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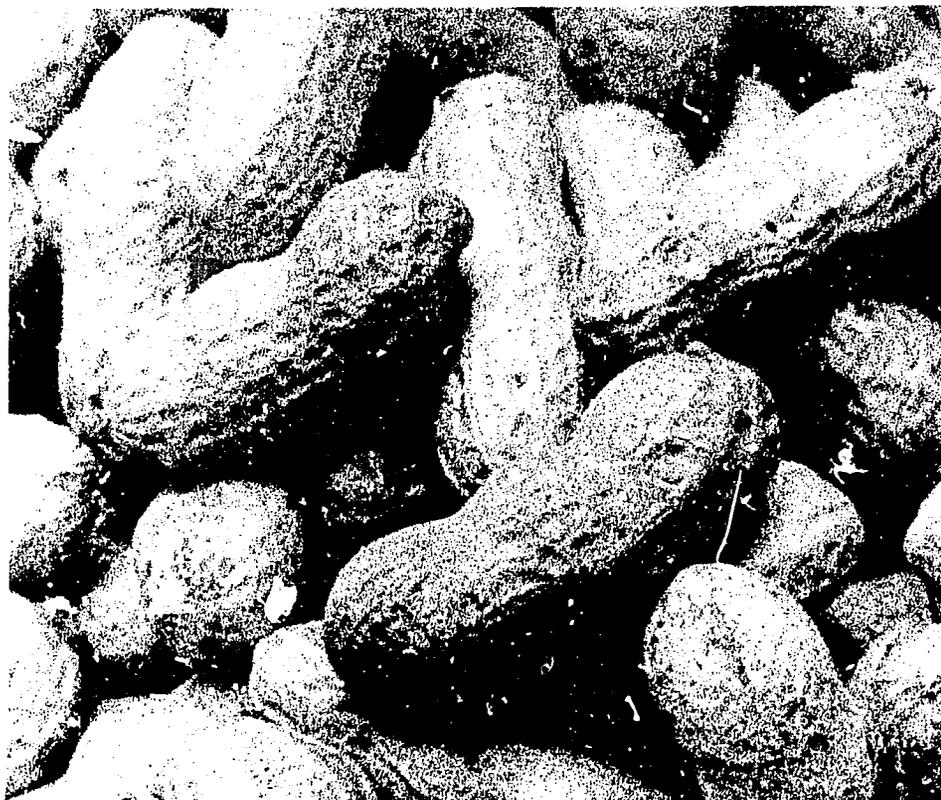
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# World Peanut Production, Utilization and Research



David G. Cummins and Curtis R. Jackson, editors

## Preface

The purpose of the United States Agency for International Development (AID) Peanut CRSP Planning Grant effort was to develop the organizational foundation for a collaborative research program between U. S. scientists and scientists in developing countries. The research should be directed toward solving socioeconomical and biological constraints to increased production and utilization of peanuts in developing countries where peanuts are an important economic food crop of rural and urban poor. A State-of-the-Art (SOTA) on peanut production and utilization was to be developed as a background for the CRSP including: a tabulation of production by countries throughout the world where peanuts comprise a reasonably important component of agricultural production, an inventory of U. S. and developing country institutions with a manifest interest and capability in peanut research, and an inventory of research being conducted in the U. S. and to the fullest extent possible the rest of the world.

For accomplishment of the Peanut CRSP Planning effort, Grant No. AID/DSAN-G-0247 was awarded to the University of Georgia Research Foundation, Inc. for the period August 1, 1980 to January 31, 1982. Responsibility for the planning effort was given to Curtis R. Jackson, Planning Director and David G. Cummins, Associate Planning Director. Elaine E. Pritchard served as Administrative Secretary. A contract was awarded to Alabama A & M University to assist in the planning, specifically in the areas of socioeconomics and food technology. B. Onuma Okezie and Gerald C. Wheelock were appointed Assistant Planning Directors with Bharat Singh, John C. Anderson, D. Ramikishan R. Rao, Hezekiah Jones, and Virginia Caples as resource personnel.

This SOTA document contains the information collected as background material for the Peanut CRSP and fulfills the SOTA requirements of the Grant.

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*Cover design by Terry Johnson*

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# World Peanut Production, Utilization, and Research

edited by David G. Cummins and Curtis R. Jackson

## I. World Peanut Production and Research Institutions, Personnel, and Programs

D. G. Cummins and C. R. Jackson

### INTRODUCTION

The peanut (groundnut), Arachis hypogaea L., is an annual legume native to South America, likely originating in Eastern Bolivia. It is now grown in most tropical, subtropical, and temperate countries between 40 degrees north and 40 degrees south. The peanut is unique in that after flowering, fertilization, and fruit set, the pegs elongate and penetrate the soil surface where the fruits enlarge and mature in the soil.

In 1978 there was an estimated world production of 18.4 million metric tons of peanuts on 18.9 million hectares. More than half of this production is in developing countries. India, China, and the United States produce almost 60% of the world crop. A major change in world production came with the decline in West African production following the drought years of the early 1970's and the rosette virus epidemic of 1975. Peanuts provide, and have the potential of providing more, cash income and food source for small-scale farmers and urban poor in developing countries. In countries such as Gambia, Niger, Senegal, and Sudan, peanuts comprise a large part of the gross national product. Peanuts are one of the major cash income crops for many small-scale farmers in these and other developing countries.

Peanuts have traditionally been an important food legume crop for small-scale farmers and urban poor in developing countries, and now contribute significantly to the food supply of developed countries. The seed contains approximately 25% protein and 50% oil. In recent times, large quantities of peanuts have entered world trade for oil extraction and direct edible use, making it one of the worlds major oilseed and edible nut crops.

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Curtis Jackson is planning director and David Cummins is associate planning director of the Peanut Collaborative Research Support Program planning effort. Dr. Cummins is a professor of agronomy and Dr. Jackson is resident director of the Georgia Station in Experiment.

Peanuts are eaten raw, boiled, or roasted; made into confectionery and snack foods; used in soups and as toppings on meat and rice dishes, either whole or the cake after home oil extraction; and made into peanut butter (50% of the domestic U. S. consumption). A significant amount is extracted for oil used in cooking, and the resultant oilcake is used primarily for animal feed. The haulms are an excellent forage. On the average worldwide 60% of the production is marketed for direct consumption or oil production, and 32% used as food locally, and 8% retained for seed.

The three largest producers (India, China, and the U. S.) all consume the major part of their production domestically, so that the proportion of the world output traded is relatively small. However, peanuts, peanut oil, and peanut meal (oilcake) traded in the 1977-1979 period reached 2.6 million tons. Over 60% of the export value came from developing countries. The largest developing country exporters during the 1977-1979 period were Senegal, Argentina, India, Sudan, Brazil, Gambia, and Mali.

Peanut production schemes around the world range from almost primitive practices of complete hand production with only a hoe as a tool and very little inputs of fertilizer or pesticides to highly mechanized production utilizing high inputs of fertilizer and pesticides. Intermediate levels of production introduce animal and sometimes small-engine power into different operations and utilize moderate fertilizer and pesticide inputs. Food products are home made, produced in small, cottage scale industries, and produced in large, commercial plants. Likewise, marketing ranges from individual farmer sales, through village markets, to large domestic and export operations.

Research dependent technological advances in peanut science are necessary to support and improve present levels of production and utilization and to aid in expanding peanut production and utilization to more fully utilize the potential of peanuts as a world food source. Research programs must be structured to solve constraints that face the clientele at all technological levels to improve their situation on their level or move them to other levels.

Most peanut producing countries have research programs at some level dealing with various aspects of production and utilization. In most countries research activities are the responsibility of governmental agencies which range from institutes specializing in peanut technology to situations where peanuts are a part of a general agricultural effort. In some countries universities are heavily involved in peanut research. Peanut research by the African Groundnut Council (AGC) and the Institute de Recherches pour le Hules et Oleagineux (IRHO) in Paris crosses national boundaries primarily in West and Francophone Africa. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) at Hyderabad, India has peanuts as one of five crops in its research mandate.

The vast majority of peanut research activities are national programs. Some examples of international activities are: a germplasm collection program has been augmented through the International Board for Plant Germplasm Resources; ICRISAT sponsored a workshop in 1980 which provided an international forum for research discussions; IRHO and AGC serves a limited international research base; and the American Peanut Research and Education Society publishes an international research journal - Peanut Science. Although some degree of international cooperation has been achieved through these activities, there is still no overall global coordination of peanut research.

The United Nations Conference on Trade and Development has drafted a global program of research and development for peanuts and their products. The program has not been funded, but it proposes 19 projects with durations of three to five years and a budget of \$38.55 million. One project in this program proposes to collect and disseminate information on all aspects of the peanut industry and serve as a coordinating unit for various world programs. The proposed Peanut CRSP would serve to some extent as a base for international coordination of research.

World research has been concerned in varying degrees with such areas as breeding and genetics, agronomics, physiology, diseases, insects, weeds, mechanical aids, aflatoxin, storage, processing, product development, nutrition, farming systems, and socioeconomics. Constraints in the above areas still exist in most countries and are especially prevalent in developing countries. Depth and breadth of the research varies and is inadequate in most developing countries due to limitations in financial means and the number and capability of research personnel.

The objective of the Peanut CRSP is to identify researchable biological and socioeconomic problems limiting production and utilization of peanuts in developing countries and design and implement a general research program for acquiring information needed to solve the problems. Major emphasis must be placed on the problems of the small farmer and ways to improve his capability to adapt the required technology.

## PRODUCTION, UTILIZATION, AND RESEARCH STATUS IN VARIOUS COUNTRIES

Yield and area harvested estimates for world peanut production are presented on pages four-six based on information in the USDA publication, "Agricultural Statistics". These estimates may differ from figures sometimes used in the country reports that follow, which were given to us on site visits. Information contained in the country reports was obtained from several sources including site visits, correspondence, "Proceedings of the International Workshop in Groundnuts, ICRISAT-1980", and other personal contacts. The reports are divided into high and low technology countries based on level of mechanization and use of production inputs such as fertilizer and pesticides. Constraints to production and utilization and research needed to relieve these constraints are included. The United States is not included in this discussion section, since numerous publications are readily available from experiment stations and extension services in peanut producing states.

GROUNDNUT HECTARAGE AND PRODUCTION IN  
MAJOR PRODUCING COUNTRIES, 1975-79

<u>Country</u>	<u>Harvested Area (1000 hectares)</u>				
	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>
North America	<u>703</u>	<u>729</u>	<u>723</u>	<u>727</u>	<u>724</u>
Cuba	15	15	15	15	15
Dominican Republic	49	56	52	54	50
Mexico	25	38	38	42	38
United States	610	616	614	612	617
Other Countries	4	4	4	4	4
South America	<u>656</u>	<u>735</u>	<u>749</u>	<u>752</u>	<u>699</u>
Argentina	357	309	428	393	315
Brazil	240	367	255	275	290
Paraguay	19	21	21	21	21
Uruguay	2	2	3	3	3
Other Countries	38	36	42	60	60
Europe (including Soviet Union)	<u>12</u>	<u>13</u>	<u>12</u>	<u>12</u>	<u>12</u>
Africa	<u>6302</u>	<u>6138</u>	<u>6072</u>	<u>5623</u>	<u>5680</u>
Cameroon	202	202	202	202	202
Egypt	13	13	15	13	13
Gambia	173	173	100	100	100
Ghana	113	113	105	105	105
Ivory Coast	52	52	52	52	52
Madagascar	42	42	43	35	43
Malawi	239	239	239	239	239
Mali	97	97	97	97	97
Mozambique	200	200	200	200	200
Niger	254	254	160	160	160
Nigeria	920	920	820	600	600
Senegal	1303	1315	1079	975	975
South Africa	220	156	214	213	215
Sudan	850	745	1104	981	980
Zaire	270	270	270	270	270
Zambia	100	100	35	35	35
Zimbabwe (Rhodesia)	170	170	170	170	170
Other Countries	1084	1077	1167	1176	1224

<u>Country</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>
Asia	<u>11,086</u>	<u>10,756</u>	<u>10,993</u>	<u>11,537</u>	<u>11,518</u>
Burma	668	668	668	668	668
China	2202	2202	2300	2300	2525
India	7228	6953	7029	7548	7275
Indonesia	475	411	514	530	530
Israel	5	6	6	6	6
Japan	41	38	35	35	35
Pakistan	44	45	51	36	47
Philippines	55	61	48	48	48
Taiwan	64	64	53	58	60
Thailand	120	120	102	120	130
Turkey	18	23	22	22	23
Other Countries	166	165	165	166	171
Oceania: Australia	<u>24</u>	<u>27</u>	<u>30</u>	<u>36</u>	<u>36</u>
World Total	<u>18,783</u>	<u>18,385</u>	<u>18,579</u>	<u>18,687</u>	<u>18,659</u>

<u>Country</u>	<u>Production (1000 metric tons)</u>				
	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>
North America	<u>1891</u>	<u>1836</u>	<u>1797</u>	<u>1921</u>	<u>1911</u>
Cuba	15	15	15	15	15
Dominican Republic	60	70	40	40	40
Mexico	64	48	50	55	50
United States	1750	1701	1690	1809	1804
Other Countries	2	2	2	2	2
South America	<u>766</u>	<u>919</u>	<u>786</u>	<u>1211</u>	<u>945</u>
Argentina	375	338	372	672	400
Brazil	335	514	340	462	470
Paraguay	15	18	18	18	18
Uruguay	3	4	3	3	3
Other Countries	38	45	53	56	54
Europe (including Soviet Union)	<u>24</u>	<u>23</u>	<u>23</u>	<u>24</u>	<u>26</u>

Africa	<u>5099</u>	<u>4576</u>	<u>4397</u>	<u>4480</u>	<u>5238</u>
Cameroon	80	90	90	90	90
Egypt	28	28	30	26	26
Gambia	137	125	94	145	145
Ghana	93	86	64	64	64
Ivory Coast	48	48	49	50	50
Madagascar	48	48	47	29	48
Malawi	165	165	165	165	165
Mali	100	125	120	150	150
Mozambique	72	72	70	100	100
Niger	125	125	82	82	85
Nigeria	332	350	390	315	250
Senegal	1424	1182	671	1050	900
South Africa	256	146	311	179	850
Sudan	931	765	1021	829	1100
Zaire	268	289	295	295	295
Zambia	100	100	6	6	6
Zimbabwe (Rhodesia)	120	122	120	120	120
Other Countries	772	770	772	785	786
Asia	<u>11,200</u>	<u>9,736</u>	<u>9,988</u>	<u>10,569</u>	<u>10,266</u>
Burma	450	450	450	450	450
China	2700	2750	2065	2377	2638
India	6755	5262	6087	6387	5700
Indonesia	542	475	743	725	792
Israel	19	22	21	27	22
Japan	71	65	69	62	67
Pakistan	62	63	72	45	65
Philippines	36	40	37	40	40
Taiwan	91	89	72	92	88
Thailand	260	272	106	120	150
Turkey	40	55	50	52	52
Other Countries	174	193	216	192	202
Oceania: Australia	<u>32</u>	<u>35</u>	<u>39</u>	<u>52</u>	<u>51</u>
World Total	<u>19,012</u>	<u>17,125</u>	<u>17,030</u>	<u>18,257</u>	<u>18,437</u>

Source: U. S. Department of Agriculture, Agricultural Statistics, 1978 and 1980.

PEANUT PRODUCTION AND RESEARCH STATUS IN COUNTRIES  
UTILIZING HIGH LEVELS OF TECHNOLOGY

CANADA

The year 1980 was very significant in the development of a peanut industry in Canada - a shelling plant went into operation along with 200 acres of commercial production. Yields ranged between 1800 and 2600 pounds per acre. Production is under a high level of technology.

Moving a new crop into the "land of ice and snow" puts Canadian researchers in a unique position, a challenge they are meeting with other crops such as flu-cured tobacco, corn and soybeans. Corn and soybeans are moving into shorter season areas each year.

Canadian scientists realize that, although they sit outside the "mainstream" of peanut production and research, being in the marginal production area climatically often presents an opportunity to work on what may first appear as unique problems. These problems eventually have important implications in the more traditional areas, as experienced with other crops such as corn and soybeans. Over a period of time, they will probably contribute to the improved understanding of how peanuts grow.

Research. The research is presently a singular program at the University of Guelph, Department of Crop Science, under the direction of

Dr. J. W. Tanner, Plant Physiologist and Department Chairman. The work has been jointly funded by Ag Canada and the Ontario Ministry of Agriculture (OMAF). Future funding is being planned by these two groups, and the probability is that Ag Canada will conduct the agronomic and protection aspects and OMAF (through the University of Guelph) will support a breeding program.

Major constraints to peanut production that need addressing through research are: environmental limitations, breeding (cold tolerance is a unique requirement in new varieties), seed technology, mechanical technology, plant pests, crop management, and basic physiological factors.

AUSTRALIA

Peanut production in Australia has been somewhat constant in recent years ranging from 32,000 to 36,000 ha with average yields of 1250 kg/ha. There are cases of yields exceeding 6000 kg/ha. About 67% of the crop is grown in southern Queensland, and the balance on the Atherton Tableland and adjacent areas in northern Queensland, a region of rapid expansion. Very little irrigation is used. Rainfall during the growing season in the southern area is 700 mm and variability is high. In the northern area 1300 mm of rain is received, leading to the expansion of production in this area.

Future peanut production is faced with high production costs (primarily fuel and pesticides) and low yields. These problems must be addressed if production is maintained or increased. A possible stimulus to future production is the potential use of peanut oil as a diesel fuel. Australian peanut production utilizes a high level of technology, including complete mechanization and heavy capital inputs.

Peanuts produced in Australia are intended for the edible market as confectionery items, peanut butter, or ingredients in baked goods. Oil production is incidental to edible kernel production. Per capita consumption of peanuts are relatively low allowing substantial exports to New Zealand, Hong Kong, Japan, Korea, and the United Kingdom.

Research. Research is conducted by two interdisciplinary teams, one within the Department of Primary Industries, Bjelke-Peterson Research Station, Kingaroy, Queensland (K. Middleton is Plant Pathologist in this team) and one in North Queensland.

Past work has identified lack of water as a major limiting factor in peanut yields. Little irrigation is used. The use of higher moisture holding capacity clay soils, rather than sandy soils typical to peanut production, has resulted in soil physical limitations to production. Diseases and aflatoxins in the harvested products are major identified problems. A wide range of seeding, foliar, stem and pod rots, and virus diseases have been observed.

Varietal improvement will seek to improve yield, incorporate disease resistance, and maintain drought tolerance and market competitiveness. Research will attempt to improve soil physical conditions by production systems that will not destroy preceding crop residues. An integrated program of agronomy, breeding, soil conservation, engineering, and pathology is needed to find answers that will improve yields and cut production costs. All this research will be aimed at a reduction in production costs and improvement of yields which are low due to unreliable and limited rainfall.

#### ARGENTINA

The harvest area of peanuts in Argentina averaged 346,000 hectares per annum during the 1970's, and is generally declining with 281,000 hectares harvested in 1979-80. Average annual yields are 811 kg/ha. About 97-98% of the production is located in central region of Cordoba province. The region is semi-arid, with 600-800 mm of rainfall between October and March. Peanuts are seeded in the rainy spring in November and early December and harvested in the dry period after March. The harvest period is dry enough to permit harvest and drying of the crop under good conditions.

International markets, lower prices, and less demand by the oil industry are expected to cause an additional decline in area seeded to peanuts in Argentina.

Peanuts in the Cordoba province are grown under a high level of technology. Operations from tillage to combining are mechanized. Herbicides and fungicides are used. About 30% of the growers have digger-shaker-windrow machines and 20% have combines. Growers who do not possess diggers and combines employ contractors.

