. Cross pollination may be greater in varieties or strains with an open habit resembling that of the wild ancestor, but the bunched types are more likely to be self pollinated.

- 085 DOKU, E.V. 1969. Growth habit and pod production in Bambarra groundnut (*Voandzeia subterranea*). Ghana Journal of Agricultural Science, 2(2): 91-95. French summ. 6 Ref. Illus.

In a small-plot trial, 14 Bambarra groundnut cultivars were ringed with 5% DDT powder to prevent access by pollinating ants. Mean number of pods/plant for controlled and uncontrolled groups of the Bunch, Semi-bunch and Open cvs were 15.24, 8.36 and 7.13, respectively.

- 086 DOKU, E.V. and KARIKARI, S.K. 1970. Flowering and pod production of Bambarra groundnut (*Voandzeia subterranea* Thouars) in Ghana. Ghana Journal of Agricultural Science, 3(1): 17-26. French summ. 3 Ref. Illus.

The flower of *Voandzeia subterranea* is typical of the Papilionaceae. Flowering starts 28 days after germination and, depending on the variety, may not cease before the end of the life of the plant. More flowers and pods are produced during the dry than the rainy season. Fertility coefficient, which is higher for bunch than open varieties, does not differ much in the two seasons although coefficients are slightly higher in the dry season. It is suggested that if water can be provided, the dry season would be better for the cultivation of Bambarra groundnut.

- 087 DOKU, E.V. and KARIKARI, S.K. 1970. Fruit development in Bambarra groundnut (*Voandzeia subterranea*). Annals of Botany, 34(137): 951-956. 4 Ref. Illus.

Flowers of Bambarra groundnut were positively geotropic, whether fertilized or not. The ovary developed only when it was on or beneath the surface of the soil. The pod developed first, during the first 30 days after fertilization; seed development took a further 10 days. There were always two ovules/pod; seeds were not mature until the parenchymatous lining of the shell had disappeared and brown patches had appeared on the sides of the shell.

- 088 DOKU, E.V. and KARIKARI, S.K. 1971. The role of ants in pollination and pod production of Bambarra groundnut [*Voandzeia subterranea*]. Economic Botany, 25(4): 357-362. 7 Ref. Illus.

The role of three species of ants, two of which were identified as *Pheidole megacephala* and *Monomorium pharaonis*, in the pollination and pod production of Bambarra groundnut was studied by comparing plots to which the ants had access with ones from which they were excluded by DDT treatment. Pod production was significantly higher in the presence of ants, while unburied discs were significantly more numerous in their absence; these results applied only to semi-bunched and open varieties. There were no significant differences between treatments when numbers of pods and discs were taken together. It was considered doubtful that the movement of ants in and out of the openings at the tip of the keel petal was the only means of pollination, although they are the only insects known to be associated with the plant.

- 089 KARIKARI, S.K. 1969. Flowering, pollination and pod formation in Bambarra groundnut (*Voandzeia subterranea* Thouars) in Ghana. M.Sc. Thesis, University of Ghana, Legon.

This work attempts a general classification of cultivated Ghanaian varieties of Bambarra groundnuts. Seasonal effects on flowering and yield are also touched upon.

- 090 SKENE, M. 1959. The biology of flowering plants. London, UK. Sidgwick and Jackson Ltd. 8th edition. p. 404.

In *Voandzeia subterranea*, a post-floral movement of the peduncle leads to the burying of the fruiting head.

- 091 SMYTH, K.J.F. 1968. Flowering, pollination and pod formation in the Bambarra groundnut. Ukiriguru Research Notes No. 16

A one-page note on the occurrence of both self and cross pollinated varieties of Bambarra groundnut.

- 092 VISSER, J.H. 1975. Germination stimulants of *Alectra vogelii* Benth seed. Zeitschrift fuer Pflanzenphysiologie, 74: 464-469.

The parasitic plant *Alectra vogelii* is stimulated to germinate by root exudates of host plants once the seed of the parasite has been sensitized by moist conditions at 28°C. Extracts were made of pot leachates from pot grown *Voandzeia*, *Vigna unguiculata*, *Phaseolus multiflorus* and sunflower. After chromatographic separation of the extract fraction, the activity of the extracts was tested with germinating sensitized *A. vogelii* seed. A number of stimulatory zones were discovered which are apparently common to all the hosts investigated.

D00 CHEMICAL COMPOSITION

- 093 ADRIAENS, L. 1943. Les oleagineux du Congo Belge. [Oil containing crops of the Belgium Congo]. Bulletin Agricole du Congo Belge, 34(1-2): 3-110. French.

On pages 87-90, *Voandzeia subterranea* Dupetit - Thouars is discussed. Chemical values of the seeds, mineral matter and the results of an analysis of the pods are presented. Physical and chemical properties of the oils are also given. The chemical composition of seeds from Nigeria, Africa, Mauritius, Madagascar, Congo Belge and the French and English colonies of Africa, as presented by various authors are tabulated.

- 094 ADRIAENS, E.L. 1951. *Voandzeia subterranea* Thouars. In: Les oleagineux du Congo Belge. [The oil plants of the Belgian Congo]. Brussels. Ministere Colonial Director d'Agriculture. p. 122-125. French. 15 Ref. Illus.

Chemical composition, including both organic and mineral contents of Bambarra groundnuts, is given in tabular form. The chemical composition of Bambarra groundnuts from different sources are also compared.

- 095 ADRIAN, J.; OLIVEIRA, J.S. and HELIAS-FRAGNE, R. 1969. Teneur en tryptophane et en vitamine PP des produits vegetaux alimentaires de l'Afrique intertropicale. Annales de la Nutrition et de L'Alimentation (Paris), 23(4): 233-252. French. 17 Ref. Illus.

Bambarra groundnut contains 19.05% protein of which 0.90% is tryptophane, and 1.95 mg vitamin PP/100 g of dry matter. Chemical values are also given for cowpeas, pigeon peas, *Lablab niger* (= *Lablab purpureus*), groundnuts, *Parkia* sp., Kersting's groundnuts, jack bean, *Phaseolus* sp. and *Sphenostylis stenocarpa*. The origin of the Bambarra groundnuts is recorded as Cameroun.

- 096 AMUTI, K.S. and POLLARD, C.J. 1977. Soluble carbohydrates of dry and developing seeds. Phytochemistry, 16(5): 529-532. 29 Ref.

Sucrose was present in seeds of 31 species including groundnut, Bambarra groundnut, pea, cowpea, mung bean, adzuki bean, soya bean and broad bean at all ages and stages of their development. The raffinose family of oligosaccharides was present in most mature and dry seeds.

- 097 ANON. 1909. Some African food grains: Bambarra groundnuts. Bulletin of the Imperial Institute, 7(2): 151-153.

Analyses of a sample of Bambarra groundnut seeds gave the following results: moisture 13.1% ash 2.4%, fat 6.2%, fibre 3.9%, albuminoids (N x 6.25) 16.0%, starch 58.4%, and nutrient value 88.5%.

- 098 ANON. 1916. *Voandzeia subterranea* from the Sudan. Bulletin of the Imperial Institute, 14: 156-158.

Two samples of Bambarra groundnut seeds were analyzed and compared with samples from the northern provinces of Nigeria and from Zanzibar. The nutrient ratio of the Sudan samples was 1: 3.4 and were practically identical in composition but superior to the samples from the northern provinces of Nigeria and from Zambia which had nutrient ratios 1:4.5 and 1:3.9, respectively. No cyanogenetic glucosides or alkaloids were present in the seeds.

- 099 BALLAND, M. 1901. Chimie vegetale - sur le voandzou. [On Bambarra groundnut (Plant chemistry)]. Comptes Rendus de l'Academie des Sciences (Paris), 132(17): 1061-1062. French. 1 Ref.

The geographical distribution and seed characters of *Voandzeia*, a native of tropical Africa, are discussed. When crushed, the seeds yield a white flour with a characteristic beany taste, but when boiled they taste like chestnuts. Chemical composition of the sample from Upper Ubangi is: water 9.8%, fat 6%, nitrogen 18.6%, starch 58.3%, cellulose 4% and ash 3.3%. The author remarks that *Voandzeia* is a natural foodstuff possessing all the chemical components of a complete food in balanced quantities.

- 100 BALLAND, M. 1903. The principal vegetables used as food in the French colonies. Comptes Rendus de l'Academie des Sciences (Paris), 136(15): 934-936.

Chemical composition of the African peanut (*Voandzeia subterranea*), *Cajanus indicus* (= *C. cajan*) and several varieties of beans is reported.

- 101 BONAME, P. 1909 Pistache malgache. [Bambarra groundnut]. Bulletin Economique Colonie de Madagascar et Dependances, 9(2): 446-450. French.

Values for the water, ash, cellulose, fat, dry matter and nitrogen contents of green and ripe Bambarra groundnuts are 56.90, 13.30; 1.73, 3.54; 2.41, 4.37; 3.14, 6.94; 27.40, 55.81; and 8.42, 16.04%, respectively.

- 102 BURTT-DAVY, T. 1907. The Bambarra groundnut. Transvaal Agricultural Journal, 5: 453-456.

Analyses of the Bambarra groundnut (*Voandzeia subterranea*) and other data are quoted. The nuts, which are a favourite article of food in the Transvaal, are similar to peanuts but contain little fat.

- 103 BUSSON, F. and BERGERET, B. 1958. Contribution a l'étude chimique des graines de *Voandzeia subterranea*, Papilionaceae. [Contribution to the chemical study of Bambarra groundnuts, Papilionaceae]. *Acta Tropica*, 15(3): 246-250. French. 18 Ref. illus.

Dry seeds of *V. subterranea*, native of Madagascar and Indonesia, contain H₂O 9.8-12.5, ash 2.45-4.00, Ca 0.038-0.112, Mg 0.091-0.108, P 0.207-0.280, protein 14.7-20.1, fat 6.0-6.9, sugars 56.0-60.0, cellulose 4.0-5.7% and 3.0-5.0 mg vit. B₁/Kg. Paper and column chromatography showed the following amino acids to be present: aspartic acid 11.8, threonine 3.8, serine 5.8, glutamic acid 17.7, proline 5.3, glycine 4.1, alanine 4.7, valine 5.5, methionine 1.9, isoleucine 4.5, leucine 8.1, tyrosine 3.8, phenylalanine 5.8, lysine 6.9, histidine 3.1, and arginine 7.6%; cystine and tryptophan were absent.

- 104 BUSSON, F.; CARBIENER, R.; GEORGIN, A.; LANZA, J. and DUBOIS, H. 1960. Contribution a l'étude de l'influence des facteurs varietaux et ecologiques sur la composition en aminoacides des vegetaux. [A contribution to the study of the influence of varietal and ecological factors, on the amino acid composition of plants]. *Annales de la Nutrition et de l'Alimentation* (Paris), 14(2): 171-176. French. 14 Ref.

Tabulated information is given on the amino-acid composition of the seeds of a number of varieties of *Arachis hypogaea*, *Kerstingiella geocarpa*, *Glycine max*, *Phaseolus lunatus*, *P. vulgaris* and *Voandzeia subterranea* from different parts of Africa. Percentages were found to be remarkably constant within the species. Amino acid values for Bambarra groundnut varieties ranged as follows: aspartic acid 11.5-12.1, threonine 3.6-3.8, serine 5.4-5.8, glutamic acid 16.6-17.0, proline 4.9-5.2, glycine 3.9-4.3, alanine 4.3-4.7, valine 5.1-5.5, cystine 0.9-1.1, methionine 1.7-1.9, isoleucine 4.2-4.6, leucine 7.7-7.9, tyrosine 3.3-3.7, phenylalanine 5.3-5.9, lysine 6.4-6.6, histidine 2.8-3.3 and arginine 6.0-6.7%.

- 105 BUSSON, F. 1970. [Proteines de cereales tropicales et proteines de legumineuses]. Proteins in tropical cereals and leguminous plants. *Voeding*, 31(2): 98-107. French.

Amino acid values of Bambarra groundnut varieties collected from Cameroun and Madagascar ranged as follows: aspartic acid 11.5-12.1, threonine 3.6-3.8, serine 5.4-5.8, glutamic acid 16.6-17.0, proline 4.9-5.4, glycine 3.9-4.3, alanine 4.3-4.7, valine 5.1-5.5, cystine 0.9-1.1, methionine 1.7-1.9, isoleucine 4.2-4.6, leucine 7.7-7.9, tyrosine 3.3-3.7, phenylalanine 5.3-5.9, lysine 6.4-6.6, histidine 2.8-3.3 and arginine 6.0-6.7; and protein content was 19.9%. Chemical values are also given for *Arachis hypogaea*, *Cajanus* sp., *Canavalia* sp., *Dolichos* sp., *Kerstingiella geocarpa*, *Mucuna* sp., *Parkia* sp., *Phaseolus* sp., *Sphenostylis* sp. and *Vigna* sp.

- 106 CERIGHELLI, R.; BUSSON, F.; TOURY, J. and BERGERET, B. 1960. Contribution a l'étude chimique de quelques legumineuses tropicales utilisees dans l'alimentation. [Contribution to the chemical study of some tropical legumes used in nutrition]. *Annales de la Nutrition et de l'Alimentaire*, 14: 162. French.

The amino acid composition of cowpeas, jack beans, Bambarra groundnuts, *Lablab niger* (= *Lablab purpureus*) and some other legumes are presented.

- 107 DENDY, D.A.V.; EMMETT, B. and OKE, O.L. 1975. Minor food seeds: Bambarra groundnut. In: N.W. Pirie, Food protein sources. London, U.K. Cambridge University Press. p. 19.

Bambarra groundnut, *Voandzeia subterranea* contains 10.0% moisture, 21.1% protein, 53.5% carbohydrate, 6.5% fat and a high lysine content of 6.4 g/16 g N. It grows well in light soils, warm to hot climate and the seeds mature in 100-180 days.

- 108 DILHAC, P.; BUSSON, F. and GEORGIN, A. 1959. Note sur l'étude chimique des graines de *Voandzeia subterranea* Thouars. [Note on the chemical study of Bambarra groundnuts]. Riz et Riziculture et Culture Vivrières Tropicales (France), 5(2-3): 120. 2 Ref.

Chemical values for six varieties of Bambarra groundnut (one from the Camerouns and five from Madagascar) ranged as follows: 18.4-21.5 protein N, 11.4-12.0 aspartic acid, 3.6-3.8 threonine, 5.4-5.8 serine, 16.6-17.0 glutamic acid, 4.9-5.2 proline, 3.9-4.3 glycine, 4.3-4.7 alanine, 5.1-5.5 valine, 0.9-1.1 cystine, 1.7-1.9 methionine, 4.2-4.6 isoleucine, 7.7-7.9 leucine, 3.3-3.7 tyrosine, 5.3-5.9 phenylalanine, 6.4-6.6 lysine, 2.8-3.3 histidine, and 6.0-6.7% arginine. No significant varietal differences were found with respect to nutrition.

- 109 EVANS, I.M. and BOULTER, D. 1974. Chemical methods suitable for screening for protein content and quality in cowpea (*Vigna unguiculata*) meals. Journal of the Science of Food and Agriculture, 25(3): 311-322. 12 Ref.

Amino acid and amino acid N, S and cysteine contents, calculated by different chemical methods, are tabulated for Bambarra groundnut, jack bean, lima bean and tepary bean. Bambarra groundnut contains (in g/16 g N): 11.90 aspartic acid, 3.20 threonine, 5.40 serine, 17.00 glutamic acid, 4.10 proline, 3.80 glycine, 3.60 alanine, 4.80 valine, 1.18 methionine, 3.50 isoleucine, 7.40 leucine, 3.20 tyrosine, 5.80 phenylalanine, 3.10 histidine, 7.70 lysine, 7.70 arginine, 1.14 cystine; 3.77 g amino acid N/100 g of meal, 4.48 g total N/100 g of meal, 0.377% total sulphur and 0.154% sulphur amino acids.

- 110 GRESHOFF, M. 1906. Bambarra groundnut. Bulletin of Miscellaneous Information of the Royal Botanic Gardens Kew, 20: 192.

In Western Java, the beans are eaten by the natives and is known to them under the name Katjang bogor (Buitenzorg Beans), because the plant was introduced by the Botanic Gardens at Buitenzorg. At the Laboratory of the Colonial Museum, the composition of *Voandzeia* was found to be: water 12.78%, oil 6.41%, nitrogenous matter 19.12%, starch 49.28%, cellulose 5.79% and ash 3.33%.

- 111 GRIMME, C. 1911. Oil from plants belonging to the order Papilionaceae. Pharmazeutische Zentralhalle (E. German), 52(43): 1141-1149. [Abstract in Journal of the Society of Chemical Industry, 30(24): 1460, 1911].

Oil contents of the seeds of *Cicer arietinum*, *Lens esculentum*, *Cajanus indicus* (=C. *cajan*), *Phaseolus mungo* (=Vigna *mungo*), *P. vulgaris*, *P. lunatus*, *Dolichos lablab* (=Lablab *purpureus*), *Vigna catjang*, *Canavalia ensiformis* and *Voandzeia subterranea* etc. were examined. Physical and chemical constants are reported, and the fatty acids were also studied. All the oils were non-drying in nature.

- 112 HOLLAND, J.H. 1922. *Voandzeia subterranea*. In: The useful plants of Nigeria. Kew Bulletin Additional Series, 9: 231-232.

Bambarra groundnut is widely distributed throughout Africa. Analysis of a sample of seeds from N. Nigeria showed it to contain moisture 13.1, ash 2.4, fat 6.2, fibre 3.9, albuminoids 16.0 (total nitrogen 6.25), starch and other carbohydrates 58.4%, nutrient value of 88.5 and a nutrient ratio of 1: 4.5

- 113 KINYAWA, P.L. 1969. Bambarra nuts - a well-balanced food. Ukiriguru Research Notes No. 27.

Bambarra groundnut (100g wt) contains 11g H₂O, 15.6-21.9g protein, 5.0-7.5g fat, 64g carbohydrates and fibre, 30-100 mg Ca, 100-280 mg P, 7mg Fe, 100mg Mg and 1.2g K.

- 114 MONGODIN, B. and RIVIERE, R. 1965. [Nutritive value of 150 feeds from French-speaking West Africa]. Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux (France), 18(2): 183-218. French. English & Spanish summ.

Data are given on the chemical composition of the seeds of *Vigna unguiculata* and *Voandzeia subterranea*, and of the seeds and leaves of *Cajanus indicus* [= *C. cajan*].

- 115 OLIVEIRA, J.S. 1976. Grain legumes of Mozambique. Tropical Grain Legume Bulletin, No. 3: 13-15. 6 Ref.

Data on the chemical composition of six legumes, including *Voandzeia subterranea* eaten in Mozambique are presented. In Bambarra groundnut protein content is 19.24%, fat 7.84%, carbohydrates 69.28%, cellulose 5.50% and the Energy in calories/100g dry matter is 414. Mineral and vitamin composition are also listed. The other legumes are *Cajanus cajan*, *Dolichos lablab* (= *Lablab purpureus*), *Phaseolus lunatus*, *Mucuna* sp. and *Vigna catjang*.

- 116 OYENUGA, V.A. 1968. *Voandzeia subterranea* Thouars. In: Nigeria's foods and feeding-stuffs - their chemistry and nutritive value. 3rd edition. Ibadan, Nigeria. Ibadan University Press. p. 52-53.

The fat of Bambarra groundnut (*V. subterranea*) is made up of 34.2% linoleic acid, 24.4% oleic acid, 19.4% palmitic acid, 11.8% stearic acid, and 10.2% arachidic, behenic and lignoceric acids. It contains Ca 90.0, P 7.6, Fe 4.0, Vit A 30.0, ascorbic acid 1.0, thiamine 0.30, riboflavin 0.12 and niacin 2.1 mg/100g food. Essential amino acids content in mg/g N are: arginine 394, histidine 188, isoleucine 275, leucine 494, phenylalanine 350, lysine 400, tyrosine 2.9, cystine 180, methionine 113, threonine 219, tryptophan nil and valine 331. Values for its protein content are also given. Nutritive values for groundnut, soyabean, cowpea, lima bean, locust bean, pigeon pea, green gram, kidney bean and *Lablab niger* (= *Lablab purpureus*) are also given.

- 117 PEREIRA, C.A. and SANTOS, D.C.S. 1958. Food of the Angola natives. Chemical composition of *Voandzeia subterranea* seed. Boletim da Escola de Farmacia, Universidade de Coimbra, 13/14: 47-56.

The seeds contain 3.39% total ash, 9.17% fatty oil, 49.25% starch, 4.77% cellulose, 17.51% proteins, 0.038% Ca, 0.224% P, 0.0027% Fe, 242 γ% vit. B₁, 160 γ% vit. B₂, 2 mg niacin, 12.43% water and an energy value of 350 cal./100g.

- 118 PIERAERTS, J.; ADRIAENS, L. and CASTAGNE, E. 1931. Contribution a l'étude du Voandzou. [Contribution to the study of Bambarra groundnut]. Les Matieres Grasses, Paris. No. 274. p. 9090. French.

A sample of *Voandzeia subterranea* seeds from Eala, Belgium Congo contains 15.34% moisture, 3.36% ash, 5.90% oil, 3.17% cellulose, 20.65% nitrogenous matter, 41.93% amylaceous matter 51.58% non-nitrogenous matter and a nutritive value of 178.7.

- 119 PLATT, B.S. 1945. Tables of representative values of foods commonly used in tropical countries. Medical Research Council Special Report Series No. 253. London, UK. HMSO.

Chemical values for Bambarra groundnuts/100g edible portion are: water 10.0 ml, protein 18.0 g, fat 6.0 g, carbohydrate 55.0 g, Ca 90.0 mg, Fe 4.0 mg, aneurine 0.03 mg, riboflavin, nicotinic and ascorbic acids nil, and 346 calories.

- 120 PLATT, B.S. 1965. Tables of representative values of foods commonly used in tropical countries. Medical Research Council Special Report Series No. 302. London, UK. HMSO. p. 1-4, 10-11.

This is the revised edition of the food tables first published in 1945 as No. 253. The chemical values for Bambarra groundnuts/100g edible portion are: water 10.0 ml, protein 18.0, fat 6.0 g, carbohydrate 60.0 g, fibre 3.3, Ca 65.0 mg, Fe 6.0 mg, thiamine 0.3 mg, riboflavin 0.1 mg, nicotinamide 2.0 mg and 367 calories. Values are also given for other crops including *Cicer arietinum*, cowpea (*Vigna spp.*), *Parkia spp.*, *Vigna mungo*, *Cajanus cajan*, goa bean (*Psophocarpus tetragonolobus*), groundnut (*Arachis hypogaea*), sword bean (*Canavalia ensiformis*) etc.