About 75% of the peanut crop is utilized for oil (about 228,000 metric tons in 1979-80). The remainder is apparently exported, directly consumed, or retained for seed. Two old cultivars Colorado Comun and Blanco Rio Segundo occupy 50% of the planted area and the rest is seeded to improved varieties developed at the Manfredi Experimental Station.

Research. Since 1944, the Manfredi Research Station, INTA, Manfredi, Argentina has been responsible for varietal and cultural improvements in peanuts. Dr. Jose R. Pietrarelli, Agronomist, leads this work. The INTA Microbiology Institute in Castelar (province of Buenos Aires) analyzes for aflatoxin contamination in samples from growers fields, and also aids in the identification of varieties and lines of peanuts with possible resistance to *Aspergillus flavus*. The Botanical Institute of the Northeast in Corrientes conducts research on the physiology, cytogenetics, and cytotaxonomy of peanuts.

Varietal improvement research has resulted in seven varieties which occupy 50% of the peanut production in Argentina. Problems associated with the present varieties are (1) no seed dormancy with a consequent preharvest germination risk, (2) fragility which causes great yield losses due to the easy separation of pods from the pegs, (3) generally a low oil content, (4) low yield potential, and (5) high susceptibility to early and late leafspot.

Diseases and insects are not yet major problems. In addition to leafspot (late leafspot more common), isolated cases of scab, root rot, and pod rot are observed. Some problems with subterreanean insects and red spiders have been observed.

Development of new cultivars is done by selection, and intervarietal and interspecific crossing. One of the earlier goals was to increase oil content in new varieties; now goals include high kernel quality and adequate size for direct consumption and to meet world market demands. Disease resistance is another breeding goal.

Investigations are conducted to improve production methodology, especially sowing density, row spacing, digging and picking machinery, natural drying, crop rotations, irrigation, chemical disease control measures, soil fertility needs, and herbicide evaluations.

## BRAZIL

Peanut production declined in Brazil during the 1970's. In 1978, there was a harvest area of 252,000 hectares. Sao Paulo State produces 70% of Brazil's peanuts, with Parana and Mato Grosso do Sul contributing 16 and 8% of the remaining area. About 75% of the production comes from the rainy season crop seeded in late August to early September, and 25% from the dry season crop seeded in late January to early February.

Increases in peanut production in the future will depend on: (1) government policies that would encourage production especially in the area of the use of vegetable oils for diesel fuel, (2) a favorable price for peanuts, (3) a shift of pasture lands from productive soils of Sao Paulo State allowing for row crop expansion or development of peanut production in the drier northeast area of Brazil, and (4) application of improved technology.

Most of the peanuts have been grown in the northwest part of Sao Paulo State by small farmers in fields ranging from 5-30 hectares using a low level of technology. Production in 1978 averaged 1290 kg/ha. Recently production has expanded to the northeast region in fields ranging from 300-500 hectares. Cultivation during the rainy season under a higher level of technology has resulted in yields of 2200-2500 kg/ha in the northeast. Should the decision be made to expand production into the drier, northeast Brazil irrigation and/or drought tolerant peanut varieties would be necessary. A new cash crop would be advantageous to the poor farmers in the northeast region.

The utilization of the Brazilian peanut crop (450,000 metric tons in 1979) is as follows:

- 75% for oil (92% of oil exported),
- 11% consumed directly,
- 4% exported as whole nuts,
- 10% retained for seed.

In 1979, oilcake production was 122,000 metric tons of which 80,000 tons were exported. Brazil is a major exporter of poultry and should be able to utilize more oilcake as protein supplement. Dry beans, the major human source of protein, are in short supply which could influence interest in peanut protein for food supplements.

Most of the peanuts are still grown by small farmers with less than optimum harvest, drying, and storage conditions, which result in a major problem of aflatoxin contamination. The small farmers generally save their own seed, often of low quality; which leads to the difficulty of introducing new, improved varieties. Brazil has a seed agency, CATI, for the certification and distribution of seed, but peanut seed are expensive (120 kg/ha at \$0.50/kg.) for the small farmer.

Research. The peanut production research program is in the Instituto Agronomico, Campinas, Sao Paulo, Brazil. The primary researcher is Dr. A. S. Pompeu, Plant Breeder, with supporting work by at least five other individuals in soil fertility, agronomy (cultural practices), plant pathology, and soil microbiology.

Research has fairly well established the macronutrient needs such as phosphorous, potassium, nitrogen, and calcium. Soil pH is generally about 4.8 on cropped soil where lime is not applied. Lime or calcium is needed to reduce the percentage of unfilled nodules. Micronutrient relationships and needs are less well established, including zinc, cobalt, boron, molybdenum, manganese, and aluminum. Potassium is the major element being studied at this time.

Cultural practices such as row spacing, plant densities, crop rotations, and cultivation have been studied with older varieties, but this work should be continued as new varieties are introduced. The Brazilian farmers generally throw soil on the plant crowns during cultivation at pegging time, which likely reduces yield. The effect of improved land preparation on stands and yields should be considered.

Leaf spots, scab, and rust are the primary disease problems at present. Since most of the present varieties are susceptible to these diseases, pathological research should assist in finding sources of resistance in germplasm. Fungicides are used sparingly by farmers for disease control. The economic importance of other diseases such as crown rot should be evaluated as they are observed to be potential problems.

Soil microbiological research is aimed toward evaluating the level of nitrogen fixation by the natural rhizobium populations in the soil. More efficient rhizobium strains are being isolated and compared to naturally occurring strains. A cooperative project with the University of Hawaii is concerned with the selection of rhizobium that tolerate acid soil conditions.

Presently, breeding efforts are being made to transfer desirable traits from wild peanut species to cultivated species through interspecific crosses. Some success is being made in obtaining fertile strains. Resistance to foliar diseases are of interest in these crosses. Breeding needs to include resistance to thrips, a major insect pest.

Peanut production in Brazil will be enhanced with improved varieties resistant to diseases and insects, improved cultural and fertility practices, increased mechanization, and irrigation.

At this point in Brazil, peanuts are not considered a food crop for protein, only for oil. The primary problem of high protein oilcake utilization for human food is aflatoxin contamination. Secondly, new food products are accepted reluctantly by the population. Since Brazil has a protein problem due to dry bean shortages, peanuts command a favorable position to provide needed protein. Adequate supplies of peanuts at competitive prices would be necessary for peanuts to gain acceptance as a food protein supplement.

There are two research facilities in Campinas well equipped and staffed for food science, technology, and engineering research. One is ITAL, an Institute in the Ministry of Agriculture dealing with food science and technology. ITAL has a large, well equipped physical plant for a wide range of research with about 80 staff members. Some 10 of these staff members have a Ph.D. degree. An FAO project developed the ITAL facility. Second, the University of Campinas is an institution with 80 staff members (50 Ph.D.'s), 350 undergraduate and 150 graduate students, and facilities to conduct a wide range of research in food science. ITAL is better equipped and the university better staffed, but together provide research capabilities for aflatoxin decontamination and product development unmatched in Latin America, and probably most of the developing world.

#### PARAGUAY

Approximately 50% of the peanut production in Paraguay is under a high level of technology. The western region of Paraguay (west of the Paraguay river) is called the Chaco. There are 10,000 to 11,000 hectares of peanuts in the central part of the Chaco, all produced by a Mennonite settlement. Average production is 1000 to 1300 kg/ha annually. Mechanized production of other crops such as cotton has contributed to the economical mechanization of peanut production. Necessary inputs of fertilizers and pesticides are used.

All the peanut production in the Chaco has gone into oil production. The crushing equipment is owned by the Mennonites. Present intentions are to expand production to peanuts for direct consumption. Most of the oil is exported to Brazil and to Europe.

Research. Research on peanuts in Paraguay is not very extensive. A small variety evaluation program is conducted at the Institution Agronomico Nazionale (an experiment station near Caacupe) by Manuel Mayeregger. Some supportive research comes from entomology and plant pathology. The Mennonite farmers do some research themselves in variety selection, agronomics and pest management.

Research directed toward increased yields with less production cost will aid in raising the export market potential for the Chaco region. A new contract with the European Economic Community should provide continued oil sales and the hopeful entry into the fresh peanut market would demand more production.

## ST. KITTS

About 400 acres of the estimated 3000 acres of peanuts produced in the Caribbean Community (CARICOM) are grown on St. Kitts. There are eleven other English speaking countries in CARICOM.

Production on St. Kitts is from one sugar cane plantation. The peanuts are interplanted into the young sugarcane and harvested before the cane is very large. The nuts are pulled from the vines by hand with the objective of utilizing sugarcane labor force during offseason.

Research. Research conducted by CARDI (The Caribbean Agricultural Research and Development Institute and headquartered at the University of the West Indies, St. Augustine, Trinidad) applies to production problems on St. Kitts. This research includes variety selection, agronomics, and pest management. A more complete description of CARDI research will be included later in this report under the CARICOM report in the Low Technology Countries Section.

## VENEZUELA

The harvest area of peanuts was estimated at 14,684 ha. in 1979 up from 9700 ha. in 1970. Average annual yields were 1839 kg/ha. in 1979 compared to 729 kg/ha in 1970. Production is accomplished using a high level of technology. Irrigation (about 25% of the area and 50% production from irrigated fields) and improved varieties are apparently responsible for a large part of the per hectare increase in yields during the 1970's. Peanuts were produced on a family scale by small farmers, until 20 years ago when introduced into the eastern Llanos region of Venezuela using a high level of technology (including complete mechanization). The sandy soil in the eastern Llanos region is characterized by a rainy season of about 100 mm, which is unevenly distributed from May to November. There is practically no rain in the dry season from November to May.

There is likely to be an expansion of peanut production in the eastern Llanos region. Improvement of yields, easy availability of land, a support price sustained by the government, and the recent introduction of other crops for rotation with peanuts are reasons for this probable expansion of peanut production.

The high level of production technology employs good agronomic practices, chemical pest control, irrigation, and mechanical harvest.

Approximately 50% of the crop is processed for oil with the resultant oilcake production. The balance is directly consumed as roasted peanuts and other confectionery products.

Research. Peanut research in Venezuela is conducted at several Ministry of Agriculture and University Experiment Stations. Approximately 600 cultivars and lines are maintained at two locations, Maracay and El Tigre. Dr. Bruno Mazzani, Centro Nacional de Investigaciones Agropecuarias, IIA, Maracay is a leading peanut authority.

Major research problems are varietal improvement emphasizing disease resistance, cultural practices, pest control, soil fertility, and rhizobium relationships. An overall objective is to reduce the cost of the most expensive production practices.

#### ZIMBABWE

Accurate production figures for peanuts in Zimbabwe are not available, but estimates of production and sales show 254,900 ha planted and 114,000 tons produced in 1978-79 and 374,600 ha planted and 126,000 tons produced in 1979-80. More than 90% of this production comes from rural areas, and this sector retains about 90% of its production for local use. Peanuts are a controlled product in the country and must be sold through the Grain Marketing Board, and estimated deliveries to the Board are 20,000 tons annually. An estimated 5000 tons are exported annually as confectionery nuts, and about 2000 tons of confectionery nuts are consumed in the country. The remainder of the delivered peanuts are used for seed or crushed for oil. Oil export figures are not available. Future increases in deliveries are likely to come from yield increases rather than expansion of area planted.

Peanuts are an important source of food in the rural areas and surpluses are an important cash earner. Most of the agricultural industry is in the central plateau region of the country on elevations between 300 and 1600 m, although cropping below 800 m is largely dependent on irrigation. Annual rainfall ranges between 455 and 936 mm, most falling from November to March.

Almost 10% of the peanut production in Zimbabwe employs a high level of production technology. The production is mechanized and employs good production practices, and is classified as both large and small scale farming with part of the production under irrigation. The highest reported field scale yield in the world was in this country, 9.6 tons/ha of unshelled nuts.

Research. Most of the research effort in Zimbabwe in the past decade has been on variety improvement, physiology, and growth analyses. A number of varieties have been released for commercial production, and a significant contribution made to the understanding of peanut growth. In addition, research has included disease control, agronomic practices, mechanization, weed control, aflatoxins, and plant nutrition. Research in agronomic practices has provided the basis for recommendations for production in the large scale farming areas, and has also provided principles for production recommendations in the rural areas.

Certain problems still exist which are limiting yields and for which solutions must be sought. These include variety improvement (improved yield and quality, drought tolerance, pest resistance, higher pod-top ratio, seed dormancy at harvest, and good shelling quality), disease and insect control, agronomic practices (method to facilitate earlier planting and nematode damage assessment), and plant nutrition.

A peanut breeder and spokesman for research in Zimbabwe is Dr. G. L. Hildebrand, Crop Breeding Institute, Department of Research and Specialist Services, P. O. Box 8100, Causeway, Zimbabwe.

## PEANUT PRODUCTION AND RESEARCH STATUS IN COUNTRIES UTILIZING LOW LEVELS OF TECHNOLOGY

### BURMA

Peanuts have been grown in Burma since 1880. Several local varieties have been developed. Most of the production goes into oil production since peanut and sesame oils are the primary cooking oils in Burma.

The area devoted to peanuts is variable due to frequent droughts during the growing season and high seed prices during some years. In 1979-1980 there were 594,000 ha, which yielded an average of 831 kg/ha. There are two production seasons; the rainy season in the semi-arid region, and the winter season crop in the valley and islands along the Irrawaddy River. In the semi-arid region rainfall patterns favor a good crop in only one year in ten. Often there are 25-40 days between rains. The winter crop produces 50-100% higher yields than those in the semi-arid region.

Production is primarily by hand, except for possibly the land preparation by animal power.

Research. Research is conducted by Agricultural Research Corporation of the Ministry of Agriculture at various locations. U. Win Niang is the peanut breeder.

The following types of research conducted in 1980-1981, give an idea of production problems: varietal yield tests; rhizobium inoculation tests; effects of lime, gypsum, phosphorus and micronutrients on yields; land preparation, and herbicide and insecticide studies. Future research needs are cited as varietal improvement for higher yield potential, and cultural practices work to include row spacing and plant density, and fertilizer studies on a wide range of soil types.

## INDIA

India is the world's largest producer of peanuts with 1978 production estimated at 6.2 million tons on 7.3 million ha for an average yield of 849 kg/ha. By comparison this is 39% of world production area (ha) and 34% of the total production (tons). Most of the peanuts produced in India are consumed locally, with only an estimated 5% exported. Peanuts are the primary source of vegetable oil in India. Only about 1.5% of the production is consumed directly as confectionery and other products.

Most of the crop is grown by small farmers who utilize bullock power for preparatory plowing, harrowing, furrowing for hand or drill planting, cultivation in addition to hand weeding, and digging. Fertilizers and lime are used to a limited extent with usage varying from year to year.

Research. The Indian Council for Agricultural Research, Directorate of Oilseeds Research conducts peanut research through the All India Coordinated Research Program for Groundnuts, directed by Dr. Vikram Singh, Rajendranagar, Hyderabad-500030, Andhra Pradesh (India). Research is conducted on peanuts at 17 of the 62 research centers in India that work with oilseeds. Additionally, peanut research is conducted in various universities.

In 1979, the National Research Centre for Groundnut was established at Junagadh, with a mandate to generate and distribute breeding material at early stages and to engage in basic research with a view to break yield barriers in the peanut crop.

In the past two to three decades, the Central Food Technological Research Institute (CFTRI) located in Mysore, has developed a variety of nutritive food items from peanuts. Notable among these are: Bal-Ahar - a food for infants and children, toned milk, peanut milk, yogurt, and coffee whiteners.

The scientific strength at a main center in the National Oilseeds Research Project normally consists of a breeder, agronomist, plant pathologist, entomologist, biochemist, and a statistician, while that of a subcenter is limited to a breeder, or a maximum of assistant agronomist, in addition.

The specific objectives of the peanut research program which reflects present constraints are:

1. Development of high yielding varieties possessing resistance/field tolerance to diseases and pests of economic importance for the different peanut growing agroecological zones.
2. Development of production technology for maximum yield exploitation under irrigated and nonirrigated conditions in different peanut growing zones.

3. Development of simple and cheaper crop protection technology with an emphasis on integrated control of the disease-pest complex.

4. Demonstration of the proven research results through on farm trials for the benefit of farmers and extension workers.

5. Identification of the stable sources of resistance to diseases and pests, and other desirable agronomic traits in the germplasm, and their use in future breeding programs.

6. Production and maintenance of a continuous supply of breeder's seed for multiplication into further categories for ultimate supply to the farmers.

7. Resolving any other problems.

Future needs are to reallocate priorities and strengthen weak links in the research program. Special emphasis will be given to basic problems of breeding, disease and pest control, irrigated production, physiology, and soil microbiology. Such efforts will be closely coordinated with the ICRISAT program. Food items developed from peanuts have not become very popular. This may be due to: 1) cost and 2) preference.

#### INDONESIA

Peanuts have been identified along with mungbean and soybeans as legume crops to receive attention in the Indonesian research program to provide protein in the diets of the population and an income source for the small farmers. There were 410,000 ha grown in 1978 that produced 400,000 tons for an average 975 kg/ha.

Most of the peanuts in Indonesia are grown in central and east Java, the southern Celebes, and southern Sumatra. They are mostly grown by small farmers with about 0.3 ha per farm. The crop is grown largely by hand, including hand pulling of the pods from the vines for drying. In drier areas, the pods are dried prior to pulling from the vines. Most of the peanuts are consumed directly, but some are pressed for oil and the cake fermented for human consumption or fed to animals.

Farmers tend to limit inputs to the peanut crop. Fertilizer and lime usage is usually inadequate or not used at all. Seed of new varieties are distributed to advanced farmers, and the farmers save their own seed. Some farmers use insecticides, but no fungicides are used.

Research. The Indonesian peanut research program is in the Central Research Institute for Agriculture (CRIA) Bogor and the Institut Pertanian, Bogor (IPB, the Agricultural University). Mr. Sadakin Somaatmadja is the breeder for CRIA. Dr. Gasurano Sapardo, IPB, has conducted some soil fertility research with peanuts. Presently the CRIA research program on peanuts is somewhat low key, and little or no work is being done at IPB except for an occasional graduate student program.

Major constraints to production of peanuts in Indonesia include: diseases (rust, wilt, peanut mottle virus, and leafspot), aflatoxins, low yields, seed germination prior to harvest, low protein content of present varieties, low pH, and Mg deficiency.

Emphasis in the legume research program appears to be on soybeans and mungbeans rather than on peanuts.

## PHILIPPINES

Peanuts are grown on a small scale throughout the Philippines, but the primary production area is in north Luzon in the Cagayan and Isabelle provinces. This area has a wet-dry season of about 6 months each. There are about 90,000 ha grown annually with a total production of 45,000 tons or 500 kg/ha.

The peanut crop is consumed as a snack or confectionery food and as peanut butter. There are two large peanut butter manufacturers, as well as many local, cottage industry factories. There are virtually no peanuts used for oil in the country. There is a project underway to build two oil mills in North Luzon, the first of which would require 300,000 ha of new peanuts to supply its needs. The present market system consists of a series of collectors who in turn sell to large wholesalers. Shelling and processing plants in north Luzon often loan money to farmers for seed and buy the crop in advance at low prices. Farmers who qualify can obtain government credit for production inputs.

The average farm size in the Philippines is two-three ha and the average area devoted to peanuts is 0.6 to 1.0 ha. The small farmer has essentially no mechanization, only a caribou, wooden plow, and hoe for all operations in producing and harvesting peanuts.

The Philippine government is interested in increasing peanut production to expand cash income for small farmers. Additionally, the food production base needs to be expanded since it is generally understood that 70% of the school age children are malnourished.