- 121 UCCIANI, E. and BUSSON, F. 1963. Contribution a l'étude des corps gras de *Voandzeia subterranea* Thouars. [Contribution to the study of fatty acids of *V. subterranea* Thou.]. Oleagineux, 18(1): 45-48. French. 19 Ref. Illus.

A sample of seeds of Bambarra groundnut obtained from Bambey, Senegal was analyzed for its oil content. Physical and chemical properties of the oils are given. It contains 6.8% oil, whose fatty acid component is made up of 19.4, 11.8, 24.4, 34.2, 5.3 and 4.9% palmitic, stearic, oleic, linoleic, arachidic and behenic acids, respectively.

- 122 VAN ROSSEM, C. 1927. The composition of the most important vegetable foodstuffs of the Dutch East Indies. Mededelingen vat het Algemeen Proefstation voor den Landbouw. (Buitenzorg) No. 24: p. 76. and also in the International Review of Agriculture, (N.S.). 19(5): 465-466.

Analyses are given of the principal foodstuffs of vegetable origin in the Dutch East Indies including *Arachis hypogaea*, *Glycine max*, *Phaseolus radiatus* (= *Vigna radiata*), *Vigna sinensis* and *Voandzeia subterranea*.

E00 BOTANY, TAXONOMY AND GEOGRAPHICAL DISTRIBUTION

- 123 BAKHAREVA, S.N. 1975. [*Voandzeia* - a useful leguminous crop]. Trudy po Prikladnoi Botanike, Genetike i Seleksii, 54(3): 164-169. Russian. English summ.

Morphological and biological features of *V. subterranea* are described, with information on some local West African varieties which fall into various groups according to their seed colour. The seeds may be spotted, as in Kloglo Apelou Klenzoua, or of one colour, whether white as in Kloglo Oufoue, red as in Kloglo Kokore or black as in Kloglo Ble. The stems and leaves are fed to cattle, while the seeds are boiled or made into soup.

- 124 BAUDET, J.C. 1977. Recherches sur la classification generique des Papilionaceae - Phaseoleae. [Studies on the generic classification of the Papilionaceae-Phaseoleae]. Ph.D Thesis, Universite Pierre et Marie Curie. 213p. French. 166 Ref. Illus.

A choro-ecological hypothesis based on a critical study of non-organographic data at the generic level comprising new observations in areas such as palynology, dermatology, blastology and flavonoid chemistry was adopted in the classification of the Phaseoleae into three subtribes - Cajaninae, Glycininae and Phaseolinae. *Voandzeia subterranea* was classified under the Phaseolinae-Phaseolastreae.

- 125 BRAY, G.T. (ed). 1954. Notes and news section: Bambarra groundnuts. Colonial Plant & Animal Products, 4: 76.

A brief botany of Bambarra groundnut, including its distribution and usefulness, is given. Used mainly for human consumption and livestock feed.

- 126 BRONCKERS, F.; DE KEYSER, B. and STAINIER, F. 1972. Contribution a l'etude palynologique des Papilionaceae-Phaseoleae-Phaseolinae. 2. Etude des genres *Haydonia* R. Wilczek, *Phaseolus* L., *Vigna* Savi et *Voandzeia* Thouars au Zaire. [Contribution to the palynological study of the Papilionaceae-Phaseolaeae-Phaseolinae. 2. Study of the genera *Haydonia* R. Wilczek, *Phaseolus* L., *Vigna* Savi and *Voandzeia* Thouars from Zaire]. Bulletin du Jardin Botanique National de Belgique, 42(1-2): 251-267. French. 11 Ref. Illus.

The pollen of *Voandzeia subterranea* was found to be similar to that of *Vigna campestris* but could still be clearly distinguished.

- 127 BROUK, B. 1975. Plants consumed by man. Bambarra groundnut. London, UK. Academic Press. p. 72-74.

The botany of the Bambarra groundnut is described. It was introduced into Brazil in the 17th century and later to the Philippines and Indonesia.

- 128 DE CANDOLLE, A. 1959. Origin of cultivated plants. New York, Hafner Publishing Company. p. 347-348.

Bambarra groundnut (*Glycine subterranea* Linnaeus Jr.; *Voandzeia subterranea* Petit Thouars) has its probable centre of origin in Africa. It has been found in Madagascar, Southern Asia, on the banks of the Nile from Khartoum to Gondokoro and in Brazil.

- 129 DECARY, R. 1963. Plantes introduites a Madagascar et toponymie locale. [Plants introduced into Madagascar and local toponymy]. Journal d'Agriculture Tropicale et de Botanique Appliquee, 10(5/7): 204-218. French.

This annotated list of plants included Bambarra groundnuts (*Voandzeia subterranea*), pigeon peas (*Cajanus indicus* = *C. cajan*) and dolichos bean (*Lablab vulgaris* = *L. purpureus*).

- 130 DUKE, J.A.; HURST, S.J. and TERRELL, E.E. 1975. Economic plants and their ecological distribution. In: Ecological Distribution of 1000 Economic Plants Informational Dia Alerta. IICA-Tropicos. Agronomia No. 1. Turrialba, Costa Rica. 32p.

Bambarra groundnut, *Voandzeia subterranea* is a subtropical annual herb that grows well in moist and dry habitats. Diploid chromosome number of 22 and an African centre of diversity is recorded for it. It requires a pH of 4.3-6.3, annual precipitation (DM) 5-33 and an annual temperature of 19-27°C. Values for *Cajanus cajan*, *Canavalia ensiformis*, *Dolichos lablab* = *Lablab purpureus*, *Glycine* sp., *Phaseolus* sp., *Psophocarpus tetragonolobus* and *Vigna* sp. are also reported.

- 131 HARMS, H. 1908. Über geocarpie bei einer afrikanischen legumineuse. [Geocarpy in an African leguminous plant]. Berichte Der Deutschen Botanischen Gesellschaft (West Germany), 26a: 225-231. German. Illus.

The botany of the subterranean Bambarra groundnut is described.

- 132 HARMS, H. 1912. Über die heimat der erderbse, *Voandzeia subterranea* (L.) Thou. [Habitat of the Bambarra groundnut, *V. subterranea* (L.) Thou.]. Notizblatt des Königl Botanischen Gartens und Museums zu Dahlem bei Steglitz (Berlin), 5(49): 253-258. German. Illus.

The botany of Bambarra groundnut is discussed.

- 133 HUTCHINSON, J. 1964. *Voandzeia* Thou. In: The genera of flowering plants. (Angiospermae) Dicotyledons. 1. London, UK. Oxford University Press. p. 443. 6 Ref.

Voandzeia subterranea Thou. is a widely cultivated tropical African crop of Madagascar origin. The botany of the crop is briefly described.

- 134 MASEFIELD, G.B.; WALLIS, M.; HARRISON, S.G. and NICHOLSON, B.E. 1969. Exotic legumes: Bambarra groundnut. In: The Oxford book of food plants. London, UK. Oxford University Press. p. 34-35.

Bambarra groundnut, (*Voandzeia subterranea*) seeds have a low oil but a high starch and protein content. The botany of the crop is briefly described. West Africa is given as its

center of origin. Brief notes are also given on pigeon pea, some *Phaseolus* species, cluster bean, winged bean and the *Kerstingiella geocarpa*.

- 135 NEWPORT, H. 1911. The Bambarra groundbean (*Voandzeia subterranea*). Queensland Agricultural Journal, 26(6): 324-327. Illus.

The cultivation and botany of the Bambarra groundnut are discussed including its similarity with the ordinary groundnut (*Arachis hypogaea*). Some of the various common and native names of the crop are also given. Nitrogenous nodules were found on the small fibrous root in fair quantities.

- 136 OCHSE, J.J. and BAKHUIZEN VAN DENBRINK, R.C. 1931. *Voandzeia subterranea* (L) Thouars. In: Vegetable of the Dutch East Indies. Buitenzorg-Java, Archipel Drukkerij. p. 439-441.

The botany of the plant is described. The pods, which develop underground, are widely eaten. It is native to Africa where it is usually cultivated.

- 137 PELLEGRIN, F. 1951. Les legumineuses du Gabon. [The leguminosae of Gabon (French Equatorial Africa)]. In: Memo. No. 1 de l'Institut d'études Centrafricaines. p. 160-161. French.

The book gives a botanical description with keys for the determination of genera and species of 126 genera and 450 species of Leguminosae with notes on their use, common names and geographical distribution. Among them are *Voandzeia* species.

- 138 STEELE, W.M. 1965. The cowpea *Vigna unguiculata* L. Walp., the Bambarra groundnut *Voandzeia subterranea* L. DC. and the lima bean *Phaseolus lunatus* L. in Northern Nigeria. Samaru, Institute for Agricultural Research, 7p. [Paper read at FAO Technical Meeting on Improvement of Vegetable and Grain Legume Production in Africa, Dakar, 18th-24th January, 1965]. 13 Ref. Illus.

Bambarra groundnut (*Voandzeia subterranea*) is second in importance to cowpea although not as widely distributed and there is little variation in the Northern Nigeria collection.

- 139 UPHOF, J.C. TH. 1968. *Voandzeia*. In: Dictionary of economic plants. Lehre, Verlag von J. Cramer. 2nd Edition. p. 548.

Voandzeia poissoni Chev. is a herbaceous tropical African bean eaten by natives of Dahomey. *V. subterranea* Thou. is an annual herb of uncertain origin, probably from tropical Africa. It is extensively cultivated, its fruits ripen in the ground like those of *Arachis hypogaea* L. and the seeds are consumed as food by the natives of Africa.

E01 HISTORY, ORIGIN AND EVOLUTION

- 140 DARLINGTON, C.D. and JANAKI-AMMAL, E.K. 1945. Chromosome atlas of cultivated plants. London, UK. George Allen and Unwin Ltd. p. 172.

Bambarra groundnut (*Voandzeia subterranea*) seeds are edible by man and Madagascar is regarded as the centre of origin.

- 141 ESCALANTE, M.G. 1956. *Voandzeia subterranea* (L) Thouars. Una interesante leguminosa geocarpica introducida por la Division de Exploraciones e Introduccion de Plantas. [*V. subterranea*, an interesting geocarpic legume introduced by Division of Plant Exploration and Introduction]. Revista de Investigaciones Agrícolas B. Aires, 10(1): 35-42. Spanish. 7 Ref. Illust.

Seeds of *V. subterranea* introduced into Argentina from Australia in 1951 germinated well. A morphological and histological description is given of this plant as well as notes on seed germination.

- 142 GUILLEMIN, J.A.; PERROTTET, G.S. and RICHARDS, A. 1832. *Florae Senegambiae* Tentamen. Paris 1831-1832. p. 254.

Voandzeia subterranea occurs both wild and in cultivation in Senegambia.

- 143 HARLAN, J.R. 1971. Report of survey of genetic resources in Africa. 20p. Mimeo. 11 Ref. Illus.

A survey was undertaken to determine the location of primitive cultivars of sorghum, millets, barley, wheat, African rice, cowpeas and *Voandzeia*, and when possible to obtain information on their genetic characteristics and the degree of genetic erosion present in these regions. Reports that wild or cultivated forms of *Voandzeia* are present in Botswana, Cameroon, Chad, Dahomey, Ethiopia, Ghana, Ivory Coast, Malawi, Mali, Nigeria, Rhodesia, Tanzania, Uganda, Upper Volta, Zaire and Zambia.

- 144 HEPPER, F.N. 1963. Plants of the 1957-58 West African Expedition. 2. The Bambarra groundnut (*Voandzeia subterranea*) and kersting's groundnut (*Kerstingiella geocarpa*) wild in West Africa. Kew Bulletin, 16(3): 395-407. 20 Ref. Illus.

An account of the finding of *Voandzeia subterranea* and *Kerstingiella geocarpa* is given and reasons stated for the belief that they grow wild in North Eastern Nigeria-North Cameroon region. Notes on the seed-types and their germination are given.

- 145 JACQUES-FELIX, H. 1946. Remarques sur l'origine et la geocarpie du *Voandzeia subterranea* Thou. (Pap). [Observations on the origin and geocarp of *Voandzeia subterranea* Thou. (Pap)]. Bulletin de la Societe Botanique de France, 93(9): 360-362. French. 5 Ref. Illus.

New facts on the Bambarra groundnuts since Harm's work of 1912 are reported. The samples studied are from Yola Garoua, Oubangui and Adamawa, all in the Cameroun.

- 146 MUNDY, H.C. 1932. Twenty-one years of plant introduction and trial in S. Rhodesia. Rhodesia Agricultural Journal, 29: 503-516.

On page 507, Bambarra ground-bean (*Voandzeia subterranea*) is said to be a native of N'Yemo and a good drought resister but small yielder.

- 147 PERRIER DE LA BATHIE, H. 1931. Les plantes introduites a Madagascar. [Plants introduced to Madagascar]. Revue de Botanique Appliquee et d'Agriculture Tropicale, 11(121): 719-729.

Briefly described is the introduction and cultivation of Bambarra groundnut and its use as human food.

- 148 SIMMONDS, N.W. (ed). 1976. Bambarra groundnut. In: Evolution of crop plants. London, UK. Longman Group Limited. p. 314-315.

Wild Bambarra groundnut, *Voandzeia subterranea* subsp. *spontanea* can be found from the Jos Plateau and Yola (northern Nigeria) to Cameroun and possibly to the Central African Republic. It differs greatly from the subsp. *subterranea* which has a clustered habit with short nodes, in having diffuse growth and more scattered pods. Both have chromosome number $2n=22$.

- 149 STAPF, O. 1912. A new ground bean (*Kerstingiella geocarpa*, Harms.): With a note on the discovery of *Voandzeia subterranea* in the wild state. Bulletin of Miscellaneous of the Royal Botanic Gardens, Kew. 26(5): 209-213. 7 Ref.

Morphological differences between *Kerstingiella geocarpa* and *Voandzeia subterranea* are noted. The simultaneous discovery of the wild form of *Voandzeia subterranea* in August, 1909 by Dr. Dalziel in the Kilba country, north of Yola and close to the frontier of German Adamaua, and by C. Ledermann, near Garua in German Adamaua is also reported.

- 150 WILLIS, J.C. 1966. *Voandzeia* Thou. Leguminosae. In: A dictionary of the flowering plants and ferns. 7th edition. Cambridge, UK. University Press. p. 1185.

Briefly mentions the fact that *V. subterranean* Thou. is a tropical African crop of Madagascar origin. Its young fruit is buried in the ground like those of *Arachis*, the seed is edible and the plant is largely cultivated.

- 151 ZEVEN, A.C. and ZHUKOVSKY, P.M. 1975. *Voandzeia subterranea* Thouars. In: Dictionary of cultivated plants and their centres of diversity, excluding ornamentals, forest trees and lower plants. Wageningen, Centre for Agricultural Publishing and Documentation, p. 120.

Bambarra groundnut (chromosome number $2n=22$) occurs wild in Africa, and is distributed throughout Africa from where it later spread to America and Asia.

F00 GENETICS AND PLANT BREEDING

- 152 KARIKARI, S.K. 1972. Correlation studies between yield and some agronomic characters in Bambarra groundnut (*Voandzeia subterranea* Thouars). Ghana Journal of Agricultural Science, 5(1): 79-83. French summ. 11 Ref.

In 27 local varieties of Bambarra groundnut, there was some association between the number of days from sowing to germination, earliness, internode length, petiole length, number of stems/plant, terminal leaf area, shell thickness, number of pods/plant, number of seeds/pod, seed size and yield of seeds/plant. Fifty-five coefficients show the degree of correlation between 11 agronomic characters. Yield was highly significantly and positively correlated with days to first germination and maturity, number of pods/plant, number of seeds/pod, and 100 seed weight, and negatively correlated with the other characters. Although yield is highly correlated with all 10 characters, earliness in germination and maturity, number of pods/plant, number of seeds/pod, number of stems/plant and seed size appear to be the best criteria for selection.

- 153 KARIKARI, S.K. and LAVOE, S.K. 1977. Preliminary evaluation and utilization of fourteen cultivars of Bambarra groundnut (*Voandzeia subterranea* Thouars). Acta Horticulturae (Netherlands), 53: 195-199. 3 Ref.

Agronomic parameters of 14 local cultivars of Bambarra groundnut ranging in plant habit from bunch to semi-bunch, were correlated with yield. Days to maturity, number of pods/plant, number of seeds/pod and 100-seed weight were very highly correlated with yield, the coefficients in all 14 cvs. being greater than 0.8. Days to first germination, petiole length and number of stems/plant were highly correlated with yield, these correlations being greater than 0.7 but less than 0.8. In terminal leaf area and shell thickness, correlations of less than 0.6 were observed.

- 154 REPUBLIC OF ZAMBIA. DEPARTMENT OF AGRICULTURE. 1974. Oil seeds and grain legumes. In: Annual Report of the Research Branch of the Ministry of Rural Development for 1972-1974. p. 41, 48 and 127.

At Kataba valley substation in the Western Province, local cultivars far out-yielded imported varieties. At Sesheke, Bambarra groundnuts gave practically no yield in the drought season. Leaf spot of *Voandzeia* caused by *Phyllosticta* sp. were recorded for the first time.

- 155 REPUBLIC OF ZAMBIA. DEPARTMENT OF AGRICULTURE. 1975. Minor grain legumes. B. Bambarra (*Voandzeia* sp.). In: Annual Report of the Research Branch of the Ministry of Rural Development for 1973-1974. p. 82.

At Kataba, emergence and early growth of 20 selections of Bambarra groundnut was good although infection by *Cercospora* leaf spot and *Elsinoe* (scab) together with a poor climate resulted in poor yields. At Lusitu, planting on the flat in the wet season gave good results probably because of good drainage. Other crops tested include lima bean, pigeon pea, mung bean, winged bean, velvet bean, cowpeas, groundnuts and soybeans.

- 156 TARDIEU, M. 1958. Les cultures d'appoint dans la zone d'action du CRA de Bambeý. [Secondary crops in the action zone of the Agronomic Research Centre, Bambeý]. Bulletin Agronomique Ministère de la France d'Outre Mer., 17: 5-54. French. 37 Ref. Illus.

Varietal characters and the cultivation of crops of secondary importance grown in Sudanese region of French Africa, are described. These crops include *Vigna sinensis*, *Dolichos lablab* (= *Lablab purpureus*), *Voandzeia subterranea* etc. In some cases, mention is made of ways in which breeders could improve these crops.

F01 BREEDING AND SELECTION

- 157 ADANSI, M.A. 1975. Master register of economic plants (excluding cocoa) in Ghana. Crops Research Institute Bulletin No. 4. Ghana, Council for Scientific and Industrial Research. p. 74.

The varieties of *Voandzeia subterranea* in Ghana, including source and year of introduction and station where kept are reported in tabular form.

- 158 ANON. 1911. The Bambarra groundnut. Queensland Agricultural Journal, 26(2): 78-81.

Seeds of a species of earthnut received from Mr. R. Echlin, of Gatton are being tested. The native African name of the seeds is "Masubla" and its usefulness as human food was proved after the nuts were used to sustain a native on a 100-mile journey. Available information on the crop contained in Bulletin No. 21 of the "Agricultural News" (Barbados) is presented.

- 159 CORRIOLS, J. 1951. Les cultures vivrières dans les territoires relevant du secteur Soudanais de Recherches Agronomiques: leur améliorations. [The food crops of the territories in the sphere of activity of the Sudanese Agronomic Research Sector: their improvement]. L'Agronomie Tropicale, 6(7/8): 412-419. French.

The principal food crops grown in the Sahel, Sudan and Guinea (French Africa) are reviewed and the possibility of improving them through selection is examined. These crops include (*Vigna catjang* = *V. unguiculata cylindrica*), lima bean, hyacinth bean (*Dolichos lablab* = *Lablab purpureus*), Kersting's groundnut (*Kerstingiella geocarpa*) and Bambarra groundnut (*Voandzeia subterranea*).

- 160 DOKU, E.V. and KARIKARI, S.K. 1971. Operational selection in wild Bambarra groundnuts. Ghana Journal of Science, 11(1): 47-56. 5 Ref. Illus.

From observations on 27 types of Bambarra groundnut in the Legon collection (nine each with bunch, semi-bunch and open habit), it was concluded that the cultivated *Voandzeia subterranea* var. *subterranea* originated from the wild *V. subterranea* var. *spontanea* through a series of gradual changes, which are still taking place. These changes include change from open to bunch habit, change from outbreeding to inbreeding, and a reduction in shell thickness and in leaf area.

- 161 FOOD AND AGRICULTURE ORGANIZATION. 1961. Agricultural and horticultural seeds. FAO Agricultural Studies, No. 55. Italy, Rome. FAO.

Seed yield of Bambarra groundnut is usually between 300 and 800 kg/ha.

- 162 INSTITUT NATIONAL POUR L'ETUDE AGRONOMIQUE DU CONGO BELGE. (INEAC). 1950. Rapport annuel pour l'exercice 1949. [Annual report for 1949]. Gembloux. p. 285.

Investigations were reported from various INEAC stations. *Voandzeia subterranea* varietal trials were discussed.

- 163 INSTITUT NATIONAL POUR L'ETUDE AGRONOMIQUE DU CONGO BELGE. (INEAC). 1951. Rapport annuel pour l'exercice 1950. [Annual report for 1950]. Gembloux. p. 352.

Investigations were reported from various INEAC stations. *Voandzeia subterranea* varietal trials were discussed.

- 164 INSTITUT NATIONAL POUR L'ETUDE AGRONOMIQUE DU CONGO BELGE. (INEAC). 1951. Rapport annuel pour l'exercice 1951. [Annual report for 1951]. Gembloux. p. 381.

Investigations were reported from various INEAC stations. *Voandzeia subterranea* varietal trials and sowing methods were reported.

- 165 INSTITUT NATIONAL POUR L'ETUDE AGRONOMIQUE DU CONGO BELGE. (INEAC). 1961. [Bambarra groundnuts]. Report of INEAC for 1959-1960. p. 229 & 231.

In selection trials at Kiyaka Experimental station, the yields of varieties of Bambarra groundnuts, (*Voandzeia subterranea*) ranged from 1725 to 1792 kg of seed/ha. In cultivation trials, the highest yields were obtained from sowing at a depth of 3-6 cm.

- 166 MALAWI. AGRICULTURAL RESEARCH COUNCIL. 1972. Groundbean (*Voandzeia subterranea*). In: The Annual Report of the Agricultural Research Council of Malawi for 1971. p. 42.

From a red kernelled sample, chosen from some ten distinct types originally mass selected on kernel appearance ranging from cream to deep purple, some 120 single plant selections were made and progeny rowed. Within the progeny rows there was no variation in foliage, pod or kernel characters but there were obvious differences between the rows, which included variation in plant size and amount of anthocyanin intensity in leaves and stems. Other crops under the minor legumes section include chickpea, cowpea, lima beans and velvet beans.