Research. Coordination of research programs and financial planning is the responsibility of the Philippine Council for Agriculture and Resources Research (PCARR), Los Banos, Laguna. Dr. Ponciano A. Batugal is Director of the International Projects Division. Research is conducted at Ministry of Agriculture Research Stations at various locations and in Universities such as the University of the Philippines at Los Banos (UPLB). Mr. Rudy S. Navarro is responsible for the peanut breeding program in the Institute of Plant Breeding, College, Cagula. Support is given in related disciplines. Other peanut researchers include Dr. Issac Cagampang, Agronomist, UPLB, and Dr. Elias E. Escueta, Food Scientist, UPLB. Considerable socioeconomic expertise to investigate aspects of peanut production and utilization may also be accessed through PCARR.

Primary constraints to production of peanuts appear to include the following items.

1. Diseases. Leafspot, rust and peanut mottle virus are the most common diseases. Resistant varieties are needed.
2. Adequate knowledge of basic agronomic practices, such as planting date, population, and fertilization is not available to attain maximum yields.
3. Lack of small equipment for production, harvesting and shelling limits the amount of peanuts the small farmers can produce.
4. Rhizobia do not fix enough nitrogen for maximum yields in many cases.
5. Cropping systems need to be developed to best utilize peanuts.
6. Food science concerns are in the areas of development of high protein beverages from peanuts, improvement of traditional products produced by the cottage industries, and utilization of peanut flour in noodles for protein enrichment.

#### THAILAND

Peanuts are believed to have been cultivated in Thailand for about 300 years. The major growing areas are in the North and Central Plains and in the Northeast. There are distinct wet and dry seasons, the rainy season from May to October followed by the dry season. About 20% of the land is irrigated for crop production during the dry period. Thus peanuts are grown in both the wet and dry seasons, with planting in May-June and January-February.

For the period 1969-1978 an average of 114,000 ha/year of peanuts have been grown with an annual production of 137,000 tons. Average yields are about 1200 kg/ha. Peanuts are a high labor crop in Thailand with bullock traction utilized in land preparation, cultivation, and in some digging operations. Other operations are by hand. Most plantings are less than 1 ha/farm.

Peanuts are grown as a mono-crop following rice and often as an intercrop in cassava and other crops. Most Thai farmers consider peanuts a marginal crop, especially in the rainy season, therefore production inputs are utilized to a minimum. The farmers prefer to grow peanuts in the paddy fields, wherever irrigation is available because of the nitrogen contribution to the following rice crop, in addition to the extra income from the peanuts.

Peanuts are utilized in Thailand in various types of confectionery products, peanut meal for food products, for oil extraction, and oil cake for animal feed. There was a brief period of interest in producing milk from peanuts but the idea was not successful. Most of the production is consumed in the country although some are exported as whole peanuts and a few are imported. A legume inoculum plant is being established in Bangkok. It will process 200 tons of inoculum per year.

The Thai government has a USAID program called the Northeast Rainfed Project. Funds for support of the program will also come from World Bank, The Japanese Government and other places. A major facet of the Project will be to increase the role of peanuts in the cropping systems of the Northeast Region, characterized by a predominance of small farmers. An increased production of peanuts will increase farmer income, provide high protein food, and supply nitrogen for grain crops in the rotation.

Research. The primary research program in peanuts is the responsibility of the Department of Agriculture, Bangkok. Much of the research is under the direction of Dr. Arwooth Nalampang, Division of Agronomy who is a plant breeder. The primary research location in the Northeast is the Field Crops Station at Kalasin. Peanut research is also conducted at Khon Kaen University and at Kasetsart University in Bangkok.

Constraints to present peanut production and to an expanded industry in the Northeast appear to include the following areas.

1. Breeding. Varieties need to be developed that are disease resistant and drought tolerant. Larger seeded varieties with a shorter growing period are needed to meet the market demands. Soil salinity is a growing problem in the northeast, therefore saline tolerance should be emphasized in the breeding program.

2. Cropping systems on middle terrace and upland need to be developed that would utilize peanuts to a maximum, which include socioeconomic concerns of farmer adoption of new practices. Peanut markets in the Northeast need developing since most peanuts are consumed locally.

3. Soil fertility problems include calcium and phosphorous deficiencies. Rhizobium present are apparently not efficient fixers of nitrogen, and there is a question whether they survive flooded conditions prevalent during the rice season.

4. Seed quality is presently low resulting from poor harvest and storage conditions. Also varietal purity is lacking.

5. Aflatoxin contamination is high and means of reduction need to be developed through breeding, cultural practices, storage, and detoxification. New food products could be developed following aflatoxin control, thereby better utilizing the protein supply potential of peanuts.

## CARICOM

CARICOM is the Caribbean Community of 12 English speaking countries. The countries are Belize, Jamaica, Antigua, Montserrat, St. Kitts-St. Christopher-Nevis-Anguilla, Dominica, Barbados, St. Vincent, Grenada, Trinidad and Tobago, St. Lucia, and Guyana. CARDI, Caribbean Agricultural Research and Development Institute, is responsible to CARICOM for agricultural research programs. Dr. St. Clair Forde is Chief of Research and is located at the University of the West Indies, St. Augustine, Trinidad.

Peanut production is rather limited in the CARICOM, about 3 million pounds on 3,000 acres. In addition some 13 million pounds are imported. Jamaica has about 1500 acres, St. Vincent 500 acres, Guyana 500 acres, St. Kitts 400 acres, Barbados 100 acres, and Belize 100 acres. The peanuts are consumed almost entirely as a snack food with some processed into peanut butter. There is no oil production. Most of the peanuts in CARICOM are grown on small farms of less than two acres (2.47 acres = 1 hectare), the exception being St. Kitts where the total acreage is on one sugar cane plantation.

Rain generally begins in the Caribbean in late May or early June. There is a short dry season of about two weeks in September with rain continuing until mid-January. Rainfall varies from 750-1000 mm in the leeward islands to 1250-5000mm in the windward islands.

Peanuts are intercropped into young sugar cane and monocropped. A typical cropping pattern on St. Vincents is to plant during May or June and harvest in mid to late September (120 day season), followed by a second planting 15-20 days later which is harvested in late January or early February. A 60-day cowpea may follow the second peanut crop. The crop is grown entirely by hand labor with few inputs.

There is an interest in increasing peanut production by the small, poor farmers since peanuts are a semi-perishable item that can be shipped within CARICOM or exported outside to increase their income. The poor farmers also need the peanuts for a source of protein.

Research. The peanut research program was initiated primarily to help the small, poor farmers on the lesser developed islands with secondary emphasis on the medium developed island farmer problems. There has been no breeding program, only varietal evaluations consisting mostly of United States varieties. Research has adapted production practices cited in the literature to Caribbean conditions.

Constraints to production include the need for small hand and gasoline powered machinery, higher yielding disease and insect resistant varieties, and a better understanding of lime and gypsum needs. Also there is a shortage of protein in the diets of young children and mothers who are carrying or nursing children that peanut products could help overcome. Socioeconomic research could seek ways to improve the production and utilization potential of peanuts in the CARICOM.

#### PARAGUAY

Approximately 50% of the peanut production in Paraguay is under a low level of production technology, and is located in the Eastern part of the country (east of the Paraguay river). It is a subsistence crop for small farmers, who grow an average of 0.25 ha of peanuts. Most of the production is consumed directly by the farmers, with a small amount reaching the local market. Average production in this region with few inputs range from 900 to 1000 kg/ha.

Research. Peanuts rank sixth in crop importance in Paraguay, following cotton, tobacco, soybeans, wheat, and sunflowers. This probably accounts for the fact that peanut research is limited in respect to scientific man years, equipment and supplies. A small variety test program is conducted by Mr. Manuel Mayeregger at the Institution Agronomico Nationale near Caacupe. Some supportive research comes from entomology and plant pathology. Primary constraints to production among this farming sector are availability of good varieties to the farmers, and inadequate knowledge and use of good cultural practices. Seed kept by the farmers are often of low quality and are a mix of varieties. Other constraints are thrips and caterpillars, seedling and foliar diseases, credit for buying fertilizers and pesticides, low prices, and low priority placed on peanuts by the government.

#### MALI

In Mali, peanuts are both a cash crop and a primary food crop within the country (15kg per capita annual consumption).

Estimated peanut production in Mali varies, and was affected by the drought and rosette epidemic of the 1970's. USDA agricultural statistics list 97,000 ha annually from 1974-78 (115,000 tons annually) while IRHO in Paris cites 152,000 ha in 1977-78 (102,400 tons). Oil and oilcake exports were reported as 42,000 tons in 1977-78 and the remainder consumed as food. Reported exports in 1979-80 were 32,000 tons. Population increases and food shortages within Mali probably account for the decrease in exports, but peanuts are the number two export item in the country.

Most of the peanuts are grown in northeast and southcentral Mali. Farm sizes are usually under 2 ha, with probably less than 1 ha peanuts per farm. The crop is often grown with no inputs of fertilizer or pesticides. The government has no program to furnish resources to the farmers, but an IBRD project lends money for inputs which are repaid after sale of peanuts to the oil mills.

Research. Mr. D. Soumano, Engineer of Agronomic Research, SRCVA, Ministry of Agriculture, Bamako, has responsibility in peanut research. Both financial support and research time devoted to peanuts is inadequate.

Research needed to help reduce constraints to production have been identified as follows:

1. Selection of adapted, high yielding cultivars, especially tolerant to drought and diseases.
2. Improvement in cultural techniques, such as planting dates and fertilization.
3. Develop economic usage patterns for fertilizers and pesticides.
4. Determine rhizobium inoculation needs.
5. Detection and control of aflatoxins.

#### MALAWI

Production reports on peanuts in Malawi show 165,000 tons produced on 239,000 ha for an average production of 690 kg/ha. In 1979, in part due to low government prices, official exports were only 24,300 tons. If there were no unofficial exports this shows that most of the production may be consumed within the country. Most of the peanuts are grown by small farmers, and plantings are usually less than 1 ha. On the average, a farmer will probably sell half of his production and keep the other half for food and seed. Area planted to peanuts will probably remain stable since farmers in Malawi are extended to the maximum in utilizing available land and labor. Yields are low because in general farmers do not use fertilizer and pesticides on their peanuts, but divert most available capital to grain crops.

Most of the production is in Central Malawi. Elevations in this area average about 1000 m. Only one crop per year is grown in the November-May rainy season.

Research. The problems encountered in peanut production in Malawi, since it is a small holder crop, have related to varieties, agronomic practices, and diseases. Research has been carried out since the early 1950's, and the program is largely breeding, agronomy, and pathology reflecting the major types of problems encountered in peanut production in the country.

Varietal improvement has been approached by introduction, selection, and breeding. Varietal introduction has been very fruitful, since the three major varieties grown have been introduced from abroad. These varieties are being improved for disease resistance and consumer acceptability. Rosette and rust are the main disease concerns in the breeding for resistance program.

Agronomic research has answered such questions as fertilizer use, spacing and plant density, crop rotations, time of seeding, harvest time, and drying procedures.

Pathology research has identified disease problems and developed or adapted cultural and chemical control procedures. Leafspot control has been a major concern in past research.

In addition to breeding for disease resistance, future research will aim to develop varieties to meet the demand for large confectionery nuts. Yields per unit area need to be increased through good management and genetic improvement. Research into the physiological aspects of Malawi peanut cultivars is giving insights into probable yield limiting factors. Breeding programs can in turn develop improved cultivars based on the physiological data.

The Florida/AID Institutional Development Project at Chitedze has an extensive training component, and will locate 7 staff members on a 2-3 year assignment. The anthropologist, economist, and physiologist have particular relevance to the Peanut CRSP.

#### MOZAMBIQUE

Peanut production in Mozambique was estimated at 155,000 ha in 1969. USDA figures show 200,000 tons in 1978. Still, total production is low and short of needs, because average yields are only 400 kg/ha. About 99% of the peanuts are grown on small family farms, averaging about 0.34 ha/farm. Most of the plantings are in the coastal zones. Short season varieties are grown in the southern region (600-800 mm annual rainfall), and later maturing varieties in the central and northern region (600-1200 mm rainfall annually). Most of the peanuts produced are consumed directly.

Over 60% is used as a flour additive to foods such as meat, fish, vegetables, cassava, and sweet potatoes. Peanuts are a significant protein source in a protein deficient country. Local consumption of peanut oil is high, but most comes from imported peanuts. Peanuts are also boiled, roasted, and water extracted for "milk" to use in cooking.

The main cause of low yields are unimproved varieties, traditional or unimproved cultural methods, non-use of fertilizers, and diseases. Rosette, leafspot, and recently rust are major diseases present.

Research. The Institute Nacional de Investigacao Agronomico (INIA) of the Ministry of Agriculture is responsible for agricultural research in Mozambique. The Faculty of Agriculture, University Eduardo Mondlane in Maputo is conducting research on peanuts collaborative with INIA. A. D. Malithano is the Advisor to the Peanut Improvement Project in Maputo. Research was neglected in the colonial era, therefore few improved cultural practices and varieties are in use.

The present short-term research objectives are the identification of high-yielding varieties and the improvement of cultural practices. Field demonstrations in villages are planned. Long-term objectives are the breeding of high-yielding varieties adaptable to local conditions and resistant to diseases and pests and with high oil and protein content. Cropping systems, cultural practices, fertilization, plant density, date of planting, and irrigation also are needed. Mechanization needs to be introduced to the small farmer.

## NIGER

In 1968-69, peanuts ranked second after millet among Nigers' five major crops. Foreign sales of shelled peanuts, peanut oil, and oilcake accounted for 45% of the export value in 1972. The peanut situation then deteriorated due to a 1973 drought and a 1975 rosette epidemic. Area planted in peanuts from 1970-72 averaged 390,000 ha, which produced 240,000 tons for a 615 kg/ha average. Yields dropped to 212 kg/ha in 1973 and 130 kg/ha in 1975. Since 1976 average amount of land devoted to peanuts has been 170,000 ha, with average yields between 400 and 450 kg/ha. This lack of production led to inactivity of marketing corporations, shelling mills, and oil mills.

The peanut production regions are in the East (Zinder) with 60%, central (Maradi) with 35%, and west (Dosso) with 5% of the total national production. One crop per year is grown in the July to September rainy period. The peanut crop is grown primarily by small farmers with plantings in the range of one ha per farm. Inputs for seed and fertilizer can be obtained through SONORA (National Society for the Commercialization of Peanuts). Due to the uncertainty of production, recent use of fertilizers has been limited. The seed multiplication centers are too small to provide adequate seed of good varieties. In order to rectify the deteriorating situation in peanut production, Niger adopted a policy to improve peanut production through technical (improved land use, use of selected seed, and fertilizers) and financial (increase in financing available and higher prices paid to producers) incentives. Production figures for 1977-1979 have shown a gradual growth in production.

Research. The research program is trying to make a contribution to the national effort to improve the position of peanuts in the economy.

Until 1974, research was focused on comparative trials of introduced varieties and of cropping techniques. Program objectives were expanded in 1975 to include breeding, foundation seed production, and to improve cultural practices (fertilization, crop protection treatments, irrigation, etc.). Apparently, this new program has not been functional since present research (as observed during the Peanut CRSP Planning site visit) is limited practically to screening varieties which have been received from other locations such as Senegal and Sudan. Primary production constraints in Niger presently are drought, aphids and rosette disease complex, flower abortion because of rosette, low price, and fertility. There is a shortage of trained persons for the research program.

Active peanut research is only being carried out by INRAN (Institut National De Recherches Agronomiques) at the Tarnu Research Station in Maradi. Mr. Amadon Mounkaila is the Plant Breeder.

## NIGERIA

The peanut has been one of the most important commercial crops in Nigeria, but there has been a general decline in production during the past decade. Most of the peanuts are grown in the Northern part of the country where the sandy soils are more conducive to the crop. Some 33-50% of the production was in Kano State during the 1960's. Several factors have contributed to the decline in production, including low prices, petroleum wealth luring farmers to the cities, high labor requirement in peanut production coupled with a loss of farm labor, the 1971-1973 drought, and the 1975 rosette virus epidemic. Production estimates are misleading and almost invariably an underestimate. Yields from 47 experimental trials ranged from less than 300 to 1000 kg/ha in the northern areas during the 1970's (where farmers have virtually stopped growing peanuts), and a 1976-1977 project at Zaria with about 50 farmers showing a production range of 400 to 3000 kg/ha. Purchases by the Marketing Board show annual purchase of 200,000 tons since 1977, but this probably represents from 33-50% of the total production because of local consumption, local oil production, and sale outside of the Marketing Board system.

In order for production to return to levels of the 1960's about 400,000 ha of new peanut farms would have to replace those out of production in the northern area. This replacement has not occurred because of economic, environmental, and farmer reasons. In the Northern and Southern Guinea Savannas where rainfall is adequate for peanuts, farmers may not regard peanuts as an important crop and lack production experience. Soils can set hard and make harvesting difficult, and late rain frequently damages harvested crops and drying can be a problem.

Peanuts will probably continue to be grown as a subsistence crop by the small farmers, but the major production constraints discussed above will have to be overcome in order for the crop to regain its commercial status.

Research. The government of Nigeria has marked peanuts as a crop for rehabilitation efforts. The Institute of Agricultural research is attempting to expand their work rather dramatically on peanuts. The Institute for Agricultural Research, Ahmadu Bello University, PMD 1044, Zaria, Nigeria conducts peanut research in three distinct zones; the Sudan Savanna near and around Kano, the northern Guinea Savanna in and around Zaria, and the southern Guinea Savanna in and around Mokwa. These zones are typical and run in an east/west direction across Africa and are similar in many countries. Dr. Colin Harkness devotes full time to peanut breeding and an additional eight individuals in entomology, virology, soil science, plant pathology, agronomy, general agriculture, weed science, and agricultural engineering contribute 3.95 EFT's to peanut research.

There are several specific constraint areas that research must be addressed toward if peanuts regain commercial status.

1. Breeding. Major concerns are drought tolerance, rosette resistance, and rust & leafspot resistance.
2. Mechanization. The essentially hand produced peanut crop is so labor intensive and labor is becoming so scarce that mechanization is needed. Mechanization for land preparation, planting, weeding, and harvesting are of interest to the farmer. About 2000 hours are required to produce a hectare of peanuts, with 800 hours devoted to hand shelling. The Marketing Board will only buy shelled peanuts.
3. Crop protection. Insects and diseases are a problem and chemical controls are expensive. In addition to the breeding programs for resistance, low cost control measures are needed.
4. Agronomy. Research is needed on agro-climatic factors, flower production and initiation, pod formation, and plant nutrition (calcium and magnesium, pH, micronutrients, and organic matter contribution to production). These studies are needed to determine why crops grow well but produce no fruit. In addition, the cropping systems research should combine mechanical, chemical and hand weed control into one program. Ultra low volume herbicide spray techniques are needed.

#### SENEGAL

Peanuts are the major cash crop in Senegal, and represent from 1/3 to 1/2 of the Senegalese exports. The aim of the Senegalese government is to stabilize peanut production at 1.2 million tons of unshelled nuts annually. This would minimize the fluctuation in tons exported, and consequently stabilize the annual income of the producers. For the past 18 years, an average of 1.2 million ha were seeded annually, yielded 905,000 tons and averaged 830 kg/ha. In 1980, late onset of the rain and erratic rainfall during the growing season reduced yields about 50% and resulted in many low quality peanuts.

Most of the peanuts are grown in the West-Central part of the country north of Gambia, with some grown in the north, east, and southern areas. Rainfall averages from 900 mm in the south to 400 mm in the north part of this area. The south has a longer wet season and can grow longer season peanuts than the north.

Small farmers grow most of the peanuts and average 0.5-1 ha per farm with plantings up to 4 or 5 ha. Small oxen drawn equipment is often used for preparing land, seeding, cultivation, and digging. The peanuts are usually hand threshed (with sticks), and hand operated cleaners are available at the buying points.

From the 0.9 million tons of peanuts produced annually, 120,000 tons are kept for seed, 30,000 tons exported in edible form, and the remainder eaten directly or crushed for oil. Part of the oil and essentially all the oilcake is exported. It is estimated that half of the production is exported.