- 167 MALAWI GOVERNMENT. DEPARTMENT OF AGRICULTURAL RESEARCH. 1973. 3. Groundbeans variety trial Chitala. In: Annual Report of the Department of Agricultural Research for the years 1970-1971. Zomba, Malawi. Government Printer. p. 111.

Trial reports on groundbeans (*Voandzeia subterranea*), cowpeas, chickpeas and guar are given under the Minor legumes section (p. 111-113). Yields of seven varieties of groundbeans varied from 363-1196 lb/ac shelled beans. Mbawa D was the highest yielder and Mbawa A, the lowest.

168. MALAWI GOVERNMENT. DEPARTMENT OF AGRICULTURE. 1973. D. Groundbeans. In: Annual Report of the Department of Agriculture (Part 2) for the year 1969-1970. Zomba, Malawi: Government Printer. p. 122.

Trial reports on groundbeans (*Voandzeia subterranea*), cowpeas, chickpeas and grams are given under the Minor legumes section (p. 119-122). The trial on groundbeans, conducted at Tuchila, gave extremely low yields despite a basal dressing of 200 lb/ac single superphosphate and 100 lb/ac sulphate of ammonia. Mean germination percentage was 63%, and Mbawa C was the highest yielder with 484 lb/ac.

- 169 MITTELHOLZER, A.S. 1968. Section 1. Miscellaneous grain legumes: Groundbeans (*Voandzeia subterranea*). In: Annual Report on Grain Legume Research of the Agricultural Research Council of Malawi for October 1967-September 1968. 5p.

Good yields were obtained from nine groundbean varieties tested, the mean yield being 1852 lb/ac. Barotse land selection was the highest yielder with 2797 lb/ac. This crop is extremely well adaptable and resistant to many pests and diseases. There is a wide range of seed coat colour enhancing the attractiveness of this large, round seeded legume, which appears ideal for canning. It is a popular food crop in Africa. Other crops reported include groundnuts, pigeon peas, jack beans, guar, soybeans, beans (*Phaseolus spp.*) dolichos, velvet beans and cowpeas.

- 170 MITTELHOLZER, A.S. 1968. Section 2. Observation experiment No. 1 - Grain Legumes - Chitedze collection. In: Annual Report on Grain Legume Research of the Agricultural Research Council of Malawi for October, 1967-September, 1968. 6p.

A total of 30% population loss was recorded for Groundbeans (*Voandzeia subterranea*) with 20% at germination and 10% at emergence. Along with *Vigna spp.*, it suffered the lowest loss due to poor seed germination. It is the highest yielder with 1657 lb/ac while guar is the poorest (155.1). There was an appreciable damage due to mosaic and *Aschochyta blight*. No damage due to insect activity was recorded on *V. subterranea*.

- 171 MITTELHOLZER, A.S. 1968. Section 2. Observation experiment No. 4 - Grain Legumes-Bvumbwe collection. In: Annual Report on Grain Legume Research of the Agricultural Research Council of Malawi for October, 1967-September, 1968. 4p.

All the eight varieties of Groundbeans (*Voandzeia subterranea*) were outstanding yielders, with Barotse land and Mbawa B the highest yielders (over 2000 lb/ac.). Seed coat colour ranged from purple to yellow, seeds have good adaptability to canning and are used as food.

- 172 MITTELHOLZER, A.S. 1969. Section 1. Miscellaneous grain legumes: Groundbeans. In: Annual Report on Grain Legume Research of the Agricultural Research Council of Malawi for October 1968-September 1969. 3p.

Due to unfavourable weather conditions, yields of Groundbeans (*Voandzeia subterranea*) were low, the highest yielding variety gave 978 lb/ac which was 41% of its yield in the previous season. The crop is a high yielding one and presents a good gene pool for selection towards the production of stable varieties. Other crops reported include velvet beans, beans (*Phaseolus spp.*) and soybean.

- 173 MITTELHOLZER, A.S. 1969. Section 3. Experiment 16: An evaluation of the yield of ten groundbean (*Voandzeia subterranea* L.) selections. In: Annual Report on Grain Legume Research of the Agricultural Research Council of Malawi for October 1968-September 1969. 3p.

Yield studies with nine groundbean varieties indicated no significant difference between established varieties and the selections from Tuchila and Mbawa (Malawi) but these were all significantly different from the Chitedze selection. The yields of all varieties were relatively low due to adverse environmental conditions. Yellow and tan seeded varieties are very stable but the purple seeded varieties tended to re segregate.

- 174 MITTELHOLZER, A.S. 1969. Section 3. Experiment 17. A study of the yield potential and stability of groundbean (*Voandzeia subterranea*) segregates. In: Annual Report on Grain Legume Research of the Agricultural Research Council of Malawi for October 1968-September 1969. 2p.

Seven selections of groundbeans, based on the colour of the seed coat, were tested. Yield data indicated differences between types. Types with purple seed coats were relatively instable and re segregated into a series of shades ranging from dark purple to light pink. Types with tan, red, brown and yellow (black eyed) seed coats were stable and bred true to type.

- 175 SMYTH, K.J.F. and KINYAWA, P.L. 1968. Bambarra groundnut breeding. In: Annual Report of the Research Institute. Ukiriguru, Tanzania. p. 38-43.

Yields of 25 varieties ranged from 596-1615 lb seeds/ac, the highest being for the local variety Kasholishoro.

F02 CYTOLOGY AND CYTOGENETICS

- 176 DUSSEAU, A. and MAGNANT, C. 1941. Etude caryologique et denombrement chromosomique chez une Phaseolee, *Voandzeia subterranea* Thouars. [Cytological study and chromosome counts in a Phaseoleae, *Voandzeia subterranea* Thouars]. Comptes Rendus de l'Academie des Sciences (Paris), 212: 455-456. French.

Observation on the meristem, radicle and morphology of the 22 chromosomes of two varieties of Bambarra groundnuts, one with red seeds and the other white, in Tchad are reported.

- 177 FRAHM-LELIVELD, J.A. 1953. Some chromosome numbers in tropical leguminous plants. Euphytica, 2(1): 46-48. German summ. 3 Ref.

Lists the chromosome numbers in 36 tropical legume species which are used either as food and forage or as cover crops. The legumes include *Voandzeia subterranea*, *Phaseolus calcaratus* Roxb. [= *Vigna umbellata*], *P. radiatus* L. [= *Vigna radiata*], *Dolichos lablab* [= *Lablab purpureus*] and *Cajanus indicus* [= *C. cajan*], all of which have a chromosome number of $2n=22$, and *Arachis hypogaea* L. var Schwarz 21, $2n=40$.

- 178 FRAHM-LELIVELD, J.A. 1957. Observations cytologiques sur quelques legumineuses tropicales et subtropicales. [Cytological observations on some tropical and subtropical legumes]. Revue de Cytologie et de Biologie Vegetales (France), 18: 273-287. French. 55 Ref. Illus.

Voandzeia subterranea Thouars from the green house in Wageningen has a chromosome count of $2n=22$. Information on chromosome numbers and source, of *Cicer arietinum*, *Cajanus indicus* (=C. cajan), *Dolichos lablab* (=Lablab purpureus), *Glycine soja*, *Phaseolus calcaratus* (*Vigna umbellata*), *P. radiatus* (=Vigna radiata), *Sphenostylis holosericeae* Harms and *Arachis hypogaea*, is tabulated.

- 179 MIEGE, J. 1954. Nombres chromosomiques et repartition géographique de quelques plantes tropicales et équatoriales. [Chromosome numbers and geographical distribution of some tropical and equatorial plants]. Revue de Cytologie et de Biologie Vegetales (France), 15: 312-348. 35 Ref. Illus.

Chromosome numbers of 37 plant species including grain legumes are reported. Bambarra groundnut has a chromosome number of $2n=22$. It is widely cultivated in Africa and its distribution extends to Senegal, Ivory Coast, Madagascar, Sudan and Tchad.

- 180 NETOLITZKY, F. 1926. Anatomie der Angiospermen-Samen. In: K. Linsbauer, Handbuch der Pflanzenanatomie, 10(14). Berlin, Gebr Borntraeger. p. 163. German.

Microscopic details of the testa and embryo of *Voandzeia subterranea* are given. True "pillar" cells are absent in *V. subterranea*.

- 181 ROWSON, J.M. 1952. The hypodermal zone in the testa of certain leguminous seeds. Journal of the Royal Microscopical Society, 72(1): 46-55. 10 Ref. Illus.

The hypodermal layer of the testa of *Voandzeia subterranea* is one-layered, hour-glass shaped, $14-22\ \mu$ in height, $20\ \mu$ wide at the ends and $14\ \mu$ at the centre with smooth thickenings of anticlinal walls. The lumen is large and the intercellular spaces are lenticular. The testa (excluding hypodermis) is up to $300\ \mu$ thick with a thin cuticle. The epidermis is one layered, $100\ \mu$ in height, $8-14\ \mu$ thick and contains bands of thickenings. The parenchyma is many-layered and cells are somewhat flattened. Endosperm is usually scanty or absent. The "pillar" cells form a single layer in *V. subterranea*.

G00 INSECT PESTS AND CONTROL

- 182 BUNTING, B. and MILSUM, J.N. 1930. The culture of vegetables in Malaya. Bulletin of the Department of Agriculture, Kuala Lumpur No. 1. 78p.

Brief notes on the more important insect pests of vegetables in Malaya are given. *Prodenia litura* F. deposits large masses of eggs on the leaves of Bambarra groundnut, the larvae feeding together for a few days and then dispersing. Control measures recommended are picking off the egg masses by hand and spraying with lead arsenate while the larvae are still clustered together.

- 183 HARRIS, W.V. 1933. Report of the Assistant Entomologist. Annual Report of the Department of Agriculture, Tanganyika, for 1932, pp. 73-75. Dar-es-Salaam.

Apion sp. injured the developing pods of the earth nut (*Voandzeia subterranea*), in parts of Bukoba.

- 184 MARSHALL, G.A.K. 1936. Curculionidae (Col) attacking cultivated plants. Bulletin of Entomological Research, 27(2): 253-259. Illus.

Apion (*Piezotrachelus*) *ugandum*, Wagn., is recorded as a very serious pest of Bambarra groundnut (*Voandzeia subterranea*), a most important food crop in the Bukoba district, Tanganyika Territory. The adults are found in the soil round the collar of the plants and oviposition takes place when the nuts or peas are well formed and beginning to harden.

- 185 PARSONS, F.S. 1929. Bambarra groundnuts. In: Reports from Experiment Stations, Empire Cotton Growing Corporation, 1927-1928. p. 87-88.

Bambarra groundnuts (*Voandzeia subterranea*) were attacked by the jassid, *Empoasca facialis*, Jac., and the crop is difficult to harvest owing to the slender peduncles which break when the plants are lifted with the result that most of the nuts are left in the soil.

- 186 SEEGER, J.R. and MALDAGUE, M.E. 1960. Infestation de nodules de legumineuses en region equatoriale par des larves de *Rivellia* sp. (Dipt.). [Infestation of the nodules of legumes in the equatorial region by the larvae of *Rivellia* spp]. Parasitica, 16(3): 75-84. French. English & German summ. 9 Ref. Illus.

About 50-60% of root nodules of groundnuts near Yangambi in the Congo (Zaire) were damaged by Dipterous larvae of the genus *Rivellia*. Experiments with six species of legumes sown in alternate rows showed that *Rivellia* would attack cowpeas, *Phaseolus aureus* (= *Vigna radiata*), *Voandzeia subterranea* in addition to groundnuts, but neither larvae nor adults were found on *Crotalaria longithyrsa* or soybeans.

- 187 SMEE, C. 1938. Report of the Entomologist. In: Annual Report of the Department of Agriculture Nyasaland for 1937. p. 19-26.

Apion (*Piezotrachelus*) *ugandum*, Wagn. is reported on Bambarra groundnuts (*Voandzeia subterranea*).

G01 STORAGE AND STORAGE PESTS

- 188 LEPIGRE, M. 1965. Etude sur les possibilites d'amelioration de la conservation des haricots au Togo en milieu rural. [Improving storage of beans in rural areas of Togo]. L'Agronomie Tropicale, 20(4): 388-430. French, English & Spanish summ. Illus.

Gives the results of a survey of methods used by farmers in Togo, Dahomey and Senegal for storing beans, groundnuts, sorghum millet, Kersting's groundnut and Bambarra groundnuts. Photographs of various rural storage structures are presented. Estimates of losses caused by insects are given and the effects of prices are discussed. Short-term and long-term recommendations for improvement are made.

- 189 MAYNE, R. 1948. Les insectes et acariens des matieres alimentaires. [Injurious insects and mites of stored products]. Bulletin et Annales de la Société Entomologique de Belgique, 84(3-4): 100-104. French.

Pests infesting stored products in Belgium included *Bruchus* (*Callosobruchus*) *maculatus* F., *B. tristicus* and *B. refimanus* var *velutinus* Muls. and Rey in seeds of *Voandzeia subterranea*. An unidentified Chalcididae was found parasitizing *C. maculatus*.

- 190 POINTEL, J.G. 1968. Contribution a la conservation du niebe, du voandzou, du mais, des arachides et du sorgho. [Contribution to the storage of cowpea, Bambarra groundnut, maize, groundnut and sorghum]. L'Agronomie Tropicale (Paris), 23(9): 982-986. French. Illus.

Results from 1967 trials in various regions of West Africa confirmed those of 1966 with respect to the effective conservation of the germinating power of grains stored in carbon tetrachloride environment inside plastic bags.

- 191 PREVETT, P.F. 1966. Observations on the biology of six species of Bruchidae (Coleoptera) in Northern Nigeria. Entomologists' Monthly Magazine, 102: 174-180. 8 Ref. Illus.

Oviposition in *Callosobruchus subinnotatus* (Pic), a storage pest of Bambarra groundnuts, commences only when pods, in which a succession of generations develops are nearly dry. In laboratory culture, oviposition commenced within one day of emergence and a total developmental period of 6-7 weeks was recorded at room temperature. The adult beetle, with head extended is normally 4.5-5.5 mm long.

- 192 PREVETT, P.F. 1967. Notes on the biology, food plants and distribution of Nigerian bruchidae (Coleoptera), with particular reference to the northern region. Bulletin of the Entomological Society of Nigeria, 1(1): 3-6. French summ. 5 Ref.

Callosobruchus subinnotatus (Pic), a storage pest of Bambarra groundnuts is widely distributed in the Kano, Zaria and Ibadan provinces of Nigeria. It produces several generations a year in dry pods only.

- 193 PREVETT, P.F. 1970. *Callosobruchus subinnotatus* (Pic) (Coleoptera, Bruchidae): A potential pest of stored groundnuts. Journal of Stored Products Research, 6(3): 279-280. 4 Ref.

C. subinnotatus is a pest of stored seeds of the Bambarra groundnut, *Voandzeia subterranea*. Development was much slower on groundnuts than on Bambarra groundnuts.

- 194 SOUTHGATE, B.J. 1958. Systematic notes on species of *Callosobruchus* of economic importance. Bulletin of Entomological Research, 49(3): 591-599. 20 Ref. Illus.

A Bruchid from the seeds of *Voandzeia subterranea* in Ghana was provisionally identified as *Bruchus vicinus* var *subinnotatus* (F).

- 195 ZACHER, F. 1921. Schädlinge der Nutzpflanzen im West Sudan. [The pests of economic plants in Western Sudan]. Der Tropenpflanzer, 24(7/8): 97-108; (9/10): 132-142. German.

The beetle *Bruchus vicinus* var *subinnotatus* is a pest of Bambarra groundnut, from three to five insects being found in one seed.

- 196 ZACHER, F. 1928. Nahrungsauswahl und fortpflanzungsbiologie der samenkafer. Vorläufige Mitteilung. [Food preference and biology of reproduction of seed infesting beetles. Preliminary communication]. Anzeiger fuer Schaedlingskunde, 4(11): 148. German.

The larvae of bruchids usually have a series of more or less closely related preferred food plants which include Bambarra groundnuts.

H00 PLANT PATHOLOGY

- 197 BILLINGTON, R.V. 1970. The effects of planting dates on disease incidence on legumes and its effect on final yields. Ukiriguru Research Notes Tanzania, 44: 5-7.

Late planting causes *Cercospora* on Bambarra groundnuts, and anthracnose and bacterial rot on cowpeas.

- 198 KINYAWA, P.L. 1969. Bambarra nut research at Ukiriguru. Ukiriguru Research Notes No. 24.

Disease incidence on Bambarra groundnuts is less than that of the common groundnut.

- 199 KINYAWA, P.L. 1969. Diseases of Bambarra nuts at Ukiriguru. Ukiriguru Research Notes No. 31.

A one-page note on the important diseases and pests observed on Bambarra groundnut during the year which included *Cercospora* leaf spot, *Fusarium* wilt, virus rosette, nematode root knots and powdery mildew.

- 200 VISSER, J.H.; DORR, I. and KOLLMAN, R. 1977. On the parasitism of *Alectra vogelii* (Scrophulariaceae). 1. Early development of the primary haustorium and initiation of the stem. Zeitschrift für Pflanzenphysiologie, 84(3): 213-222. 10 Ref. Illus.

Morphological and anatomical studies of the development of the primary haustorium of the hemiparasite, *Alectra vogelii* on *Voandzeia subterranea* roots were discussed. Localized swelling of host root tissue occurs upon contact between parasite seedling and host, and several lateral roots originate in the swollen area.

H01 FUNGI AND FUNGAL DISEASES

- 201 ARMSTRONG, G.M.; ARMSTRONG, J.K. and BILLINGTON, R.V. 1975. *Fusarium oxysporum* forma specialis *voandzeiae*, a new form species causing wilt of Bambarra groundnut. Mycologia, 67(4): 709-714. 8 Ref.

An isolate of *Fusarium oxysporum* that caused wilt of the Bambarra groundnut (*Voandzeia subterranea*) in Tanzania was used to inoculate 44 different cultivars in numerous genera of plants. From host-plant reactions, the *Fusarium* from *Voandzeia* is thought to be a new forma specialis, *F. oxysporum* f. sp. *voandzeia*.

- 202 BOURIQUET, G. 1946. Les maladies des plantes cultivees a Madagascar. Maladies du *Voandzeia subterranea*. [The diseases of cultivated plants in Madagascar. Diseases of *V. subterranea*]. Encyclopedia Mycologique, 12: 352-359. French. 4 Ref. Illus.

Bambarra groundnut (*V. subterranea*) has been widely affected by powdery mildew which the author names *Sphaerotheca voandzeiae*. The superficial hyphae measure about 7 μ in diameter and penetrate the epidermal cells. *Cercospora voandzeiae* causes a leaf spot of *V. subterranea*.

- 203 CHEVAUGEON, J. 1952. Maladies des plantes cultivees en moyenne-Casamance et dans le Delta Central Nigerien. [Diseases of cultivated plants in middle Casamance and the Central Niger Delta]. Revue de Pathologie Vegetale, 31(1): 3-51, 55. French.

Voandzeia subterranea is attacked by *Phyllosticta voandzeiae* in Casamance and the French Sudan, and by *Corticium solani* in Casamance.

- 204 DEIGHTON, F.C. 1956. Diseases of cultivated and other economic plants in Sierra Leone. 3. Other crops. Sierra Leone, Government Printing Department. p. 34.

Bambarra groundnut is attacked by *Meliola vignae-gracilis* Hansf. & Deight. which forms a black mould-like coat on the leaf surfaces. *Rhizoctonia solani* may cause the destruction of all the above-ground parts of the plant in the wet season. *Phyllosticta* sp. also causes leaf spot in Bambarra.

- 205 EBBELS, D.L. 1971. Plant pathology. Progress Report of the Experiment Stations of the Cotton Research Corporation. (Tanzania) for 1968-1969. p. 19-27.

An isolate of *Fusarium oxysporum* from Bambarra groundnut (*Voandzeia subterranea* Thouars) at Ukiriguru and another from cotton were tested for pathogenicity to three varieties of Bambarra groundnuts and one of cotton by root dip inoculation. Results showed that each isolate infected only the host species from which it originated and *Fusarium* wilt of *V. subterranea* is not caused by *Fusarium* sp. *vasinfectum*.

- 206 EBBELS, D.L. and BILLINGTON, R.V. 1972. *Fusarium* wilt of *Voandzeia subterranea* in Tanzania. Transactions British Mycological Society, 58(2): 336-338. 4 Ref.

Symptoms of the wilt disease are described. Isolates UKP 218 and UKP 322 of *Fusarium* from the *Voandzeia* wilt were used in pot experiments to inoculate eight plants which included *Arachis hypogaea*, *Cajanus cajan*, *Cicer arietinum* cv CH/11, *Phaseolus vulgaris* cv 'Selection 16', *Vigna unguiculata* cv CP/17, and five cvs of *Voandzeia subterranea*. The isolates were pathogenic to *P. vulgaris*, *Vigna unguiculata* and *Voandzeia subterranea*. Only isolate UKP 218 infected *C. arietinum*. Results indicate a close affinity between *Voandzeia*-wilt *Fusarium*, and *Fusarium oxysporum* f. sp. *tracheiphilum*. Population of *V. subterranea* showed considerable variation in resistance to *Fusarium* wilt.

- 207 LEATHER, R.I. 1959. Diseases of economic plants in Ghana other than cacao. Ghana Ministry of Food and Agriculture Bulletin. No. 1

Late blight of Bambarra groundnut is caused by *Corticium solani*. The plants die before they reach maturity, the leaves and stems becoming dried out and brown. The disease is most common during the wet season in the forest zones and no control is economically practicable. A small but unimportant leaf spot is also caused by *Phyllosticta* sp.

- 208 MADUEWESI, J.N.C. 1975. Host range and thermal inactivation of a cowpea isolate of *Sclerotium rolfsii*. Nigerian Journal of Plant Protection, 1(1): 23-28.

Voandzeia subterranea is a host of the cowpea isolate of *Sclerotium rolfsii* (= *Corticium rolfsii*). Other hosts include cowpea, pigeon pea, groundnut, sword bean, soyabean, velvet bean, lima bean and kidney bean.

- 209 MARCHAL, E. and STEYAERT, R.L. 1929. Contribution a l'etude des champignons parasites des plantes au Congo Belge. [Contribution to the study of fungal parasites of plants in the Belgian Congo]. Bulletin de la Societe Royale de Botanique de Belgique, 61(2): 160-169. French. illus.

Phyllosticta voandzeia nov. spec. forms ill-defined, irregular, circular, brownish-purple spots on living leaves of *Voandzeia subterranea*.

- 210 ORIAN, G. 1953. Botanical Division. Report of the Department of Agriculture, Mauritius, 1952. p. 37-40.

Among the diseases noticed was stem rot of *Voandzeia subterranea* caused by *Sclerotium rolfsii* Sacc. [= *Corticium rolfsii*].