The government has had a program that lends seed to the farmer which is paid back with the same quantity of seed plus 12% interest. Fungicide and fertilizer is also available and is paid from the ensuing years profits. These production inputs are provided through cooperatives which also gather the peanuts at the local level. Even with this support, fertilizer usage is only about 1/3 of recommended rates. The government marketing system is undergoing reorganization and is not presently functioning properly.

Research. Peanut research began in Senegal in the 1920's. The research station at Bambey was established about 1925. The breeding program has resulted in the development of many drought tolerant varieties. Rosette has never been a big problem except in the very southern part of the country. Agronomic research has developed recommendations for plant spacings, fertilization, tillage, and cropping patterns. Crop protection research has provided guidelines for chemical control of diseases, insects, and weeds.

The research system was developed and supported by the French, but is presently undergoing a transition to Senegalese direction and staffing.

Research must continue and the results utilized by growers if the production goal is to be met with any consistency. Major production constraints which plague the producers are drought, rust, leaf spot, and aflatoxin. Resistant or tolerant varieties and chemical or cultural practices must be a continuing goal to overcome these constraints.

Regarding consumption of peanuts, 50 to 75 kg peanuts/capita/year are consumed, lost in storage, or exported through unregulated channels. One study of consumption patterns by the Bureau of the Census is underway.

## SUDAN

The Sudan is one of the largest exporters of peanuts in the world. The Sudan Oilseeds Company in 1978 exported 134,000 metric tons or about 17% of the world peanut exports. Three classes of peanuts are exported: those for oil crushing; a high quality, aflatoxin free grade; and a hand selected grade in the shell. There is a new mill at Port Sudan to produce export oil. Even with this export volume, two-thirds of the production is consumed within the country as whole nuts and a small amount as oil. There are an estimated 1 million ha of peanuts grown in the Sudan, about 200,000 ha in the irrigated Gezira region along the Nile south of Khartoum, and 800,000 ha in the Western rainfed region. Average farmer production ranges from 300 kg/ha in Western rainfed region to 700 kg/ha in the irrigated area.

Peanuts are still essentially all a small farmer crop in the Sudan with most operations done by hand. Peanuts are an important food and cash crop for the small farmer.

Seed production is a problem in the Sudan. The Plant Propagation Administration under the Ministry of Agriculture operates a seed production program. Last year about 700 tons of the Ashford Variety were produced for the irrigated Gezira region, and about 200 tons of the Barberton variety for the rainfed Western region. A complete seed processing plant will be ready in about one year. The seed program is an FAO project.

Research. Most of the peanut research in the Sudan is done by the Agricultural Research Corporation (ARC) under the Ministry of Agriculture. The ARC is a prestigious research organization, has good scientists, but is grossly under-funded. The Western rainfed region needs research attention to help the small farmers overcome production problems in this drought prone area. Labor competition is a problem with grain crops (west) and cotton (south).

Several constraints to peanut production are present in the Sudan and the following research needs are summarized:

1. Breeding. Drought tolerant varieties are needed for the Western region. The variety presently grown is an old variety and is mixed due to farmers keeping their own seed. Increased oil content, resistance to Aspergillus flavus, and adaptation to heavy clays and saturated soils of the irrigated area (including peg strength and resistance to pod rot) are needed.
2. Diseases and pests. Peanut mottle virus is a major problem. Leafspots, rust, and insects pose few problems except on late planted peanuts. As irrigated culture increases, possibly changing the cropping program (planting date, etc.), insect and disease problems may increase. Disease and insect surveys are needed to more precisely determine problem areas.

3. Mechanization research is needed to develop low-input, labor-saving devices for production.
4. Fertility research is needed to identify and relieve nutritional problems.
5. Aflatoxin research is needed to determine times and sources of contamination as well as develop detoxification procedures.

Major locations for peanut research by ARC are at Wad Medani in the Gezari region and at El Obeid in the Western rainfed region. Researchers represent the basic discipline areas.

#### PUBLICATIONS WITH EMPHASIS ON PEANUTS

Some publications on peanuts are listed in this section. It is not the intention to give an exhaustive literature survey, but to show some of the basic material that is available on peanuts.

##### Books

1. Peanuts - Culture and Uses, a Symposium. American Peanut Research and Education Association, Inc., Stone Printing Co., Roanoke, Va. 1973.

This book is a very thorough treatise on peanuts with 20 chapters covering all facets from the origin and genetics to marketing. Numerous world literature citations are utilized. A revised edition, entitled Peanut Science and Technology, is being prepared by the American Peanut Research and Education Society and should be in print in early 1982. The first edition is out of print.

2. Woodroof, J. G., 1966. Peanuts: Production, Processing, Products. The AVI Publishing Co., Inc., Westport, Conn. Second edition, 1973.

This book extends the compilation of peanut knowledge into processing and product development. A third edition of this book is being prepared.

##### Journals

1. "Peanut Science", The Journal of the American Peanut Research and Education Society. Editorial Offices - P. O. Box 31025, Raleigh, North Carolina 27622.

This journal was first published in 1974, replacing the Journal American Peanut Research and Education Association which had been published for 5 years. "Peanut Science" is distributed internationally and is the only journal devoted completely to peanuts.

2. Much of the peanut literature is published in the primary organs of the various disciplines of researchers involved in peanut research around the world. A listing of these journals will not be attempted.

### Bulletins

In the U. S., the states active in peanut research and extension publish a wide range of material related to peanuts. These vary from general bulletins covering all aspects of production and utilization to specific publications on diseases, weed control, etc. As examples, the University of Georgia Cooperative Extension Service published "Growing Peanuts in Georgia" as Bulletin 640, June, 1979; Texas A & M published a comprehensive report on "Peanut Production in Texas" as Experiment Station Publication RM 3, January 1975; and the University of Georgia Cooperative Extension published "Peanut Leafspot Diseases" Plant Pathology Leaflet 25, Revised February 1981. Numerous other publications could be cited from several states, but these show the type of current information available on request from the different states.

Most research stations and extension organizations in peanut producing countries other than the U. S. publish locally obtained information. Unfortunately, many LDC's do not have an adequate system to disseminate information to their clientele.

### Proceedings

Proceedings of Symposia and Workshops are valuable documents for current knowledge in peanuts. A notable one that deserves mentioning here is: "Proceedings: International Workshop on Groundnuts", ICRISAT Center, Patancheru A. P., India, 13-17 October 1980. The workshop was coordinated by Dr. R. W. Gibbons, ICRISAT Groundnut Research Leader and covered topics in breeding, cytogenetics, crop nutrition and agronomy, entomology, and plant pathology. Country reports were given by researchers from 17 countries. This 325 page proceedings is the broadest and most up-to-date publication presently available summarizing the status of world peanut research.

Because of their particular relevance to cropping systems including peanuts in the semiarid tropics, two other sets of proceedings published by the International Crops Research Institute for the Semiarid Tropics (ICRISAT) Patancheru P. O. Andhra Pradesh, India 502 324 are listed.

1. Socioeconomic Constraints to Development of Semiarid Tropical Agriculture: Proceedings of an International Workshop. ICRISAT Center, Patancheru, India. 19-23 February, 1979. J. G. Ryan and H. L. Thompson Editors. 434 pages.

Sessions covered issues on socioeconomics of 1) existing farming systems; 2) prospective technologies for SAT regions and 3) their field assessment; 4) food grain marketing; 5) improved animal drawn mechanization; 6) literature on SAT of West Africa, 7) risk; and 8) rural labor markets. A major objective of this socioeconomic workshop was to enhance the relevance of biological science research work.

2. Development and Transfer of Technology for Rainfed Agriculture and the SAT Farmer: Proceedings of the International Symposium. ICRISAT Center, Pantancheru, India 28 August-1 September, 1979. Vrinda Kumble, Editor. 324 pages.

This symposium in eight sessions highlighted the mission of ICRISAT; research for development of agriculture technology and its transfer in the SAT; and SAT experiences and linkages in research, development and technology transfer.

Summary Report on the Conference on Women and Food. 1978. by John L. Fisher. Consortiums for International Development (CID), Executive Office, Utah State University, UMC 35, Logan, Utah 84332, USA. 32 pages.

Recognized women as principal producers of food and the major uses of food-related technology in developing countries. Present issues and recommendations were discussed at a three day conference on the role of women in meeting basic food needs in developing countries. Includes proposals for enhancing women's participation in projects and suggestions about ways in which private and international agencies can redesign technical assistance programs to better achieve this goal.

## Institutions Conducting Peanut Research

This section lists to the extent possible domestic and international institutions that conduct peanut research and granting agencies that support peanut research. In some cases, types of research conducted will be listed. Although some countries may be missed inadvertently, hopefully at least one institution in all countries with a significant research program will be listed.

### United States

United States University and U. S. Department of Agriculture Research locations. USDA locations will be listed within states.

Agricultural Experiment Station  
Auburn University  
Auburn, Alabama 36830  
Weeds, Insects and Diseases; Cultural Practices; Physiology/Soil Microbiology.

Agricultural Experiment Station  
Department of Land, Air, and Water Resources  
University of California  
Davis, CA 95616  
Physiology/Soil Microbiology

Institute of Food and Agricultural Sciences  
Agricultural Experiment Station  
University of Florida  
Gainesville, FLA 32601  
Weeds, Insects and Diseases; Breeding & Genetics; Physiology/Soil Microbiology; Food Science

Agricultural Research and Education Center  
Rt. 3, Box 575,  
Jay, FLA 32565  
Weeds, Insects and Diseases; Breeding & Genetics; Cultural Practices/Management

Agricultural Research & Education Center  
Rt. 3, Box 383,  
Marianna, FLA 32446  
Weeds, Insects and Diseases; Cultural Practices/Management

USDA-SEA-AR  
Insect Attractant Behavioral Biology  
P. O. Box 14565  
Gainesville, FLA 32604  
Storage and Preservation

Dept. of Food Science and Animal Industries  
Alabama A & M University  
Normal, AL 35762  
Food Applications, Nutrition

Agricultural Experiment Stations  
University of Georgia  
College Station  
Athens, GA 30602  
Weeds, Insects and Diseases; Physiology/Soil Microbiology;  
Seed Technology; Economics.

Georgia Coastal Plain Station  
Tifton, GA 31794  
Weeds, Insects & Diseases; Breeding & Genetics; Cultural  
Practices/Management; Aflatoxin; Mechanical Technology

Georgia Station  
Experiment, GA 30212  
Weeds, Insects, & Diseases; Food Science; Economics

USDA Grain Insects Laboratory  
Georgia Coastal Plain Station  
Tifton, GA 31794  
Weeds, Insects and Diseases

USDA Crops Research  
Georgia Coastal Plain Station  
Tifton, GA 31794  
Weeds, Insects & Diseases; Breeding and Genetics

USDA/SEA/AR  
Southern Piedmont Conservation Research Center  
P. O. Box 555,  
Watkinsville, GA 30677  
Physiology/Soil Microbiology

USDA/SEA/AR  
National Peanut Research Lab  
P. O. Box 110  
Dawson, GA 31742  
Aflatoxin; Food Science; Mechanical Technology; Storage and  
Preservation

Stevens Industries  
Dawson, GA 31742  
(Cooperative National Peanut Lab., Mechanical Technology)

USDA/SEA/AR  
Harvesting and Processing Research  
Coastal Plain Station  
Tifton, GA 31794  
Mechanical Technology; Storage and Preservation

Georgia Institute of Technology  
Atlanta, GA 30332  
Storage and Preservation

USDA/SEA/AR  
Stored Product Insect Research and Development Lab  
P. O. Box 22907  
Savannah, GA 31403  
Storage and Preservation

USDA/SEA/AR  
Russell Research Center  
P. O. Box 5677  
Athens, GA 30604  
Economics

Agricultural Experiment Station  
University of Hawaii  
Honolulu, HI 96822  
Physiology/Soil Microbiology; Socio-Cultural Factors

Agricultural Experiment Station  
University of Illinois  
Urbana, ILL 61801  
Food Science, Economics

Agricultural Experiment Station  
Purdue University  
Lafayette, IND 47907  
Economics; Nutrition, Food Science

Agricultural Experiment Station  
Iowa State University  
Ames, IA 50011  
Physiology/Soil Microbiology

Agricultural Experiment Station  
University of Kentucky  
Lexington, KY 40506  
Weeds, Insects and Diseases

USDA/SEA-AR  
Southern Regional Research Center  
New Orleans, LA 70179  
Storage, Preservation

Southern University  
Baton Rouge, LA 70179  
Food Science, Storage and Preservation

USDA/SEA/AR  
BARC  
Beltsville, MD 20705  
Plant Stress Lab; Plant Physiology Institute  
Physiology/Soil Microbiology

Agricultural Experiment Station  
Michigan State University  
East Lansing, MI 48824  
Food Science

Agricultural Experiment Station  
University of Minnesota  
St. Paul, MN 55108  
Physiology/Soil Microbiology

Agricultural Experiment Station  
Delta Branch Experiment Station  
Stoneville, MS 38776  
Cultural Practices/Management

Agricultural Experiment Station  
Rutgers University  
New Brunswick, NJ 08903  
Food Science

Agricultural Experiment Station  
New Mexico State University  
Las Cruces, NM 88003  
Physiology/Soil Microbiology

Plains Branch Station  
Star Route, Box 77,  
Clovis, New Mexico 88101  
Weeds, Insects & Diseases

Agricultural Experiment Station  
North Carolina State University  
Raleigh, North Carolina 27607  
Weeds, Insects & Diseases; Breeding & Genetics; Physiology/Soil  
Microbiology; Food Science; Seed Technology; Mechanical  
Technology, Economics

USDA/SEA/AR  
Market Quality and Handling Research  
North Carolina State University  
Raleigh, N. C. 27607  
Aflatoxin; Food Science; Mechanical Technology

Agricultural Experiment Station  
Oklahoma State University  
Stillwater, OK 74074  
Weeds, Insects & Diseases; Breeding & Genetics; Cultural  
Practices; Storage & Preservation

USDA/SEA/AR  
Peanut Research  
Oklahoma State University  
Stillwater, Oklahoma 74074  
Breeding & Genetics

Langston University  
Langston, OK 73050  
Breeding & Genetics

USDA/SEA/AR  
Eastern Regional Research Center  
600 East Mermaid Lane  
Philadelphia, PA 19118  
Food Science

Agricultural Experiment Station  
Clemson University  
Clemson, S. C. 29631  
Weeds, Insects & Diseases; Food Science; Cultural  
Practices/Management

South Carolina State College  
Orangeburg, SC 29115  
Aflatoxin

Agricultural Experiment Stations  
Texas A & M University

College Station, TX 77843  
Weeds, Insects & Diseases; Breeding & Genetics; Cultural  
Practices; Physiology/Soil Microbiology; Aflatoxin; Food  
Science; Seed Technology; Storage & Preservation; Economics

Agricultural Research & Extension Center  
Lubbock, TX 79401  
Weeds, Insects & Diseases

Plant Disease Research Station  
Yoakum, TX 77995  
Weeds, Insects & Diseases; Physiology/Soil Microbiology

Agricultural Research and Extension Center  
Stephenville, TX 76401  
Weeds, Insects & Diseases; Breeding & Genetics; Cultural  
Practices/Management; Physiology/Soil Microbiology; Seed  
Technology.

Texas Woman's University  
Denton, TX 76204  
Food Science

Agricultural Experiment Stations  
Virginia

Virginia Polytechnic Institute and State University  
Blacksburg, VA 24061  
Weeds, Insects & Diseases; Breeding & Genetics.

Tidewater Research and Education Center  
P. O. Box 7099  
Holland Station  
Suffolk, VA 23437  
Weeds, Insects & Diseases; Cultural Practices/Management.

USDA/SEA/AR  
Peanut-Production, Diseases, Harvesting  
Suffolk, VA 23437  
Weeds, Insects & Diseases; Breeding & Genetics; Cultural  
Practices/Management; Storage & Preservation; Mechanical  
Technology.

Department of Agriculture  
Virginia State University  
Petersburg, VA 23803  
Cultural Practices; Food Science

Tetratech, Inc.  
Arlington, VA 20209  
Storage & Preservation (Cooperative USDA, BARC, Beltsville, MD)

Agricultural Experiment Station  
Washington State University  
Pullman, Washington 99163  
Food Science

U. Wisconsin  
Madison, WS 53706  
Aflatoxins

Private Research Organizations - United States

This partial listing of Private Research Organizations includes those doing peanut research or have an expressed capability for such research. Some companies do proprietary research related to their own products, and only a limited number of these are included.

Hershey Foods Corporation  
Dr. Giovanni Bigalli  
Manager, Basic Research  
Technical Center  
Hershey, Pennsylvania 17033

National Peanut Corporation  
Mr. Robert P. Gardner  
200 Johnson Avenue,  
Suffolk, Virginia 23434

Anderson Clayton Foods  
Dr. M. P. Williams  
Director, New Product Development  
333 No. Central Expressway,  
Richardson, Texas 75080

Dr. Thomas A. LaRue  
Plant Biochemist  
Boyce Thompson Institute for Plant Research  
Tower Road  
Ithaca, New York 14853

Edward T. Betty  
Corporate Marketing Director  
Systems Architects, Inc.  
Thomas Patton Drive  
Randolph, MASS. 02368

Engineering & Economics Research, Inc.  
7700 Leesburg Pike  
Falls Church, VA 22043

Mr. Chester Beavers  
Webb Foodlab, Inc.  
3309 Drake Circle  
Raleigh, N. C. 27607

Steven I. Apfelbaum  
Applied Ecological Services  
Post Office Box 2021  
Roosevelt, Utah 84066

IWK International Corporation  
617 Little River Turnpike,  
Suite 800,  
Annandale, Virginia 22003

Dr. William J. Edmunds  
Best Foods  
P. O. Box 1534  
Union, New Jersey 07083

Robert A. Burdett  
Alabama Crop Improvement Association, Inc.  
South Donahue Drive,  
Auburn University,  
Alabama 36849

Walter H. Meyer  
Associate Director, Food Product Development  
The Procter & Gamble Company  
Winton Hill Technical Center  
6071 Center Hill Road  
Cincinnati, Ohio 45224

Dr. David Kritchevsky, Associate Director  
Wistar Institute of Anatomy & Biology  
31 at Spruce Street  
Philadelphia, PA 19100

North and Central America and the Caribbean

Canada	Dr. J. W. Tanner	Department of Crop Science University of Guelph Guelph, Canada N1G2W1
CARICOM	Dr. St. Clair Forde Dr. Syed Q. Haque	Caribbean Agricultural Research and Development Institute University of the West Indies, St. Augustine, Trinidad (Member countries - Belize, Jamaica, Antigua, Montserrat, St. Kitts-St. Christopher-Nevis-Anguilla, Dominica, Barbados, St. Vincent, Grenada, Trinidad and Tobago, St. Lucia, and Guyana)
Dominican Republic	Ing. G. E. Villanueva	Dept. Agricultural Research Secretaria De Estado De Agriculture Santo Domingo
El Salvador		Ministry of Agriculture Agriculture Research Institute, San Salvador El Salvador
Honduras	Dr. Pablo E. Paz	Escuela Agriocula Panaamericana, Tegucigalpa, Honduras
Jamaica	Dr. J. R. R. Suah	CARDI University Campus Mona-Jamaica
Nicaragua		Ministry of Agriculture Managua, Nicaragua