- 211 SNOWDEN, J.D. 1921. Report of the Government Botanist for the period 1 April-31 December, 1920. In: Annual Report of the Department of Agriculture, Uganda for the nine months ending December 31, 1920. p. 43-46.

Reports that the leaves of *Voandzeia subterranea* ('mpandi') on the Kampala plantations were attacked by an undescribed species of *Cercospora*.

- 212 VEMBAR, R.N. and REDDY, M.N. 1965. An *Oidium* sp. on Bambarra groundnut. *Science and Culture*, 31(7): 371-372. 1 Ref. Illus.

A powdery mildew, mainly on the dorsal surface of the leaves, appeared on *Voandzeia subterranea* at Himayatsagar in 1963. The importance of this is stressed, in view of the attempts to use *V. subterranea* in the groundnut (*Arachis hypogaea*) breeding programme. Disease symptoms and morphology of the fungus are described.

- 213 WALLACE, G.B. and WALLACE, M.M. 1947. Second supplement to the revised list of plant diseases in Tanganyika territory. *East African Agricultural Journal*, 13(1): 61-64.

The list of plant diseases include leaf spot on Bambarra groundnut (*Voandzeia subterranea*) caused by *Cercospora canescens*.

H02 VIRUSES AND VIRAL DISEASES

- 214 BOCK, K.R.; PERRY, J.; WAINDI, E.N.; AMBETSA, T. and MWATHI, G.K. 1968. Plant pathology. Viruses of legumes. In: East African Agriculture and Forestry Research Organization, Record of Research. Annual Report for 1968. p. 90-93.

On pages 92-93, Bambarra groundnut viruses which caused a severe rosette disease of *Voandzeia subterranea* in Mwanza, Tanzania, are described.

- 215 KLESSER, P.J. 1961. The virus diseases of *Crotalaria*, *Glycine* and *Medicago* species. The virus diseases of beans. *Bothalia*, 7(3): 497-519, 521-558. 88 Ref. Illus.

In South Africa the host range of Alsike clover mosaic virus, White clover mosaic virus, Bean local chlorosis virus, isolated from *Crotalaria juncea*, *C. spectabilis* and *Phaseolus vulgaris*, respectively, includes *P. lunatus*, *Vigna mungo*, *V. sesquipedalis*, *V. unguiculata* (L) Walp and *Voandzeia subterranea* Thouärs. The viruses are transmitted by mechanical sap inoculation and by *Aphis craccivora*. A bean mosaic virus strain isolated from *Phaseolus vulgaris* was also found on *V. subterranea*, *Vigna unguiculata* and *V. sesquipedalis* causing

a systematic chlorotic flecking on the young leaves of *Voandzeia subterranea* with the later ones developing a mottle with necrotic specks. Bean chlorotic ringspot virus was also isolated from *V. subterranea*.

- 216 NIGERIA. FEDERAL DEPARTMENT OF AGRICULTURAL RESEARCH. 1971. Virology. Cowpea Mottle Virus. In: Report of the Plant Pathology Division. Nigeria Federal Department of Agricultural Research, Annual Report, 1965-1966. p. 16.

An isolate of the cowpea mottle virus from Bambarra groundnut, *Voandzeia subterranea*, was carried in the seed of *V. subterranea* but not in that of cowpea. The *V. subterranea* isolate withstood dilution to 1/1000. An antiserum prepared to the cowpea isolate had precipitation end-points of 1/512 and 1/32 against the cowpea and *V. subterranea* isolates respectively.

- 217 ROBERTSON, D.G. 1971. Report on the Plant Pathology Division. In: Report of the Federal Department of Agricultural Research for the years 1965-1966. Lagos, Nigeria. Federal Department of Agricultural Research. p. 16.

Details of an isolate of cowpea mottle virus from Bambarra groundnut (*Voandzeia subterranea*) and a virus from cowpea called cowpea green mottle virus are given. Two seedborne viruses from cowpea were shown to be strains of cucumber mosaic virus and designated CMV-CSI and CMV-CS2.

H03 NEMATODES AND NEMATODE DISEASES

- 218 MARTIN, G.C. 1959. Plants attacked by root-knot nematode in the Federation of Rhodesia and Nyasaland. Rhodesian Agricultural Journal, 56: 162-175. 17 Ref.

The paper lists all the root-knot-nematode-infected plants (including Bambarra groundnuts) found in the Federation in which specific identification of the parasites has been determined. Most of the records are of naturally occurring infections. *Meloidogyne javanica* attacked Bambarra groundnuts (*Voandzeia subterranea*) and the roots were almost totally covered with swellings. Heavy infestations of *M. javanica* were found in plants growing in apparently virgin situations.

100 NUTRITIONAL STUDIES

- 219 ADRIAN, J. 1963. Etude de la valeur protidique de trois especes de haricots africains: niebe, voandzou et dolique. [Nutritive value of three species of African beans *Vigna unguiculata*, *Voandzeia subterranea*, *Dolichos lablab* (= *Lablab purpureus*)]. Annales de Biologie Animale Biochimie Biophysique France, 3(1): 107-111. French.

Gives the nutritive values of cowpeas, dolichos and Bambarra groundnuts after cooking. The values for Bambarra groundnuts are: protein content 17.5%, growth value for rat 0.45 gained g/day, digestible N in vitro 21%, N retention 51% and a total nutritive value of 73%. Both cowpeas and Bambarra groundnut are very good sources of protein and are therefore valuable in nutrition programs to prevent Kwashiorkor.

- 220 ADRIAN, J. and HELIAS-FRAGNE, R. 1964. Etude de la valeur protidique de trois legumineuses domestiques africaines (voandzou, dolique et niebe). Evaluation of the proteins of three African legumes, Bambarra groundnut, hyacinth bean and cowpea]. Annales de la Nutrition et de l'Alimentation, 18(2): 1-18. French. 25 Ref. Illus.

Tables give the proximate composition, riboflavin and nicotinic acid/100 g and values of nine amino acids/16 g N of samples of Bambarra groundnuts (*Voandzeia subterranea*), hyacinth bean [*Dolichos lablab* = *Lablab purpureus*] and cowpeas (*Vigna unguiculata*) from Senegal. Protein content of cowpeas, lablab and Bambarra groundnuts is 23, 24.3 and 17.45%, respectively. The lipids in cowpea are about one-half to one-third those in Bambarra groundnuts. Proteins from all of these legumes are low in methionine (1.5, 0.65 and 0.95% for cowpeas, lablab and Bambarra groundnuts, respectively) and average lysine content is about 6.75, 6.95 and 8.2%, respectively. Autoclaving decreases nutritional value.

- 221 ADRIAN, J. and JACQUOT, R. 1968. Techniques agricoles et productions tropicales. 16. Valeur alimentaire de l'arachide et de ses derives. [Agricultural techniques and tropical production. 16. Nutritive value of groundnut and its derivatives]. Coste, R. (compiler) Paris, G-P. Maisonneuve & Larose, 274p. French.

Nutritive values for groundnuts, including the Bambarra groundnuts are given.

- 222 AYKROYD, W.R. and DOUGHTY, J. 1964. Legumes in human nutrition. FAO Nutritional studies No. 19. Rome, Food and Agriculture Organization. 138p.

The role of legumes and their botany, including cowpeas, pigeon peas, Bambarra groundnuts, chickpeas, broad bean, African locust bean, lima bean, green gram etc., in human nutrition are discussed. Bambarra groundnut is an annual crop maturing in 5-6 months after planting and its cultivation extends across tropical Africa and Madagascar. Together with chickpea, it has a fat content of about 4-6%. The nutritive value of the seeds, including amino acid content is tabulated.

- 223 DONATH, W.F. and SPRUYT, J.P. 1933. Het anti-beriberi vitaminegehalte van katjang bogor (*Voandzeia subterranea* (L) Thouars). [Anti-beriberi vitamin content of katjang bogor (*V. subterranea* (L) Thouars)]. Landbouwwoorlichting, 9(3): 133-144, and also Geneeskunde en Tijdschr. Nederland Indie, 73: 552-559.

V. subterranea contains an appreciable quantity of vitamin B₁. In the raw state, it contained about half that of *Phaseolus radiatus* [= *Vigna radiata*] which, despite its higher vitamin content is eaten only reluctantly whereas *V. subterranea* is eaten with relish. *V. subterranea* also has a better protein, fat and carbohydrate ratio. Increased cultivation of the crop is advocated.

- 224 DOVLO, F.E. 1977. Dietary uses of grain legumes in Ghana. In: Proceedings of the University of Ghana-Council for Scientific and Industrial Research Symposium on Grain Legumes in Ghana, 10-11 December, 1976. Legon, Ghana. Faculty of Agriculture University of Ghana. p. 160-163. 2 Ref.

The paper mentions briefly that the important grain legumes consumed in Ghana in order of their popularity and extent of use are cowpea, Bambarra groundnut, yam bean, lima bean and chickpea. Of these, only cowpeas, bambarra groundnuts and yam beans are used in appreciable quantities in the diet.

- 225 DUKE, J. 1977. Vegetarian vitachart. Quarterly Journal of Crude Drug Research, 15: 45-66.

Bambarra groundnut (*Voandzeia subterranea*) has an extremely low content (less than 1% of the recommended dietary allowance [RDA]) of vitamins A and C, a low content (from 1-10% of RDA) of calcium and riboflavin, and a high content (from 10-100% of RDA) of calories, fibre, iron, niacin, phosphorus, protein and thiamine. Values are also given for adzuki bean, African locust bean, African yam bean, cowpea, ground bean, jack bean, lima bean, mungbean, peanut, pigeon pea, rice bean and sword bean.

- 226 FERRAO, J.E.M. and XABREGAS, J. 1959. Valor alimentar da "*Voandzeia subterranea*" Thouars. [Food value of *Voandzeia subterranea*]. Agronomia Angolana, 11: 3-23. 27 Ref.

In the Portuguese Oversea Territories there is generally a shortage of foodstuffs containing proteins and vitamins in appropriate quantities. In this respect *Voandzeia* can perhaps play a significant part. Together with *Phaseolus*, *Vigna* spp. and *Arachis* it belongs to the most often consumed leguminosae in Africa.

- 227 FOFANA, I.B. 1964. Contribution a la recherche d'aliments riches en proteines a partir de quelque legumineuses tropicales. [Contribution to the research of protein-rich nutrients of some tropical legumes]. Ph.D Thesis, Universite de Bordeaux. 76p. French.

The biological values of cowpea, lablab, jack bean, groundnut and Bambarra groundnut are presented. The large, spherical ocher coloured seed of Bambarra groundnut which weighs 799.2 mg contains 2.33% total N, 12.00% moisture and 7.4% ash.

- 228 GENEVOIS, M.L. (ed). 1973. Graines de legumineuses. In: Mutations biochimiques chez les vegetaux superieurs. [Grain legumes. In: Biochemical mutations of superior vegetables]. Paris, Masson et Cie. p. 115-117. French.

Lysine, methionine and tryptophan content, biological value and protein efficiency of groundnuts, haricot beans, lima beans, Bambarra groundnuts, lablab, pigeon pea, kersting's groundnut, chickpea, cowpea and soybeans are compared. Values are from the F.A.O. tables of 1970.

- 229 GOLDBERG, L.; THORP, J.M. and SUSSMAN, S. 1945. A survey of vitamins in African foodstuffs. 4. The thiamine content of beans and other legumes. South African Journal of Medical Sciences, 10: 87-94.