## South America

Argentina	Dr. J. R. Pietrarelli Ing. E. Giandana Ing. Laura M. Giorda	INTA Manfredi Research Station Manfredi, Argentina
Bolivia	Teddy Monasterios Latorre	Ministerio de Asuntos Campesinos y Agropecuarios Instituto Boliviano de Tecnologia Agropecuaria AV Camacho 1471 5 <sup>o</sup> Piso C. P. 5783 La Paz, Bolivia
Brazil	Dr. A. S. Pompeu	Instituto Agronomico C. P. 28 13.100 Campinas, S. P., Brazil
	Dr. D. C. Giacometti Ing. L. Coradin	CENARGEN/EMBRAPA, Brasilia, D. F. Brazil
	Dr. Suquire Tango	ITAL (Institute Food Science and Technology) 13.100 Campinas, S. P. Brazil
	Dr. Ahmed A. El-Dash Dr. Jaime Amaya Farfan	Food Science Research State University of Campinas C. P. 1170 13.100 Campinas, S. P., Brazil
Colombia		Instituto Colombiano Agropecuaria Calle 37 #8-43 8 Floor Bogota, Colombia
Ecuador	Ing. Eduardo Calero	Instituto Nacional de Investigaciones Agropecuarias Estacion Experimental Boliche Apartado No. 7069 Guayaquil, Ecuador

Guatemala	R. Bressani L. E. Elias	Instit. Nutrition of Central America and Panama (INCAP) P. O. Box 1188, Guatemala, C. A.
Guyana	H. A. D. Chesney	Ministry of Agriculture Research Georgetown, Guyana (Member of CARICOM and CARDI)
	J. Ross	Ministry of Agriculture Mon Repos, East Coast, Demara, Guyana
Nicaragua	Mr. W. E. Bolton	CUKRA Development Co. Apartado 465, Managua, Nicaragua
Paraguay	Dr. Luis Alberto Alvarez	Investigacion y Extension Agropecuaria y Forestal Ministerio de Agricultura y Ganaderia Asuncion, Paraguay
	Mr. Manuel Mayregger	Institution Agronomico Nationale Caacupe, Paraguay
Peru	Ing. Rufino Montalvo	Instituto Nacional De Investigacion y Promocion Agropecuaria (INIPA) Lima, Peru
Surinam	Ing. G. D. Vermeulen	Agricultural Experimental Station P. O. Box 160 Paramaribo, Surinam
Uruguay	Ing. Agr. J. C. Millot	La Estanzuela Exper. Stat. Colonia, Uruguay
Venezuela	Dr. Bruno Mazzani	Centro Nacional de Investigaciones Agropecuarias Ministerio de Agricultura y CRIA Maracay 2101, Venezuela

Australia, Asia, Indian Subcontinent, Southeast Asia

Australia	Dr. K. J. Middleton Dr. J. Graham Dr. R. Shorter J. Rogers Dr. R.C.N. Laurence	Department of Primary Industries Bjelke-Peterson Research Station Kingaroy, Queensland 4606 Australia
Bangladesh	Mr. M. A. Hamid  Dr. L. Rahman  R. P. Dick	Institute of Nuclear Agriculture P. O. Box 4, Mymensingh, Bangladesh  Oilseed & Pulses Improvement Project (UNICEF) Bangladesh Agric. University Mymensingh  Mennonite Central Committee Box 13, Feni, Noakhali District Bangladesh
Burma	U. Win Naing  Dr. A. D. Karve	Agricultural Research Corporation Magwe Division Magwe, Burma  UNDP/FAO Project Bur/77/009 Agric. Research Institute Yezin, Pyinmana
China	Mr. Sun Darong Mr. Xu Zeyong Mr. Wang Yu Tong  Mr. Ren Zhe  Mr. Kuan Hsin-Men Mr. Kuo Lei Liang  Prof. Pan Tui-Zhi	Institute of Oil-bearing Crops Wuhan Hubei Province People's Republic of China  Secretary General Chinese Academy for Agricultural & Forestry Sciences Beijing, China  Groundnut Research Institute Yen Tai, Shantung Province, China  South China Teachers' College Guangzhou, China

	Mrs. Liou Nai Fang	Crops Research Institute Shihchiachung, Hopei Province
	Mr. Fan Ming Yin Mr. Wu Shang Zhong Mr. Zhou Liang Gao	Guandong Academy of Agricultural Science Guangzhou (Canton) Guangdong Province Crop Experiment Station
India	Dr. Vikram Singh Dr. B. Misra	Directorate of Oilseeds Research Indian Council for Agricultural Research Hyderabad 500 030, Andhra Pradesh, India
	C. Raja Reddy	National Agricultural Research Project S. V. Agricultural College Tirupati 2
	Dr. S. Thangavelu	IDRC, Vriddachalam 606 001 South Arcot Dist., Tamil Nadu
	Dr. N. M. Rangaswami	Agricultural Research Stat. Aliuarnagar Tamil Nadu 642 101
	Mr. S. Madhava Rao	Oilseeds Expt. Station., Tindivanam, Tamilnadu
	Dr. A. F. Habib Dr. M. S. Joshi	Regional Res. Station, UAS, Dharwar, Karnataka
	Dr. T. Swamy Rao	Regional Res. Station Raichur 584 101 Karnataka
	Dr. V. Arunachalam Dr. U. R. Murthy Dr. R. Pankaja Reddy V. Ravindranath M. V. R. Prasad	IARI, Regional Station, Hyderabad 500030 Rajendranagar Andhra Pradesh

Mr. A. Seshagiri Rao	Regional Oilseeds Research Station, Kadiri 515591 Andhra Pradesh
N. C. Joshi	CPPTI
V. Rangunathan	Rajendranagar Hyderabad 500 030
N. Rajagopal	Regional Oilseeds Research Station, Kadiri 515 501 Anatapur District, A. P.
Dr. D. P. Misra	National Research Centre
Dr. R. S. Dwivedi	for Groundnut
Dr. S. N. Saha	Junagadh 362002,
Dr. G. Nagraj	India
Dr. J. I. Kilkarni	
Dr. N. R. Bhagat	
Dr. Tiwari	
Dr. M. P. Ghewande	
Dr. Das	
Dr. Chauhan	
Dr. Bhadoria	

Dr. J. S. Saini Dr. I. S. Sekon Dr. J. S. Chohan Dr. K. S. Lebana Mr. S. V. Jaiswal Dr. A. S. Chahal	Punjab Agricultural University Ludhiana 141 004, India
Dr. A. Narayanan M. S. S. Reddy	College of Agriculture APAU Rajendranagar Hyderabad 5000 30 India
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	Dr. A. Djima	Kamboinse Res. Station Ougadougou, Upper Volta
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Zambia	A. J. Prior Dr. D. Naik	Mt. Makulu Research Station P. O. Box 7, Chilanga, Zambia
Zimbabwe	G. L. Hildebrand	Crop Breeding Institute Department of Research and Specialist Services P. O. Box 8100, Causeway, Zimbabwe

## INTERNATIONAL INSTITUTIONS

Some institutions conduct research that crosses national boundaries which make a significant contribution to the world effort in peanut research. Some of these were instituted by colonial powers, and since the end of colonialism are understaffed and lack support funds. Some of the institutions with significant peanut research will be described briefly.

ICRISAT - The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has as a target group the small farmer in the SAT (dry for most of the year except for a short period when rainfall is sufficient for cropping). Peanuts are one of the five crops in the research mandate which has four objectives: (1) improve genetic potential; (2) improve farming systems to stabilize production; (3) identify socioeconomic and other constraints to agricultural production, and (4) assist national and regional programs through cooperation and various training activities. The SAT touches 4 continents, covers 20 million square miles, contains 600 million people, and produces 67% of the world's 18.9 million tons of peanuts (80% produced in developing countries). Yields are low in the SAT, 800-900 kg/ha compared to about 2500 kg/ha in the developed world.

The main objective of the ICRISAT peanut program which began in 1976 is to develop high yielding breeding lines with resistance to the main factors limiting production in the SAT; diseases, insects, and unreliable rainfall patterns. Finished varieties are not released, but improved germplasm is provided to national programs for further selection under specific environmental stress patterns of the particular location.

ICRISAT is funded by the Consultative Group on International Agricultural Research. By reason of its mandate to work on problems of peanuts and the position of peanuts in the SAT, ICRISAT should have a great impact on the small farmer of this region. The staff of the ICRISAT Groundnut Improvement Program as of October 1980 is: P. W. Amin, Entomologist; I. S. Campbell, International Intern; P. J. Dark, Principal Microbiologist; S. L. Swivdei, Plant Breeder; A. M. Ghanekar, Virologist; R. W. Ribbons, Principal Plant Breeder and Program Leader; T. Goto, International Intern; D. McDonald, Principal Plant Pathologist; V. K. Mehan, Plant Pathologist; A. B. Mohammad, Entomologist; J. P. Moss, Principal Cytogeneticist; P. T. C. Nambiar, Microbiologist; D. J. Nevill, International Intern; S. N. Nigam, Plant Breeder; D. V. R. Reddy, Principal Virologist; D. C. Sastri, Cytogeneticist; A. K. Singh, Cytogeneticist; P. Subrahmanyam, Plant Pathologist; J. H. Williams, Principal Physiologist.

IRHO - l'Institut de Recherches pour les Huiles et Oleagineux or Research Institute for Oil and Oilseeds (IRHO) is headquartered in Paris and is a private nonprofit organization sponsored by the French government. Work is done in tropical areas on oil palm,

coconut, and annual oil crops including peanuts. IRHO has some 85 scientists and researchers in a wide range of disciplines. Peanut research was begun in 1948 and is almost exclusively confined to Francophone Africa. Since independence of the African countries, work is conducted on a cooperative basis with host governments or institutions sharing in support costs. The peanut program is coordinated by Dr. Pierre Gillier, IRHO, 11, Square Petrarque, 75016, Paris.

Peanut and annual oil crops represent only 20% of the IRHO's activities and utilizes about 20 scientists and technicians. Work is done in Senegal, Mali, Guinea-Bissau, Upper Volta, Niger, and Chad.

AGC - The African Groundnut Council (AGC) is an intergovernmental organization formed in 1963 by six of the major peanut (groundnut) producing countries in Africa: Nigeria, Gambia, Mali, Niger, Senegal, and Sudan. Headquarters are at 11, Ahmadu Bello Road, Victoria Island, B. P. 3025, Lagos, Nigeria, Ebraima Manneh, Director, (El Hadi El Nur is Director of Science and Technology Department) with a European office at 66 Avenue de Cortenberg, 1040 Brussels, Belgium.

The objectives of AGC include the exchange of technical and scientific know-how relative to the production of peanuts, the sales promotion of peanut products, and the issue of common contracts for sale of peanuts, peanut oil, and peanut cake. The AGC encourages, supports, and coordinates (to prevent duplication) research in member countries. Research in the member states is mainly financed from local resources, with assistance from such sources as the European Economic Community and the United Nations Development Program.

TPI - The Tropical Products Institute, (TPI) is located in London. It is funded from the United Kingdom Overseas Aid Program. It carries out a program of research and development on all aspects of peanut handling, storage, and processing, and the detection and elimination of mycotoxins.

IBPGR - The International Board for Plant Genetic Resources (IBPGR) oversees collection and maintenance of plant germplasm including peanuts. It has sponsored collection programs and has designated ICRISAT as the germplasm center for peanuts (Arachis).

### Granting Agencies

Worldwide research and development programs are supported through grants, contracts, or loans by various agencies or organizations. These are supported either by single governments or through multinational contributions. Work with peanuts may be in projects solely concerned with peanuts, but is most often

included in more comprehensive research programs. Examples of such agencies are World Bank, European Development Fund, United States Agency for International Development, International Development Research Center (Canada) and programs from many other developed countries in Europe and Japan.

UNCTAD (United Nations Conference on Trade and Development) Geneva, Switzerland has drafted a Programme of Research and Development for Groundnuts and Their Products (Document TD/B/IPC/OILS/15, 10 December 1980). World research in progress was reviewed, research priorities established and 19 projects proposed in areas including research documentation, breeding, physiology, production, aflatoxin, and utilization. The proposed budget is \$38.55 million, but as of this date has not been initiated or funded.

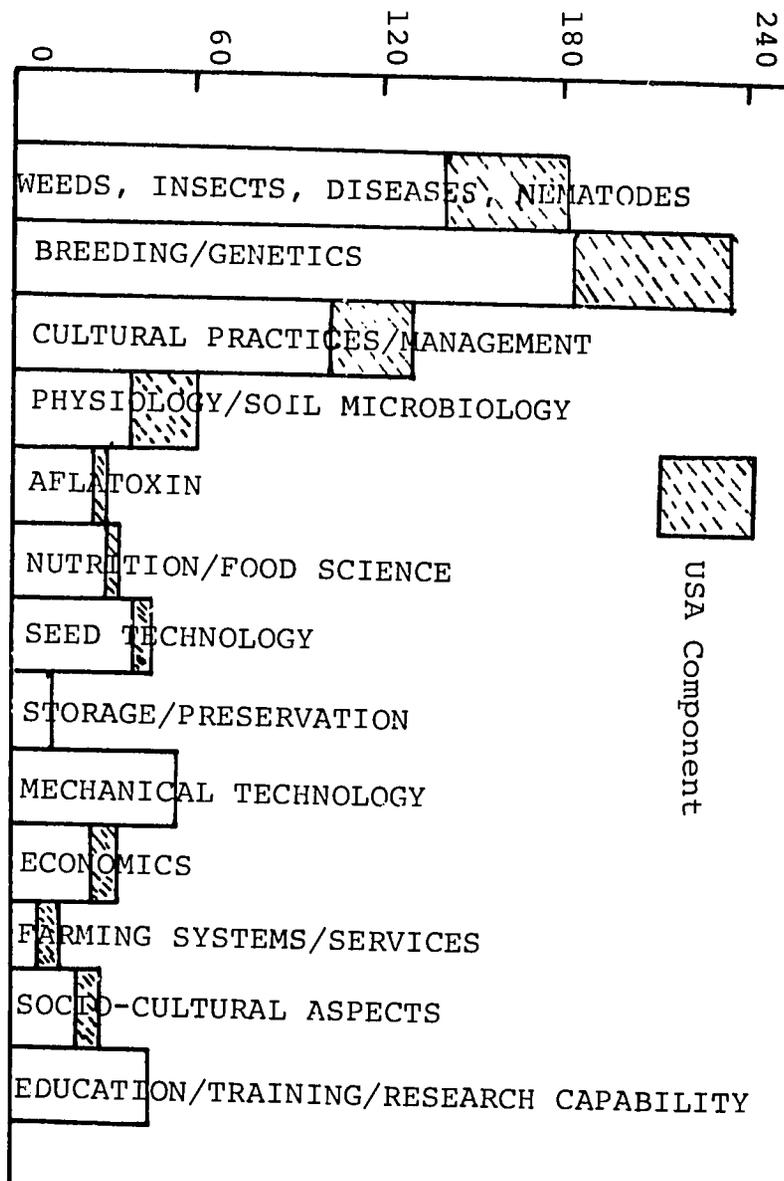
### CONSTRAINTS TO WORLD PEANUT PRODUCTION AND UTILIZATION

The determination of constraints to world peanut production and utilization was basic to the CRSP planning. Three primary sources were used to determine constraints: (1) personal interviews during site visits by the planning staff, (2) through response to questionnaires distributed widely around the world, and (3) from country reports presented (and later published) at the International Workshop on Groundnuts at ICRISAT, Hyderabad, India in October 1980.

The chart on page 61 summarizes the constraint data obtained. The 13 constraint areas identified are represented by the bars originating along the x-axis. The height of each bar was determined by the total number of times subconstraints were cited in each constraint area as limitations to production and utilization. Weeds, insects, diseases, nematodes; breeding, genetics; and cultural practices, management were the areas most frequently cited as constraints to production and utilization. The United States component was separated, because these responses were external perceptions of various country problems, whereas the other responses were internal and specific to individual country problems. However, the chart shows a close similarity in the U. S. and other country responses. The request to U. S. scientists asked for a listing of three major constraints to world peanut production and the scientists in other countries were sent a questionnaire with the 13 constraint areas and various subconstraints to use in their ratings. This could have affected the responses to some extent.

The section beginning on page 62 gives the ranking of the constraint areas and the six subconstraints most frequently cited in each area. Beginning on page 64, the respondents, constraints and subconstraints are listed by country. The numeral following each subconstraint corresponds to the individual respondent who cited that particular subconstraint. Responses from approximately 120 people are included.

TIMES SUB-CONSTRAINT CITED



Summary of Sub-Constraints from all Countries:

USA, India, Thailand, Philippines, Indonesia, Senegal, Niger, Nigeria, Sudan, Cameroon, Malawi, Paraguay, Brazil, CARICOM, Pakistan, Burma, Malaysia, Canada, Costa Rica, Argentina, Ecuador, Venezuela, Egypt, Mali, Mozambique, Zimbabwe.

Ranking Of Constraints And The Top 6 Subconstraints Cited By  
People Around the World Excluding U. S. Respondents.

- |                                        |                                  |
|----------------------------------------|----------------------------------|
| 1. Breeding and Genetics               | 8. Nutrition/Food Science        |
| 2. Weeds, Insects, Diseases, Nematodes | 9. Economics                     |
| 3. Cultural Practices/Management       | 10. Aflatoxins                   |
| 4. Mechanical Technology               | 11. Socio-Cultural Factors       |
| 5. Education, Training                 | 12. Farming Systems,<br>Services |
| 6. Physiology, Soil Microbiology       | 13. Storage/Preservation         |
| 7. Seed Technology                     |                                  |

1. Breeding, Genetics
  - a. Disease resistance
  - b. Higher yield
  - c. Drought tolerance
  - d. Insect resistance
  - e. Aflatoxin resistance
  - f. Early maturity
2. Weeds, Insects, Diseases, Nematodes
  - a. Leafspot
  - b. Rust
  - c. Foliage insects
  - d. Root, stem, and pod rots
  - e. Rosette
  - f. Root, stem, and pod insects
3. Cultural Practices/Management
  - a. Mineral Nutrition
  - b. Seeding date, plant population
  - c. Unadapted cultivars
  - d. Tillage
  - e. Soil pH
  - f. Intercropping
4. Mechanical Technology  
Lack of:
  - a. petrol powered equipment
  - b. animal power
  - c. seeding equipment
  - d. harvest equipment
  - e. drying/storage equipment
  - f. cultivating equipment
  - g. processing, shelling equipment

5. Education, Training, Research Capability.
  - a. Insufficient Research Personnel
  - b. Lack of research training
  - c. Low technical support
  - d. Low research budget
  - e. Lack of farmer training
  - f. Supplies and equipment not available
  
6. Physiology/Soil Microbiology
  - a. Inadequate nitrogen fixation
  - b. Unadapted rhizobia
  - c. Optimum leaf area and flower number
  - d. Photosynthetic efficiency
  - e. Partitioning
  - f. Basic physiology
  
7. Seed Technology
  - a. Production of low quality seed
  - b. Poor handling and harvesting
  - c. Temperature, humidity, and pest storage problems
  - d. Inadequate seed production and distribution capacity
  
8. Nutrition/Food Science
  - a. New product development
  - b. Peanut milk for infants
  - c. Simple methods of oil extraction and human food preparation
  - d. Determination of amino acids, proteins, lipids, etc.in breeding material
  - e. Fermentation processes
  - f. Product storage
  
9. Economics
  - a. Availability or cost of fertilizer
  - b. Availability or cost of pesticides
  - c. Markets or marketing systems inadequate for small farm surpluses
  - d. Availability or cost of equipment
  - e. Availability or cost of credit
  - f. Availability or cost of land
  - g. Availability or cost of labor
  - h. Other crops more profitable
  
10. Aflatoxins
  - a. Times, sources, and processes of contamination
  - b. Identification of aflatoxin
  - c. Control measures
  - d. Detoxification
  
11. Socio-cultural Aspects
  - a. Attitudes and opinions of small farm family not understood
  - b. Farmers aspire to other occupations, migration
  - c. Attitude of small farmer toward risk of new technology
  - d. Lack of farmer confidence in crop

12. Farming Systems/Services
  - a. Inadequate infrastructure, technology extension system, equipment
  - b. Inadequate research personnel and facilities
  - c. Diversity of crops, farming methods
  - d. Inappropriate technology (too advanced)
13. Storage/Preservation
  - a. Decreasing nutritive value in storage
  - b. Disease, pest infestation in storage

#### Specific Country Information - Canada

Respondents: In response to questionnaire.

1. Dr. J. W. Tanner, (Plant Physiology) Chairman, Department of Crop Science, University of Guelph, Guelph, Ontario N1G2W1, Canada

Constraint, Sub-constraint, and Respondent/s citing.

Breeding and Genetics: Higher yield-1; Disease resistance-1; Insect resistance-1; Drought resistance-1; Early maturity-1; Cold tolerance-1.

Seed Technology: Poor harvesting and handling-1.

Mechanical Technology: Harvesting equipment-1.

#### Argentina

Respondent's: Information is from ICRISAT report.

1. Dr. Jose' R. Pietrarelli, Agronomist, INTA, Manfredi Research Station, Manfredi, Argentina.

Constraint, Sub-constraint, and Respondent citing.

Weeds, Insects, and Diseases: Leafspots-1; Root, stem, pod rot-1; Foliage insects-1; Root, stem, pod insects-1; Weeds-1.

Breeding and Genetics: Higher yield-1; Disease resistance-1; Seed size-1; Oil/protein content-1; Seed dormancy-1; Peg strength-1.

Cultural Practices/Management: Seeding date, population-1; Mineral nutrition-1; Crop rotations-1.

Mechanical Technology: Harvesting equipment-1; Drying/storage equipment-1.

## Brazil

Respondents: All were interviewed by D. G. Cummins and Charles Swann on site visits.

1. Dr. Suquiro Tango (Lipids and Proteins), ITAL (Institute of Food Science and Technology, Ministry of Agriculture, Campinas, Brazil.
2. Dr. A. S. Pompeu (Plant Breeding), Institute of Agronomy, 13-100, Campinas, Brazil.
3. Mr. Angelo Savy Filho (Agronomist), Institute of Agronomy, 13-100, Campinas, Brazil.
4. Mr. Sergio Almuda del Moraes (Plant Pathologist), Institute of Agronomy, 13-100, Campinas, Brazil.
5. Mr. Antonio Rogue Dechan (Soil Fertility), Institute of Agronomy, 13-100, Campinas, Brazil.
6. Mr. Marcelo A. N. Gerin (Agronomist), Institute of Agronomy, 13-100, Campinas, Brazil.
7. Dr. Ahmed A. El-Dash (Food Science, Cereal Chemistry), Faculty Food and Agricultural Engineering, State University of Campinas, Caixa Postal, 1170, 13.100 Campinas - S.P. - Brazil.
8. Dr. Jaime Amaya Farfan (Food Science), State University of Campinas, FEAA C. P. 1170, 13-100 Campinas- SP, Brazil.

### Constraint, Sub-constraint, and Respondent/s citing.

Weeds, Insects, and Diseases: Leafspots-1,2; Rusts-1; Foliage Insects-2.

Breeding and Genetics: Higher yield-1; Disease resistance-1,2,4; Insect resistance-2; Aflatoxin resistance-1,2; Drought resistance-1,2; Early maturity-2; Oil/protein content-1; Market quality-2.

Cultural Practices/Management: Seeding date, population-2; Mineral nutrition-1,2,5; Irrigation-2,6.

Physiology/Soil Microbiology: Unadapted rhizobia-3,6; Inadequate fixation-0; Cell culture-2.

Aflatoxin: Chemical identification-7; Control measures-1; Detoxification processes for food use-1,7,8.

Nutrition, Food Preparation: New product development-1,8; Peanut "Milk" for infants-1,8.

Mechanical Technology: Harvesting equipment-1,2; Drying/Storage equipment-1.

## Paraguay

Respondents: All were interviewed by D. G. Cummins and Charles Swann on site visits, except for Robert Unruh who responded to questionnaire.

1. Alfredo Stauffer (Pathologist) Faculty of Agriculture, Ing. Agronomico, Asuncion, Paraguay.
2. Dr. Luis Alberto Alvarez, Director de Investigation y Extension Agropacuaria y Forestal, Ministerio de Agricultura y Ganaderia, Asuncion, Paraguay.
3. Wilhelm Giesbrecht (Mennonite farmer) Chaco Central, Loma Plata, Chaco, Paraguay.
4. Dr. Selva Mayeregger (Entomologist) Faculty of Agriculture, Ing. Agronomico, Asuncion, Paraguay.
5. Dr. Stella M. Barrios, Departamento de Alimentos, Instituto Nacional de Tecnologia Y Normalizacion, Av. Artigas y Gral. Roa, Asuncion, Paraguay.
6. Mr. Manuel Mayregger (Agronomist) Institution Agronomico Nationale Station, Caacupe, Paraguay.
7. Dr. Robert G. Unruh, Technical Director, Serv. Agrop. Chaco Central, Loma Plata, Chaco, Paraguay.

### Constraint, Sub-constraint, and Respondent/s citing.

Weeds, Insects, and Diseases: Leafspots-1,3,7; Rusts-7; Root, stem, pod insects-1,6; Foliage insects-1,3,4,6,7; Root, stem, pod insects-7; Weeds-7; Sclerotium-3.

Cultural Practices/Management: Seeding date, population-2,6; Unadapted Cultivar-2,6; Mineral nutrition-2,6,7; Irrigation-2,6; Tillage-2,6; Soil pH-2,6.

Aflatoxin: Times, sources and processes of contamination-1; Chemical identification-1.

Nutrition, Food Preparation: New product development-1.

Mechanical Technology: Lack of animal powered machinery-6; Lack of petrol/machinery-6; Drying/Storage equipment-6.

Economics: Credit-6.

Farming Systems & Services: Inadequate research personnel & facilities-6.

Education, Training and Research Capability: Research/training on appropriate extension methods-7; Insufficient trained research personnel-7.

## Venezuela

Respondents: ICRISAT Report.

1. Dr. Bruno Mazzani, C.N.I.A. AP Postal 4653, Maracay, Venezuela 20101.

Constraint, Sub-constraint, and Respondent/s citing.

Weeds, Insects, and Diseases: Leafspots-1; Rusts-1; Root, stem, pod rot-1; Foliage insects-1; Root, stem pod insects-1.

Breeding and Genetics: Higher yield-1; Disease resistance-1

Cultural Practices/Management: Mineral nutrition-1.

Physiology/Soil Microbiology: Unadapted rhizobia-1; Inadequate fixation-2.

Economics: Fertilizer-1; Pesticides-1; Equipment-1; Petrol energy-1.

## Zimbabwe

Respondents: Country report.

1. G. Hildebrand, Crop Breeding Institute, Box 8100, Salisbury, Zimbabwe.

Constraint, Sub-constraint, and Respondent/s citing.

Weeds, Insects, and Diseases: Leafspots-1; Rusts-1; Root, stem, pod rot-1; Foliage insects-1; Root, stem, pod insects-1; Nematodes-1.

Breeding and Genetics: Higher yield-1; Disease resistance-1; Insect resistance-1; Drought resistance-1; Oil/protein content-1; Seed dormancy-1; Higher pod-top ratio-1.

Cultural Practices/Management: Seeding date, population-1; Mineral nutrition-1; Tillage-1.

## Burma

Respondents: ICRISAT Report.

1. U. Win Naing, Agricultural Corporation, Rangoon, Burma.

Constraint, Sub-constraint, and Respondent/s citing.

Weeds, Insects, and Diseases: Root, stem, pod insects-1; Weeds-1.

Breeding and Genetics: Higher yield-1.

Cultural Practices/Management: Seeding date, population-1; Unadapted cultivar-1; Mineral nutrition-1; Tillage-1; Soil pH-1.

Physiology/Soil Microbiology: Unadapted Rhizobia-1; Inadequate fixation-1.

Mechanical Technology: Planting equipment-1.

### Caricom

Respondents: All were interviewed by D. G. Cummins and Charles Swann on site visits.

1. Dr. George M. Sammy, Department Chemical Engineering, University of the West Indies, St. Augustine, Trinidad.
2. Dr. Syed Q. Haque, Coordinator of the Peanut Research Project, CARDI, University Campus, St. Augustine, Trinidad.
3. Dr. St. Clair Ford, Chief of Research, CARDI, University Campus, St. Augustine, Trinidad.

Constraint, sub-constraint, and respondent/s citing.

Breeding and Genetics: Disease resistance-2; Insect resistance-2; Oil/protein content-2.

Cultural Practices/Management: Mineral nutrition-2.

Nutrition, Food Preparation: Simple methods of oil extraction and human food preparation-1; New product development-1; Peanut "milk" for infants-1.

Mechanical Technology: Lack of petrol/machinery-2.

### India

Respondents - Dr. Singh interviewed by C. R. Jackson at ICRISAT, Mr. Patil information in report at ICRISAT, other people at ICRISAT interviewed by Drs. Okezie, Rao and Wheelock; others returned questionnaires.

1. Dr. D. P. Misra (Genetics of Disease Resistance), Director, National Research Center for Groundnut, Junagadh 362002, India.
2. Dr. A. Narayanan (Crop Physiology), College of Agriculture, APAU, Rajendranagar, Hyderabad 500030 India.
3. I. S. Sekhon (Plant Pathology), Department of Plant Breeding, PAU, Ludhiana 141004, India.

4. Dr. J. S. Chohan (Plant Pathology), Joint-Director, Plant Disease Clinic, Punjab Agricultural University, Ludhiana 141004, India.
5. Mr. S. H. Patil (Mutation Genetics), Scientific Officer, Biology and Agricultural Division, Bhabha Atomic Research Center, Bombay 400085, India.
6. Dr. N. D. Desai (Plant Breeding and Genetics), Oilseed Research Division, Gujarat Agricultural University, Junagadh 362001, India.
7. Dr. Vikram Singh, Project Director, Directorate of Oilseeds Research, Rajendranagar, Hyderabad 500 030, India.
8. J. S. Saini (Agronomist, Oilseeds) Punjab Agricultural University Ludhiana 141004, India.
9. Dr. M. Balasubramanian (Entomology) Head, Entomology Division, Tamil Nadu Agricultural University, Coimbatore, India.
10. Dr. P. Narayanasany (Plant Pathology), Tamil Nadu Agricultural University, Coimbatore, India.
11. Mr. G. Venkatesan (Agronomy), Tamil Nadu Agricultural University, Coimbatore, India.
12. Dr. A. S. Chanal, (Pathologist), Punjab Agricultural College, Ludhiana, 141004, India.
13. Dr. J. C. Davies, International Cooperation, ICRISAT
14. Mr. G. E. Thirostein, (Agricultural Engineering) ICRISAT
15. Mr. Reddy (Local Farmer) Dokur, India.
16. Dr. Viramani (Farming Systems), ICRISAT.
17. Dr. Willey (Agronomy), ICRISAT.
18. Dr. Shetty (Agronomy), ICRISAT.
19. Dr. Miranda (Land and Water Management), ICRISAT.
20. Dr. R. W. Gibbons (Groundnut Program), ICRISAT.
21. Dr. J. G. Ryan (Economics), ICRISAT
22. Dr. Doherty (Anthropology) ICRISAT.
23. Dr. Ghodabe (Marketing), ICRISAT.

24. Dr. Walker (Economics), ICRISAT.
25. Mrs. P. Bidinger (Nutrition) ICRISAT.
26. Dr. McDonald (Aflatoxin) ICRISAT.

Constraint, sub-constraint, and respondent/s citing.

Weeds, Insects, and Diseases: Leafspots-1,2,3,4,5,6,9,10,11,12; Rusts-1,2,4,5,6,11; Rosette-5,9,10; Other virus-1,2,3,4,10,12; Root, stem, pod rot-4,11; Foliage insects-1,6,9; Weeds-2,12.

Breeding and Genetics: Higher yield-1,3,4,5,6,8,9,10,11,12; Disease resistance-1,3,4,5,6,7,8,9,10,11,12; Insect resistance-1,6,8,9; Aflatoxin resistance-1,3,4; Drought resistance-1,4,5,6,7,8,9,11,12; Early maturity-3,5,6,8; Seed size-9; Oil/protein content-4,5,8,12; Seed dormancy-5; Irrigation responsive-7; High shelling percentage-8; Responsive to fertilizers-8.

Cultural Practices/Management: Seeding date, population-1,2,12; Unadapted cultivars-12; Mineral nutrition-2,11; Intercropping-2,8,12,17,18; Irrigation-6; Water management-12,16,18,19.

Physiology/Soil Microbiology: Unadapted rhizobia-7; Inadequate fixation-1,2,7; Partitioning-7; Optimum leaf area and flowers-1,7; Basic physiology-1,2,7; Crop forecasting for yield and disease-7.

Aflatoxin: Chemical identification - 12; Detoxification processes for food use-12,26.

Nutrition/Food Science: Simple methods of oil extraction and human food preparation-3,5; New product development-3,5,9,12,20; Determination of amino acid content, etc.-3,5; Peanut milk for infants-2,5,9,12; Food Preferences-15,21.

Seed Technology: Production of low quality seed-7; Poor harvesting and handling-1,7,12; Temperature, humidity and pest storage problems-7; Inadequate seed production and distribution capacity-1,7,12.

Storage Preservation: Decreasing nutritive value in storage-3,5; Disease, pest infestation in storage-3,12.

Mechanical Technology: Lack of animal powered machinery-8,12,14; Lack of gasoline powered machinery-1,8,12; Planting equipment-1,7,12; Cultivating equipment-1,14; Harvesting equipment-1,7,9,12; Pesticide application equipment-1,7,12; Drying and storage equipment-1,9,12; Processing and shelling equipment-1,9,12.

Economics: Availability or cost of: Fertilizer-12; Petrol energy-12; Labor-12; Markets inadequate for small farm surpluses-3,12,23,24; Other crops more profitable-3,12; Economics of crop rotations and the cost: benefit ratio of inputs-8; General-13,21,51.

Farming Systems and Services: Diversity of crops, farming methods-12.

Socio-Cultural Factors: Attitude of small farmer toward risk of new techniques-7,12,21; Role of Women, 21,25; Local government policies and attitudes of people-22.

Education, Training and Research Capability: Research training on appropriate extension methods-3,4,6,7; Insufficient trained research personnel-4-6; Technical support inadequate-3,4,6,; Research budget-3,4,6,12; Supplies and equipment not available-3,4,6; Lack of farmer training-3,4.

## Indonesia

Respondents - All respondents were interviewed by C. R. Jackson and D. G. Cummins on site visits. Additional information from Mr. Sadakin Sommadmadja's ICRISAT Workshop report.

1. Mr. Lasimin Sumarsono, CRIA, Jalan Mereka-99, Bogor, Indonesia.(Plant Breeding).
2. Mrs. Sri Astuti Rais, CRIA, Jalan Mereka-99, Bogor, Indonesia. (Plant Breeding).
3. Mr. Sadakin Somaatmadja, Legume Program Leader, Central Research, Institute for Agriculture, Bogor, Indonesia. (Plant Breeding).
4. Dr. Goeswono Soepardi, Department of Soil Science, Faculty of Agriculture, Bogor Agricultural University, Bogor, Indonesia.

### Constraint, sub-constraint, and respondent/s citing.

Weeds, Insects, and Diseases: Leafspots-1,2,3; Rusts-1,2,3; Other virus-1,2,3; Root, Stem, Pod Rot-3; Foliage Insects-3.

Breeding and Genetics: Higher Yield-1,2; Disease Resistance-1,2,3; Aflatoxin Resistance-1,2; Drought Resistance-1,2; Early Maturity-1,2; Seed Size-2; Oil/Protein Content-1,2.

Cultural Practices/Management: Mineral Nutrition-4; Soil pH-4.

Aflatoxin: Times, Sources and Processes of contamination-2,3; Chemical identification-3; Control measures-1,2,3.

Seed Technology: Production of low quality seed-1,2; Poor harvesting and handling-1,2; Temperature, humidity & pest storage problems-1,2,3; Inadequate seed production and distribution capacity-1.

Storage, Preservation: Decreasing nutritional value in storage-1; Disease, Pest Infestation in Storage-1,2.

Economics: Fertilizer-1,2; Pesticides-1,2; Equipment-1,2; Land-2; Credit-2; Labor-2; Markets inadequate for small farm surpluses-1,3; Other crops more profitable-1.

Farming Systems & Services: Diversity of Crops, farming methods-2; Inappropriate technology-2; Inadequate research personnel & facilities-2.

Education, Training and Research Capability: Research/training on appropriate extension methods-1,2; Insufficient trained research personnel-1,2; Technical support inadequate-1,2; Research budget-2; Supplies, equipment not available-1,2; Lack of farmer training-1,2.

## Philippines

Respondents - All respondents were interviewed by C. R. Jackson and D. G. Cummins during site visits.

1. Dr. Ponciano A. Batugal, Director, Philippine Council for Agriculture and Resources Research, Los Banos, Laguna.
2. Dr. Rudy S. Navarro, Institute for Plant Breeding College, Cagula, Philippines; Mrs. Leonila Lanticon, Peanut Breeder, University of Philippines and a pathologist at the University.
3. Dr. Isaac Cagampang, Department of Agronomy, University of Philippines at Los Banos.
4. Dr. Elias E. Escueta, Chairman, Food Science and Technology, University of Philippines at Los Banos, Laguna 3720, Philippines.

Constraint, sub-constraint, and respondent/s citing.

Weeds, Insects, and Diseases: Leafspots-1,2; Rusts-1,2,3; Peanut mottle virus-2.

Breeding and Genetics: Higher yield-1; Disease resistance-2,3.

Cultural Practices/Management: Seeding date, population-2; Mineral nutrition-1,2; Irrigation-1.

Physiology/Soil Microbiology: Unadapted rhizobia-3; Inadequate nitrogen fixation-3.

Aflatoxin: Times, sources, and processes of contamination-4.

Nutrition/Food Science: New product development-4; Peanut "milk" for infants-4.

Seed Technology: Production of low quality seed-1.

Storage/Preservation: Decreasing nutritive during storage-4.

Farming Systems/Services: Inadequate infrastructure, technology extension system, equipment-3.

Socio-Cultural Factors: Attitudes of farm family not understood-4.

Education/Training/Research Capability: Research budget-1.

### Thailand

Respondents - All respondents were interviewed by C. R. Jackson and/or D. G. Cummins, and/or G. C. Wheelock during site visits. Additional information from Dr. Arwooth Nalampang - ICRISAT Workshop report.

1. Mr. Panoo Satayavibul, Chief, The Seed Center No. 2, Khorat, Thailand.
2. Mr. Chamroen Satayarak, Station Director, Field Crop Station, Ministry of Agriculture, Kalasen, Thailand.
3. Mr. Kasem Chompoonutprapa, et al, Northeast Agricultural Center, Khon-Kaen, Thailand.
4. Mr. Sanid Landthong, Dr. Virye Limpinuntana, Dr. Terd Charoenwatana, Dr. Aran Patanothai, Mr. Pitaksit Chayabuthi, and Dr. Viriya Limpinantana, Faculty of Agriculture, Khon Kaen University, Thailand.
5. Dr. Arwooth Nalampang, Department of Agriculture, Division of Agronomy, Kalasen, Thailand.
6. Mr. Bill Gregg, Department of Agricultural Extension, Room 416 Paholyothin Road, Bangkhen, Bangkok 9, Thailand; and Mr. George M. Doughtery, Department of Agricultural Extension, Room 416 Paholyothin Road, Bangkhen, Bangkok 9, Thailand; both on AID grant with Mississippi State, Mr. Petcharat Wannapee, Ministry of Agriculture and Cooperatives, Bangkok, Thailand.
7. Kasetsart University Staff: Dr. Srinives Peerasuk, Plant Breeder; Dr. J. Doung Patra, Seed Physiologist; Dr. Supot Faungfupong, Physiologist-Crop Production; and Dr. Isara Sooksathan, Physiologist and Cropping Systems.