The range of thiamine content and mean thiamine values of the juko bean (*Voandzeia subterranea*) are 1.82-3.98 and 2.79 r/g., respectively. The values for other legumes including groundnuts, soybeans, cowpeas, pigeonpeas, sword beans, lablab, kidney beans, lima beans, lentils, chickpeas, etc. are also given.

- 230 JONES, W.O. 1972. Marketing staple food crops in tropical Africa. London, UK. Cornell University Press. p. 30

Notes that the proteins of peanuts, beans, peas, Bambarra nuts (*Voandzeia subterranea*), and green leaves are of high quality, and when these are consumed in sufficient quantity there is little reason to expect the low consumption of animal proteins to cause trouble.

- 231 MARQUETTE, J. 1970. [Report on grain legumes in Madagascar]. Paper presented at the Ford Foundation/IITA/IRAT Grain Legume Seminar, 22-26 June, 1970. Ibadan, Nigeria. 5p. French, English translation.

Bambarra groundnut, *Voandzeia subterranea* is solely reserved for domestic consumption in Madagascar. Other legumes discussed include groundnuts, soybeans, cowpeas, pigeon peas, mungbeans, urd and lablab.

- 232 OWUSU-DOMFE, K.; CHRISTENSEN, D.A. and OWEN, B.D. 1970. Nutritive value of some Ghanaian feed-stuffs. Canadian Journal of Animal Science, 50(1): 1-14.

The nutrient composition of 12 Ghanaian feeds was studied by chemical or microbiological determination of amino acids, B vitamins, Ca, P, gross energy, and the proximate principles. Digestibility coefficients for dry matter, energy, and protein were determined with adult male mice. The feeds included cowpeas and Bambarra nuts. Heating cowpeas and Bambarra nuts increased digestibility and protein utilization of the legumes which are generally low in Ca content.

- 233 OWUSU-DOMFEH, K. 1972. Trypsin inhibitor activity of cowpeas (*Vigna unguiculata*) and Bambarra beans (*Voandzeia subterranea*). Ghana Journal of Agricultural Science, 5(2): 99-102. French summ. 9 Ref.

Heating inhibited cowpea and Bambarra groundnut trypsin activity by 20.19 and 58.11% respectively, and increased digestibility and protein utilization of the legumes.

- 234 TAUBERT, P. 1895. *Voandzeia subterranea* Thou. Engler Pflanzenwelt Deutsch Ost-Afrikas, VB. p. 122-123.

The red-brown or nearly black seeds of *V. subterranea* are more palatable with less cooking than those which are pale in colour or mottled.

- 235 WATSON, J.D. 1971. Investigations on the nutritive value of some Ghanaian foodstuffs. Ghana Journal of Agricultural Science, 4(1): 95-111. French summ.

Chemical analyses of white Bambarra groundnut (*Voandzeia subterranea*) seeds from Legon gave 11.4% moisture, 424 calories of energy, 19.7% protein, 5.6% fat, 54.5% carbohydrate, 5.3% fibre, 3.5% ash, and mineral values of Ca, P and Fe/100 g edible portion were 108, 195 and 9.7 respectively. Corresponding values for red Bambarra groundnut seeds from Northern Ghana were: 5.5%, 430 calories 17.2%, 6.6%, 62.6%, 4.5%, 3.6% and 71, 185 and 9.4, respectively.

I01 PROCESSING

- 236 LARTEY, B.L. 1977. The canning of Bambarra groundnut (*Voandzeia subterranea*). In: Proceedings of the University of Ghana-Council for Scientific and Industrial Research Symposium on Grain Legumes in Ghana, 10-11 December, 1976. Legon, Ghana. Faculty of Agriculture, University of Ghana. p. 119-126. 6 Ref.

Canning of Bambarra groundnut is described under storage, sorting, soaking, blanching, filling, exhausting and processing. Bambarra groundnut should be dried to 13-15% moisture to ensure safe storage and the beans should be sorted by electronic machines according to size and colour. A soaking time of 24 h and the addition of sodium bicarbonate or "Kawe" to the soak-water if hard, and as a means of facilitating the softening of the beans are also suggested. A steam blanch of 115.6°C for 15 minutes and a water blanch of 93-99°C for 5-10 minutes are also suggested.

J00 OTHER USES

- 237 FAO/CCTA. 1959. Report of the technical meeting on legumes in agriculture and human nutrition in Africa held in Bukavu, Belgian Congo from 10-15 November, 1958. Italy, Rome. Food Agricultural Organisation. 68p. + xxiv.

Summarises the various reports on the role of legumes, including cowpeas, *Voandzeia subterranea*, *Arachis hypogaea*, *Phaseolus lunatus*, *P. vulgaris*, *Sphenostylis stenocarpa*, *Canavalia ensiformis*, *Cajanus cajan* etc., in agriculture and human nutrition in various parts of Africa.

- 238 HOWES, F.N. 1974. Bambarra groundnut. In: A dictionary of useful and everyday plants and their common names. Cambridge, UK. University Press. p. 17.

Notes that *Voandzeia subterranea* is an important African food crop of many varieties.

- 239 OKIGBO, B.N. 1977. Role of legumes in small holdings of the humid tropics of Africa. In: Proceedings of a workshop on Exploiting the Legume-*Rhizobium* Symbiosis in Tropical Agriculture, held at Kahului, Maui, Hawaii, 23-28 August, 1976. p. 97-117.

The seeds of *Voandzeia subterranea*, a widely cultivated legume of the South Guinea Savanna vegetation zone, are used as food by human beings and livestock. It ranks next to cowpeas as the most widely grown grain legume in Africa south of the Sahara. It is also a source of traditional religions artifact.

- 240 WAKULENKO, I.L. 1913. Some further contributions to the knowledge of vegetable hemagglutinins. Landwirtschaftlichen Versuchs-Stationen, 82(5-6): 313-391.

Results of agglutination tests with *Voandzeia subterranea*, *Phaseolus mungo* [= *Vigna mungo*], *P. maximus*, *Sphenostylis stenocarpa*, *Arachis hypogaea* and some other crops are reported.

SUPPLEMENT

- 241 AMMANN, P. 1907. Le voandzobory ou voandzou. [Bambarra groundnut (*Voandzeia subterranea*)]. L'Agriculture Pratiques des Pays Chauds, 7(1): 38-43.

- 242 ANON. 1910. The Bambarra groundnut. The Agricultural News (Bridgetown, West Indies), 9(222): 340-341.

- 243 BOCK, K.R.; GUTHRIE, E.J.; MEREDITH, G.C. and NJUGUNA, J.G.M. 1976. Annual Report, East African Agriculture and Forestry Research Organization, Record of Research for 1974. Nairobi, Kenya.

The work on *Voandzeia* viruses is described.

- 244 BOCK, R.; GUTHRIE, E.J. and MEREDITH, G.C. 1977. Annual Report, East African Agriculture and Forestry Research Organization, Record of Research, for 1975. Nairobi, Kenya.

It is concluded that 750mm virus isolates from *Cassia*, *Voandzeia* and *Phaseolus lunatus* may be considered as host adapted strains of groundnut mottle virus.

- 245 DE WILDEMAN, E. 1905. *Voandzeia subterranea* ou Vouandzou. In: Notices sur des plantes utiles ou interessantes de la flore du Congo. p. 482-485.
- 246 DORR, I.; VISSER, J.H.; ALBERS, F. 1977. On the parasitism of *Alectra vogelii* Scrophuliaceae. 2. Origin of lateral roots in the contact area of the haustorium. Zeitschrift Fuer Pflanzenphysiologie, 85(4): 349-360.
- 247 DUNSTAN, W.R. 1908. Report on "paruru" seeds or Bambara groundnuts (*Voandzeia subterranea*) from Northern Nigeria. Northern Nigeria Gazette, p. 241-242.
- 248 DURBAR, A.R. (ed). 1969. Bambara groundnuts - *Voandzeia subterranea*. In: The Annual Crops of Uganda Nairobi, East African Literature Bureau. p. 86.
- Bambara groundnut, a crop indigenous to Africa grows on the highly leached soils of Bukoga. Its cultivation is similar to that of groundnut, spacing 30cm x 30cm and its diseases and pests are not regarded as serious.
- 249 JOPLIN, C.E. 1974. Pulse crops of the world and their important insect pests, Thesis Simon Fraser University Burnaby, British Columbia, Canada. 134p.
- The first chapter summarizes agronomic, economic and nutritional data on groundnuts, pigeon peas, chickpeas, soybeans, *Lablab niger* [= *Lablab purpureus*], lentils, mung beans [*Vigna radiata*], *Phaseolus lunatus*, *P. mungo* [= *Vigna mungo*], *P. vulgaris*, peas, *Vicia faba*, cowpeas and Bambara groundnuts (*Voandzeia subterranea*). References are provided to sources of information on these and 15 other important grain legume species. The 2nd chapter identifies the insect genera and species that are important pests of grain legumes and the concluding chapter discusses the role of pest management in increasing production.
- 250 MULLINS, A.J. 1962. Njugo bean or Bambara groundnut. Conservation Officers' Handbook. Salisbury, Rhodesia. Govt. Printer.
- 251 NIQUEUX, N. 1957. [Note on *Voandzeia subterranea* in the Chad]. Rapport de la service d'Agriculture du Tchad.
- 252 OLUYEMI, J.A.; FETUGA, B.L. and ENDELEY, H.N.L. 1976. The metabolizable energy value of some feed ingredients for young chicks. Poultry Science, 55(2): 611-618.
- 253 PELTIER, M. 1954. Consideration sur l'amplitude varietale du voandzou (*Voandzeia subterranea* Thou.) a Madagascar en fonction de l'origine et de espee Congres international de Botanique. [A consideration of the varietal range of voandzou (*Voandzeia subterranea*) in Madagascar, as a function of the origin of the species]. Paris.

- 254 REIMER, D. 1895. *Voandzeia subterranea*, Erderbse, Angola-Erbse. Pflanzenwelt Ost. Afr. Engler, Part B. p. 122-123.

- 255 SMARTT, J. 1976. Tropical pulses. London, UK. Longman Group Limited. 348p.

Tropical pulses discussed include the ground beans (*Voandzeia subterranea*), Kerstings groundnut, cowpeas, groundnuts, chickpeas, soybeans, lablab, *Phaseolus* sp., jack beans and pigeon peas. Botany and domestication, plant morphology, and pests and diseases of *V. subterranea* are discussed. *V. subterranea* has 2n=22 chromosomes.

- 256 STUHLMANN, F. 1909. Beitrage sur kulturgeschichte von Ostafrika. *Voandzeia subterranea*. [Contribution to E. African crop history. *Voandzeia subterranea*]. Deutsch-Ost-Afrika, 10: 228-230. German.

- 257 STURDY, D. 1939. Leguminous crops in native agricultural practice. East African Agricultural and Forestry Journal, 5: 31-32.

- 258 UWAEGBUTE, H.O. 1977. The use of local feed ingredients in livestock feeds. Canadian Journal of Animal Science, 57(4): 835.

- 259 VALENTINE, A.S. 1963. Bambarra nut advisory notes. Ministry of Agriculture Southern Rhodesia.

- 260 VERDCOURT, B. 1978. The demise of two geocarpic legume genera. Taxon, 27(2-3): 219-222.

The delineation of *Voandzeia* with *Phaseolus* shows that it cannot be maintained as a subsection since it comes close to the type *Vigna luteola* (Jacq.) Benth. and closest to *V. hosei* (Craib) Backer which, incidentally is often geotropic. A proposal for the conservation of *Vigna* for *Voandzeia* is presented.

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