Constraint, sub-constraint, and respondent/s citing.

Weeds, Insects and Diseases: Leafspots - 3,7; Rusts-3,7; Other virus diseases-3; Root, stem, and pod rot-7; Foliage insects-3,7; Root, stem, pod insects-4,7.

Breeding and Genetics: Higher yield-7; Disease resistance-2,3,6; Insect resistance-2,3; Aflatoxin resistance-2,4,5,7; Drought resistance-4,5; Early maturity-5; Seed size-5; Oil/protein content-4; Seed dormancy-7; Saline soil tolerance-2,4; Peg strength-2; Nutrient efficiency-4.

Cultural Practices/Management: Seeding date/population-4,5; Mineral nutrition-2,4,5; Intercropping-2; Tillage-5,7; Soil pH-2,5.

Physiology/Soil Microbiology: Unadapted rhizobia-5; Inadequate nitrogen fixation-2,5; Photosynthetic efficiency-4; growth rate-4.

Aflatoxin: Times, sources, and processes of contamination-5; Detoxification processes for food uses-5.

Nutrition/Food Science: New product development-4,5.

Seed Technology: Production of low quality seed-1,3,5,6,7; Poor harvesting and handling-1,3,6; Temperature, humidity, and pest storage problems-1,2,6; Inadequate seed production and distribution capacity-6.

Mechanical Technology: Lack of animal powered machinery-5; Lack of gasoline powered machinery-5.

Economics: Markets inadequate for farm surpluses-2,4; Matching seasonal labor constraints with peanut technology-4.

Socio-Cultural Factors: Attitudes of farm family not understood-1,4,5,7; Attitude of small farmer toward risk of new technology-4; Farmer-middleman relations encourage rice, discourage peanuts-4.

Education, Training, and Research Capability: Insufficient trained research personnel-2,5; Technical support inadequate-2.

Mali

Respondents: ICRISAT Report.

1. D. Soumano, B. P. 258, Bamako, Mali.

Constraint, Sub-constraint and Respondent's Citing.

Breeding and Genetics: Disease resistance-1; Seed size-1; Oil/protein content-1.

Cultural Practices/Management: Seeding date, population-1; Unadapted cultivar-1; Mineral nutrition-1.

Physiology/Soil Microbiology: Unadapted rhizobia-1; Inadequate fixation-1; Growth rate-1.

Aflatoxin: Times, sources and processes of contamination-1; Chemical identification-1; Control measures-1.

Storage, Preservation: Decreasing nutritional value in storage-1; Disease, pest infestation in storage-1.

Economics: Fertilizer-1; Pesticides-1.

## Malawi

Respondents: All interviewed by D. G. Cummins and G. C. Wheelock on site visits.

1. Mr. Allen Chiyembekeda (Plant Breeding), Chitedze Agricultural Research Station, Lilongwe, Malawi.
2. Dr. Darell McCloud (Physiology), University of Florida AID Project, Chitedze Agricultural Research Station, Lilongwe, Malawi.
3. Dr. O. T. Edje, (Crop Production), University of Malawi, Bunda College of Agriculture, P. O. Box 219, Lilongwe, Malawi.
4. Dr. Henry K. Mwandemere, Officer in Charge, Chitedze Research Station, Lilongwe, Malawi.
5. Dr. Art Hansen, (Anthropology), University of Florida AID Project, Chitedze Agricultural Research Station, Lilongwe, Malawi.
6. Mr. Charles Kisyombe, (Plant Pathologist), Chitedze Research Station, Lilongwe, Malawi.
7. Mr. Charles Maliro (Agronomist) Chitedze Agricultural Research Station, Lilongwe, Malawi.

## Constraint, Sub-constraint, and Respondent/s citing.

Weeds, Insects, and Diseases: Leafspots-1,2; Rusts-2; Rosette-2; IPM-2.

Breeding and Genetics: Higher yield-1,2; Disease resistance-1,2; Seed size-2; Seed quality-1.

Cultural Practices/Management: Seeding date, population-2; Mineral nutrition-3; Intercropping-3.

Physiology/Soil Microbiology: Partitioning-2.

Economics: Fertilizer-1,3; Pesticides-1; Land-1,3,5;  
Labor-1,5.

Farming Systems & Services: Inadequate infrastructure-1.

### Mozambique

Respondents: Country report, ICRISAT

1. A. D. Malithano, Faculty of Agriculture, University of Eduardo Mondlane; C. P. 257, Maputo.

Constraint, Sub-constraint, and Respondent's Citing.

Breeding and Genetics: Higher yield-1; Disease resistance-1;  
Insect resistance-1; Oil/Protein content-1.

Cultural Practices/Management: Seeding date, population-1;  
Unadapted cultivar-1; Mineral nutrition-1; Irrigation-1;  
Tillage-1; Soil pH-1; Cropping systems-1.

Mechanical Technology: Lack of animal powered machinery-1;  
Lack of petrol/machinery-1.

### Niger

Respondents: Information obtained through interviews by C. R. Jackson on site visit, and from ICRISAT Report by Mounkaila. Item 6 was an anonymous article.

1. Mr. Salifou Mahamane, Director, Niger Cereals Project, Niamey, Niger.

2. Mr. Soulay Nencou, Assistant Director of Agriculture, Ministry of Agriculture, Niamey, Niger.

3. Mr. Oumara Moussa (Chemist, Aflatoxins) Deputy Director of Research, INRAN, Niamey, Niger.

4. Mr. Myron Golden, Program Director, USAID, Niamey, Niger.

5. Mr. Amadou Mounkaila (Peanut Breeder), CNRA Tarni, BP 240, Maradi, Niger.

6. Anonymous. The present situation of Niger's economy. Marches Tropicaux, 190, boulevard Haussmann, 75008 Paris-563-11-66. June 1, 1979. p 48-53.

Constraint, Sub-constraint, and Respondent/s citing.

Weeds, Insects, and Diseases: Rosette-1,2,3; Foliage Insects-3.

Breeding and Genetics: Higher yield-6; Disease resistance-1,6; Drought resistance-1,6.

Cultural Practices/Management: Seeding date, population-6; Unadapted cultivar-5,6; Mineral nutrition-3,6; Tillage-6.

Physiology/Soil Microbiology: Lack of flowering-2.

Seed Technology: Production of low quality seed-2.

Economics: Low prices-3.

Education, Training and Research Capability: Insufficient trained research personnel-4. Lack of farmer training-5.

## Nigeria

Respondents: All interviewed by C. R. Jackson and B. Onuma Okezie on site visits, except for ICRISAT Workshop Report by Misair, Harkness, and Fowler. (Harkness was also interviewed on site visit).

1. Dr. John J. Davies (Formerly Pasture Agronomist), Acting Director, Institute for Agricultural Research (IAR), Ahmadu Bello University, PMB 1044, Zaria, Nigeria.
2. Dr. Joseph Y. Yayock, (Formerly Groundnut Agronomist), Deputy Director for Research and Head of Agronomy Department, IAR, Ahmadu Bello University, PMB 1044, Zaria, Nigeria.
3. Dr. Subbharayadhu (Virologist), IAR, Ahmadu Bello University, Zaria, Nigeria.
4. Dr. L. Singh (Soil Scientist), IAR, Ahmadu Bello University, PMB 1044, Zaria, Nigeria.
5. Dr. Haruna L. Musa (Agricultural Engineer) Agriculture Engineering Dept. IAR PMB 1044, Ahmadu Bello University, Zaria, Nigeria.
6. Dr. Salako (Plant Pathologist), IAR, PMB 1044 Ahmadu Bello University, Zaria, Nigeria.
7. S. M. Misari, IAR, PMB 1044, Ahmadu Bello University, Zaria, Nigeria.
8. Dr. Colin Harkness (Peanut Breeder) IAR, PMB 1044, Ahmadu Bello University, Zaria, Nigeria.
9. Mr. A. M. Fowler (General Agriculture) Superintendent IAR, Kano Experiment Station, Kano, Nigeria.

10. Dr. Nathaniel O. Ejiga and J. Olukosi (Agricultural Economists), IAR, PMBl044, Ahmadu Bello University, Zaria, Nigeria.

Constraint, Sub-constraint and Respondent/s citing.

Weeds, Insects, and Diseases: Leafspots-2,6,7,8,9; Rusts-2,6,7,8,9; Rosette-2,3,6,7,8,9; Root, stem, pod rot-2,7,8,9; Root, stem, pod insects-2,7,8,9; Weeds-2,5,7,8,9.

Breeding and Genetics: Disease resistance-2,7,8,9; Insect Resistance-2; Drought Resistance-2,7,8,9.

Cultural Practices/Management: Mineral Nutrition-2,4,7,8,9; Intercropping-7,8,9; Tillage-5; Soil pH-4; Organic matter-4; Seed treatment-7,8,9.

Physiology/Soil Microbiology: Partitioning-2; Flower production-2; Agro-climatic-2; Weed Parasitism-5; Pod set, lack of-7,8,9.

Seed Technology: Production of low quality seed-7,8,9.

Mechanical Technology: Lack of animal powered machinery-2,5,7,8,9; Lack of petrol/machinery-5,7,8,9; Planting equipment-5; Cultivating equipment-5; Harvesting equipment-5.

Socio-Cultural Factors: Attitudes of farm family not understood-7,8,9; Farmers aspire to other occupations-1,7,8,9; Migration-7,8,9,10; Farmer confidence (price, risk) in crop-1,10; Inexperience with credit-10; Labor cost-10.

Senegal

Respondents: Information from site visits by D. G. Cummins, and G. C. Wheelock. Additionally, information from ICRISAT Workshop report by Gautreau and dePins; Gillier by C. R. Jackson and D. G. Cummins at IRHO in Paris.

1. Mr. J. Gautreau and Dr. Aly Ndiaye (Physiologists), National Agronomic Research Center, Senegalese Institute for Agricultural Research, Bambey, Senegal.

2. Dr. O. dePins (Breeding and Genetics) National Agronomic Research Center, Senegalese Institute for Agricultural Research, Bambey, Senegal.

3. Dr. M'Baye N'Doyle (Entomology) Head Entomology Section, National Agronomic Research Center, Senegalese Institute for Agricultural Research, Bambey, Senegal.

4. Mr. John Balis, Food and Agriculture Officer, USAID, Dakar, Senegal.

5. Dr. Pierre Gillier, Director Du Departement Oleagineux Annuels, Institut de Recherches Pour Les Huiles et Oleagineux, 11, Square Petrarque, 75016, Paris, France.

6. Mr. Saloiu Niang, Supervisor of Experimental Units, ISRA Sectour Centre Sud, Kaolack, Senegal.

Constraint, Sub-constraint, and Respondent/s citing.

Weeds, Insects, and Diseases: Root, stem, pod insects-3; Weeds-4.

Breeding and Genetics: Higher yield-1; Disease resistance-1; Aflatoxin resistance-1; Oil/protein content-1; Market quality-1.

Cultural Practices/Management: Seeding date, population-2; Unadapted Cultivar-4,5; Mineral nutrition-2; Tillage-2; Soil pH-2.

Physiology/Soil Microbiology : Unadapted rhizobia-4; Inadequate fixation-4; Drought tolerance mechanisms-2.

Aflatoxin: Chemical identification-4; Detoxification processes for food use-2,4.

Economics: Fertilizer-6; Pesticides-6; Credit-6.

Socio-Cultural Factors: Attitude of small farmer toward risk of new technology-6, Labor at planting time-6.

Sudan

Respondents: All interviewed on site visits by C. R. Jackson and B. Onuma Okezie.

1. Dr. James Riley, Agricultural Officer, USAID, Khartoum, Sudan.

2. Dr. El Jack, Minister of Agriculture, Khartoum, Sudan.

3. Mr. Mohd. Kailani, General Manager, Sudan Oil Seeds Co. Ltd., P. O. Box 167, Khartoum, Sudan.

4. Dr. Abdullahi Mohamed Osman El Karouri, Head of the Department of Agronomy, Khartoum University; Dr. Farah Hassa Adam of the Department of Rural Economy; Dr. Ahmen Hashin Ahared of the Department of Crop Protection; Dr. Salah Eldin Osman Mahgoub, Food Scientist; Dr. Hago Mohammed Abdelmagid, Department of Biochemistry and Soil Science; Dr. Ali Ibrahim Ahmen, Department of Agricultural Botany; Dr. Ahmed Humeida Ahmed, Department of Rural Economy, Dr. Tay El Din El Sheikh Musa Hugo; and Dr. Mohammed Ali Salama, all at Khartoum University.

5. Mr. Abdel Wahab Khidi Ahmed and Professor Habadish, Food Research Center, Agricultural Research Corporation, Khartoum, Sudan.
6. Mr. El Ahmadi (Variety Improvement), Gezira Research Station, Agricultural Research Corporation, Wad Medani, Sudan.
7. Dr. Joshi and Mr. Kamal M. El Hafaim (Plant Propagation), Gezira Research Station, Agricultural Research Corporation, Wad Medani, Sudan.
8. Dr. Tigani (Entomology), Director Gezani Research Station, Agricultural Research Corporation, Wad Medani, Sudan.
9. Dr. Mohammed A. Ali (Plant Pathology), National Coordinator for Plant Diseases, Gezira Research Station, Agricultural Research Corporation, Wad Medani, Sudan.
10. Dr. Hassan Mohamed Ishag (Agronomy), Gezira Research Station, Agricultural Research Corporation, Wad Medani, Sudan.

Constraint, sub-constraint, and respondent/s citing.

Weeds, Insects, and Diseases: Other virus-4; Root, Stem, Pod Insects-8.

Breeding and Genetics: Aflatoxin Resistance-6; Drought Resistance-6,10; Oil/Protein content-5,6,10; Peg strength-6.

Cultural Practices/Management: Mineral Nutrition-4,10; Soil pH-4.

Physiology/Soil Microbiology: Unadapted Rhizobia-4; Inadequate Fixation-4; Photosynthetic efficiency-4.

Aflatoxin: Times, Sources and Processes of contamination-5,10; Chemical identification-10; Control measures-10.

Nutrition, Food Preparation: New product development-5; Storage-5.

Seed Technology: Temperature humidity and pest storage problems-3; Inadequate seed production and distribution capacity-2,7.

Education, Training, and Research Capability: Research budget-1; Supplies, equipment not available-9.

RESEARCH BEING CONDUCTED IN VARIOUS COUNTRIES

SUMMARY OF RESEARCH IN THE UNITED STATES RELATED TO PEANUTS  
BASED ON CRIS DOCUMENTATION AS OF JULY, 1981

Performing Organization:	Investigator(s)	Project Number	Termination Date	TITLE/Comments
<u>BREEDING - GENETICS</u>				
U. Florida Gainesville Agronomy	A. J. Norden D. A. Knauft	FLA AY 02006	Dec 84	BREEDING AND GENETICS OF PEANUTS (ARACHIS HYPOGAEA L.)
U. Florida Jay, FL. Agr. Resh. Ctr.	B. J. Brecke H. A. Peacock	FLA 1590	Dec 80	FIELD CROP VARIETY TESTING
Langston Univ Langston, OK	SA. Latimer	OKLX8186-15-10	Sept. 85	IMPROVEMENT OF INCOMPATIBLE INTERSPECIFIC CROSSES OF PEANUTS.
U. Florida Marianna ARC	D. W. Corbet	FLA-MA-02006	Dec 84	BREEDING AND GENETICS OF PEANUTS ( <u>Arachis hypogaea L.</u> )
U. Georgia, CPS, Tifton Agronomy Dept.	W. D. Branch	Geo. 313	June 83	PEANUT GENETICS, BREEDING/develop improved varieties.
Coastal Plain Tifton, GA	A. C. Mixon	7702-20080-001	Feb. 84	BREEDING PEANUTS FOR AFLATOXIN RESISTANCE/improve varieties-control measures.
USDA				
Coastal Plain Tifton, GA USDA	R. O. Hammons	7702-20080-004	Oct. 84	GENETIC IMPROVEMENT OF PEANUTS ARACHIS HYPOGAEA L/germ plasm improvement, breeding systems.
N. C. State Raleigh Crop Science	J. C. Wynne	NC1140	Sept. 83	PEANUT VARIETY AND QUALITY EVALUATION/evaluate adv. breeding lines and breeding methodology.
N. C. State Raleigh Crop Science	J. C. Wynne	NC3452	Sept. 84	PEANUT IMPROVEMENT THROUGH BREEDING/develop improved cultivars.
N. C. State Raleigh Crop Science	H.T. Stalker	NC5401	Sept. 84	UTILIZATION OF SPECIES OF ARACHIS TO IMPROVE PEANUTS/germplasm resources, 40- chromosome hybrid devel.

N. C. State Raleigh	J. C. Wynne W. C. Gregory	NC9023 April'82	GENETIC BASE DEVELOPMENT OF A AUTOGAMOUS, ALLOTETRAPLOID PEANUT/develop methods introgression exotic germplasm
Crop Science			
N. C. State Raleigh	H. T. Stalker	7900509 Aug. 81	PATHWAYS OF GENE TRANSFER FROM WILD PEANUT SPECIES TO ARACHIS HYPOGAEA
Crop Science			
Oklahoma St.U Stillwater	J. S. Kirby D. J. Banks	OKL1386 Aug. 84	PEANUT IMPROVEMENT - BREEDING AND MANAGEMENT/developing & evaluating new germplasm and cultivars.
Oklahoma SU Stillwater	D. L. Banks D. L. Ketring	7317-20080-004 May 85	BASIC GERMLASM RESOURCE DEVELOPMENT IN PEANUTS/ broaden genetic base, dev. gene pools.
Agronomy-USDA			
Texas AMU Stephenville	C. E. Simpson	TEX6449 Feb. 85	IMPROVING STRESS RESISTANCE IN PEANUTS/dev. lines & varieties.
Agr. Exp.Stat.			
Texas AMU Stephenville	C. E. Simpson O. D. Smith	TEX1767 Sept. 80	PEANUT BREEDING, GENETICS AND CYTOGENETICS.
Tarleton Exp. Stat.			
Texas AMU College Stat.	O. D. Smith T. E. Boswell	TEX1882 Sept 80	PEANUT BREEDING & IMPROVEMENT/ disease-insect resistance.
Soil & Crop Sci.			
Virginia PISU Suffolk	R. W. Mozingo T. A. Coffelt	VA622320 Sept 83	PEANUT VARIETY AND QUALITY EVALUATION.
Agr. Exp. Sta.			
Holland Sta. Suffolk, VA	T. A. Coffett	7812-20080-006 Apr. 83	PEANUT BREEDING AND GENETICS FOR DISEASE & INSECT RESIS- TANCE & IMPROVED QUALITY AND YIELD/dev. varieties with disease-insect resistance.
USDA			

SUMMARY OF RESEARCH IN THE UNITED STATES RELATED TO PEANUTS BASED ON  
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<u>Performing Organization:</u>	<u>Investigator(s)</u>	<u>Project Number Termination Date</u>	<u>TITLE/ Comments</u>
<u>WEEDS, INSECTS, DISEASES, NEMATODES</u>			
Virginia PISU Suffolk	O. E. Rud	VA202396 June 81	WEEDS AND THEIR CONTROL IN AGRONOMIC CROPS
P.Path & Physical.			

Virginia PISU D. M. Porter Suffolk J. L. Steele USDA	7812-20840-002 Aug 85	NON-PATHOGENIC FUNGI AND THE PEANUT FRUIT AND SEED
Texas AMU J. R. Abernathy Lubbock A. F. Wiese Agr. Exp. Sta.	TEX6209 July 81	WEED CONTROL IN AGRONOMIC CROPS ON THE TEXAS HIGH PLAINS
Texas AMU M. G. Merkle College Stat. J. R. Abernathy Soil & Crop Sci.	TEX6333 Oct. 82	THE EFFECTIVENESS AND FATE OF HERBICIDES FOR WEED CONTROL IN AGRONOMIC CROPS.
Oklahoma SU D. C. Murray Stillwater E. Basler Agronomy	OKL933 June 83	WEEDS AND THEIR CONTROL IN CULTIVATED AGRONOMIC CROPS
N. C. State U H. D. Coble Raleigh Crop Science	NC3593 Sept. 82	WEED CONTROL STRATEGIES FOR CROP MANAGEMENT SYSTEMS.
U. Georgia A. W. Johnson Athens Plant Pathology	Geo-02-0208 June 83	INTEGRATED PEST MANAGEMENT PARASITIC NEMATODES ON SELECTED CROPS.
U. Georgia A. W. Johnson Coastal Plain Tifton USDA, Plant Pathology	7702-20270-002 Jan 85	NEMATODE PATHOLOGY AND CONTROL ON VEGETABLES, FIELD CROPS AND TURF
Coastal Plain C. C. Dowler Tifton, GA E. W. Hauser USDA	7702-20281-003 May 85	DEVELOPMENT OF WEED MANAGEMENT AND INTEGRATED PEST MANAGEMENT SYSTEMS FOR THE COASTAL PLAIN
Coastal Plain N. A. Minton Tifton, GA USDA-Plant Pathology	7702-20270-001 Jan 85	NEMATODE PATHOLOGY, RESISTANCE AND CONTROL ON FIELD AND FORAGE CROPS.
Coastal Plain C. C. Dowler Tifton N. C. Glaze USDA A. W. Johnson	7702-20289-001 Oct. 80	CROP ROTATIONS FOR MANAGING NEMATODES, DISEASES, AND WEEDS IN MULTIPLE CROPPING AND MINIMUM TILLAGE SYSTEMS.
Coastal Plain E. W. Hauser Tifton Agronomy	GEO249 Dec. 83	WEED SCIENCE AS APPLIED TO THE PRODUCTION OF PEANUTS/ inter- actions of varieties pesticides-soil types.
U. Florida B. J. Brecke Jay, FL Agr. Resh. Cntr.	FLWF1844 Sept. 83	WEED CONTROL IN FIELD AND FORAGE CROPS.
U. Florida D. W. Grobet Marianna Agr. Resh. Cnt.	FLMA1844 Sept. 83	WEED CONTROL IN FIELD AND FORAGE CROPS.

Texas AMU Yoakum Agr. Resh. Sta.	T. E. Boswell W. H. Thames	TEX6117 Oct. 82	THE ROLE OF NEMATODES IN PEANUT SOIL BORNE DISEASES AND THEIR CONTROL/survey, define interactions, control.
U. Florida Gainesville Ent. & Nemato.	R. A. Dunn D.W.Dickson	FLEY 1520 Dec. 80	THE BIOLOGY AND CONTROL OF NEMATODES AFFECTING AGRONOMIC CROPS
Texas AMU College Stat. Entomology	J. W. Smith R. L. Sams	TEX 1789 June 82	INTEGRATED CONTROL OF THE INSECT PESTS OF PEANUTS/pop'n ecology, insecticides, biolo- gical control, resistant cultivars.
Coastal Plain Tifton USDA	R. E. Lynch	7702-20240-001 Aug. 85	INSECT PESTS OF OIL CROPS.
Coastal Plain Tifton Entomology	L. W. Morgan	GEO275 June 80	BIOLOGY AND CONTROL OF THE SOUTHERN ROOTWORM AND OTHER INJURIOUS INSECTS OF PEANUTS.
Auburn U. Auburn, Ala Entomology	M. H. Bass	ALA509 Sept. 84	BIOLOGY AND CONTROL OF INSECT PESTS OF PEANUTS.
Virginia PISU Blacksburg Agronomy	N. L. Powell J. C. Smith P. M. Phipps	VA336969-1 May 81	INTEGRATED PEST MANAGEMENT SYSTEM FOR PEANUTS UTILIZING AGRO-ENVIRONMENTAL DATA/Cercospora LS, Sclerotina, SC rootworm.
N. C. State Raleigh Crop Science	F. T. Corbin	NC3694 Sept. 84	INTERACTION EFFECTS OF PESTICIDES IN INTEGRATED PEST MANAGEMENT SYSTEMS.
Auburn. U. Auburn, Ala. Botany & Microbial	P. A. Backman R. K. Rodriguez	ALA450 Sept. 82	SYSTEMS FOR DISEASE MANAGE- MENT IN PEANUTS & SOYBEANS/ foliar and soil-borne.
U. Florida Gainesville P. Pathology	R. D. Berger	FLPT1838 Dec. 82	EPIDEMIOLOGY OF PLANT DISEASES/Cercospora LS, <u>et al</u>
Auburn U. Auburn, Ala. Botany & Microbiol.	K.R. Rodriguez P. A. Backman	ALA407 Sept. 80	ACTIVITIES OF NEMATICIDES AND FUNGICIDES ON NON-TARGET SOIL NEMATODES AND FUNGI.
U. Florida Gainesville P. Pathology	L. F. Jackson	FLPT 1945A Sept. 84	VARIABILITY OF PATHOGEN POPULATIONS AND CONTROL OF DISEASES OF FIELD CROPS IN FLORIDA/peanut leaf spots.

Virginia PISU Suffolk USDA	D. M. Porter F. S. Wright K. H. Garren	7812-20080-007 Oct 84	PEANUT DISEASES AND THEIR ROLE IN PEANUT PRODUCTION
Virginia PISU Blacksburg P. Pathology	G. J. Griffin	VA612259 Dec. 80	PROPAGULE GERMINATION AND SURVIVAL OF PLANT PATHOGENIC FUNGI/Cylindrocladium black rot.
Texas AMU College Stat.	R.E.Pettit R. A. Taber	TEX605 Sept 80	DISEASES OF PEANUTS IN TEXAS
Texas AMU Yoakum Agr. Resh. Sta.	D. H. Smith	TEX6145 June 80	FOLIAR DISEASES OF PEANUTS - EPIDEMIOLOGY AND CONTROL.
Clemson U. Clemson, SC P. Pathology	F. H. Smith L. W. Baxter E. B. Eskew	SC29631 June 82	THE CAUSE AND CONTROL OF POD AND STEM ROTS OF PEANUTS.
Clemson U. Clemson, SC P. Pathology	F. H. Smith	SC30 June 81	INTEGRATED DISEASE CONTROL SYSTEMS WITH ANNUAL FIELD AND VEGETABLE CROPS IN SOUTH CAROLINA.
Oklahoma SU Stillwater P. Pathology	R. V. Sturgeon	OKL1709 June 83	PEANUT SOIL DISEASE CONTROL/ Pod Rot Diseases
Oklahoma SU Stillwater P. Pathology	H. A. Melouk D. J. Banks	OKL1661 Dec. 82	EPIDEMIOLOGICAL STUDIES ON CERCOSPORA LEAF-SPOT IN PEANUT
Oklahoma SU Stillwater P. Pathology	D. F. Wadsworth	OKL1407 June 82	FUNGAL DISEASES OF PEANUTS AND THEIR CONTROL/Sclerotium, Verticillium.
N. Mexico SU Clovis, N.M. Plains Br. AES	D.C.H.Hsi	NM34-SP Jan 99	CAUSE, PREVENTION, AND CONTROL OF PEANUT FRUIT DISCOLORATION (BLACKHULL)
N. C. State U Raleigh P. Pathology	M. E. Beute	NC3508 Sept. 81	PEANUT DISEASES AND THEIR CONTROL/mites-pod rot complex
U. Georgia Athens P. Pathology	T. E. Starkey	Geo 657 June 83	ECOLOGY AND EPIDEMIOLOGY OF FOLIAR AND FRUIT PATHOGENS OF PEANUT, PECAN, APPLE AND ALFALFA.
Coastal Plain Tifton, GA P. Pathology	R. H. Littrell	Geo299 June 81	EPIDEMIOLOGY AND CONTROL OF FOLIAR DISEASES OF PEANUTS.

Coastal Plain Tifton, GA P. Pathology	D. K. Bell H. D. Wells	Geo288 Aug 80	BIOLOGICAL CONTROL OF SOIL-BORNE PATHOGENS
Coastal Plain Tifton, GA P. Pathology	D. K. Bell	Geo264 June 80	ETIOLOGY OF DISEASES OF PEANUT SEED.
U. Florida Gainesville Entomology	S. L. Poe R. D. Berger	FLEY1806 Sept. 80	A CROP MANAGMENT SYSTEM FOR INSECT AND DISEASE CONTROL OF PEANUTS/Economic thresholds.
Clemson U Clemson, SC P. Pathology-USDA	O. W. Barnett P. B. Gibson	7002-20100-002 A(1) Dec. 81	CHARACTERIZING VIRUS DISEASES OF FORAGE LEGUMES TO AID IN DISEASE CONTROL.

Regional Research Project S-127, terminating Sept. 1982, entitled FORAGE LEGUME VIRUSES. Work performed in USDA, U. Kentucky, Virginia PISU, Clemson U., N. C. State U., U. Georgia, U. Florida, Auburn U, et al. Identify, characterize and determine distribution, importance and effects of viruses in forage plants and related southern U. S. legumes.

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CULTURAL PRACTICES, MANAGEMENT

Auburn U. Auburn, Ala Agron & Soils	F. Adams	ALA508 Sept. 84	THE NATURE OF SOIL ACIDITY AND ITS EFFECT ON AGRONOMIC CROPS IN ALABAMA/soil test values critical for peanuts.
U. Florida Marianna, Fl Agr. Resh. Cntr.	D. W. Gorbet	FLMA1582 Dec. 82	SOIL AND WATER MANAGEMENT IN AGRONOMIC CROP PRODUCTION/ 'Florunner', irrigation.
U. Florida Jay, Fl. Agr. Resh. Cntr.	M. C. Lutrick	FLWF1582 Dec. 82	SOIL AND WATER MANAGEMENT IN AGRONOMIC CROP PRODUCTION/ nutrient status, spacing, tillage, etc.
Clemson U. Clemson S. C. Agronomy & Soils	E. B. Eskew T. W. Culp J. R. Hill	SC00431 June 25	CULTIVAR PERFORMANCE EVALUATION OF COTTON, SOYBEANS & PEANUTS
Coastal Plain Tifton, GA Agronomy	M. E. Walker	Geo279 Feb. 81	PEANUT NUTRITIONAL AND DISEASE INTERACTION EFFECTS ON YIELD AND QUALITY.

U. Georgia Athens Agronomy	R. L. Todd (J. L. Butler)	7005-20810-005A Sept. 81	ENERGY, BIOMASS OF NUTRIENT CYCLING IN AGRICULTURAL ECOSYSTEMS.
Mississippi Stoneville, MS Delta Br. Sta.	A. J. Halterlein	MIS1254 June 84	VARIETAL AND CULTURAL INVESTIGATIONS ON HIGH PROTEIN VEGETABLE CROPS - DRY BEANS AND PEANUTS.
N. C. State Raleigh Soil Science	U F. R. Cox J. H. Young J. E. Pattee	NC3486 Dec. 82	DEVELOPMENT OF A PEANUT PRODUCTION MODEL
Oklahoma Stillwater Agronomy	SU J. F. Stone	OKL1704 June 82	WATER CONCERNING EFFORTS OF CROPS IN NARROW, NORTH-SOUTH ROWS.
Oklahoma Stillwater Agronomy	SU D. S. Murray J. F. Stritzke T. F. Peeper	OKL1608 June 83	USE OF GROWTH REGULATORS IN AGRONOMIC CROPS UNDER SUBHUMID CONDITIONS.
Oklahoma Stillwater	R. L. Westerman B. B. Webb	OKL1427 June 82	EFFICIENT FERTILIZER USE FOR COTTON, PEANUT AND SOYBEAN PRODUCTION/fertility under irrigation-dryland.
Texas AMU Stephenville Tarleton Resh. Sta.	J. S. Newman	TEX1893 Aug 80	SUPPLEMENTAL IRRIGATION OF PEANUTS IN NORTH CENTRAL TEXAS
Texas AMU Stephenville	R. M. Jones	TEX6372 Apr 83	NUTRITIVE REQUIREMENTS OF SPANISH AND RUNNER PEANUTS/ mineral nutrients, micronutrients, rhizobia.
Virginia SU Petersburg	C. C. Lewis R. L. Chaney	1090-20791-003A July 80	EFFECT OF SOIL pH, SOIL CADMIUM, AND GYPSUM SOURCE AND RATE ON PEANUT YIELD AND CADMIUM CONTENT.
Virginia PISU Suffolk, VA	F. S. Wright D. M. Porter	7812-20080-003 Aug. 80	IMPROVING TILLAGE AND HARVESTING OF PEANUTS.
Virginia PISU Holland, VA Agr. Expt. Sta.	D. L. Hallock	VA612178 Sept. 82	SOIL-PLANT NUTRIENT RELATION- SHIPS IN VIRGINIA TYPE PEANUTS AND SOYBEANS.

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<u>MECHANICAL TECHNOLOGY</u>			
Tidewater Sta Suffolk, VA USDA	F. S. Wright	7812-20190- 003 July 80	IMPROVEMENT AND DEVELOPMENT OF A DIRECT HARVESTER TO MINIMIZE DAMAGE AND MAINTAIN QUALITY OF PEANUTS
Tidewater Sta Suffolk, Va. USDA	F. S. Wright	7812-20190- 005 Sept. 85	IMPROVE PEANUT HARVESTING AND HANDLING EQUIPMENT TO MINIMIZE FIELD ENERGY CONSUMPTION
N. C. State Raleigh Biological & Agr. Eng.	W. H. Johnson J. H. Young	NC01147 Sept. 84	ENERGY REDUCTION FOR ON-FARM PROCESSING OF AGRICULTURAL PRODUCTS
N. C. State Raleigh USDA	T. B. Whitaker	7802-20590- 004 June 80	DEVELOP SPECTROPHOTOMETRIC METHODS FOR MEASURING QUALITY OF AGRICULTURAL COMMODITIES
Nat. Peanut Lab Dawson, GA USDA	J. I. Davidson, Jr.	7704-20592- 009 Oct. 82	DEVELOP NEW AND IMPROVED METHODS AND EQUIPMENT FOR HANDLING PEANUTS
Nat. Peanut Lab Dawson, GA USDA	P. D. Blankenship	7704-20592- 007 Aug. 84	METHODS AND EQUIPMENT TO IMPROVE DRYING AND CLEANING OF PEANUTS
Stevens,Inds. Dawson, GA (Coop. Nat. Peanut Lab.) USDA	W. P. Smith I. I. Davidson, Jr.	7704-20592- 006-A Aug. 84	EVALUATING PROCESSING OPERATIONS BY SHELLING, SORTING, GRADING AND GERMINATING THE PEANUTS
Coastal Pl. Tifton, GA USDA	J. L. Butler E. J. Williams J. M. Troeger	7702-20190- 002 June 80	REDUCING THE COST OF PEANUT HARVESTING, DRYING AND CURING IN THE SOUTHEAST
Coastal Pl. Tifton, GA USDA	J. M. Troeger E. J. Williams	7702-20190- 001 June 85 May 80	DEVELOPMENT OF ENERGY EFFICIENT SYSTEMS FOR PEANUT HARVESTING AND DRYING IN THE SOUTHEAST
Coastal Pl. Tifton, GA USDA	J. M. Troeger	7702-15970- 001 Aug. 75	MOLD PREVENTION DURING HARVESTING AND CURING PEANUTS IN THE SOUTHEAST

U. Georgia Tifton Agr. Eng.	E. D. Threadgill R. E. Williamson	GEO 298 June 80	LAND PREPARATION AND SOIL COMPACTION INVESTIGATIONS FOR AGRONOMIC AND HORTICULTURAL CROPS
U. Georgia Athens Agric. Eng.	B. D. McClendon J. M. Allison	GEO00713 June 83	MICROPROCESSOR-BASED CONTROLS FOR OPTIMIZING RESOURCE UTILIZATION IN PRODUCTION AND PROCESSING SYSTEMS.
Auburn U. Auburn, AL Agr. Eng.	E. S. Renoll	ALA460 Sept. 83	DETERMINING FARM MACHINERY RELIABILITY FOR SOUTHEAST FIELD CONDITIONS

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<u>PHYSIOLOGY, SOIL MICROBIOLOGY</u>			
U. California Davis LAW	D. N. Munns	CA-D-LAW3653 March 81	EDAPHIC TOLERANCE OF GRAIN LEGUMES/soil chemical stresses
U. Florida Gainesville Agronomy	K. J. Boote R. N. Gallaher D. E. McCloud	FLAY1735 Sept. 80	PHYSIOLOGICAL BASIS FOR PRODUCTIVITY OF PEANUTS AND SOYBEANS.
S. Piedmont Station Watkinsville, GA.,USDA	J. E. Box J. E. Pallas R. R. Bruce	7903-20760-001	SOIL-PLANT-ATMOSPHERE INTERACTIONS AFFECTING THE USE OF SOLAR ENERGY AND WATER IN THE SOUTH.
U. Georgia Athens Agronomy	R. H. Brown D. A. Ashley	Geo 450 June 80	PHOTOSYNTHESIS AND GROWTH ANALYSIS OF PEANUTS.
N. C. State Raleigh Crop Science	D. A. Emery	NC3579 Sept 82	THE GENETIC CONTROL OF REPRODUCTIVE EFFICIENCY IN PEANUTS--RESPONSE TO PHOTOPERIOD.
N. C. State Raleigh, N.C. USDA	H. W. Heck R. A. Reinert A. S. Heagle	7802-20790-002 Jan 85	EFFECTS, FATES AND TRANS- FORMATIONS OF GASEOUS AIR POLLUTANTS ON AGRONOMIC AND HORTICULTURAL PLANTS.

W. C. State Raleigh Crop Science-USDA	J. M. Anderson	7802-20172-007 May 85	REGULATION OF PHOTOSYNTHESIS AND PLANT GROWTH AND DEVELOP- MENT BY ENDOGENOUS CONTROL SYSTEM.
Oklahoma SU Stillwater Agronomy	J. F. Stone J. E. Garton	OK101708 Dec 81	INTRASPECIFIC COMPETITIVE STRESS TO ENHANCE CROP PRODUCTION.
Texas AMU Yoakum Agr. Resh.Sta.	A. M. Schubert T. E. Boswell	Tex1982 Jan. 84	PHYSIOLOGICAL ASPECTS OF PEANUT PRODUCTIVITY AND PRODUCTION IN SOUTH TEXAS.
Texas AMU College Sta Biochemistry	J. W. Dieckert	TEX1306 May 81	CHEMISTRY AND BIOLOGY OF MATURING SEEDS: SEED PROTEINS PROTECTIVE COVERINGS, AND ENVIRONMENTAL EFFECTS.
Texas AMU College Sta. Biochemistry	J. M. Magill	TEX6162 Sept. 84	TRANSPORT AND METABOLISM OF NUCLEOSIDES AND BASES BY FUNGAL PATHOGENS.
U. Georgia Athens P. Pathology	R. S. Hussey	Geo. 670 June 84	ROLE OF VESICULAR ARBUSCULAR MYCORRHIZAE IN REDUCING PLANT STRESS INDUCED BY PLANT-PARASITIC NEMATODES.
Auburn U. Auburn, Ala Botany & Microbiology	E. A. Curl	Ala 352 Sept 82	RHIZOSPHERE ECOLOGY AS RELATED TO PLANT HEALTH AND VIGOR.
U. California Davis LAW	D. N. Munns	CA-D-LAW-3203 Sept 80	NUTRITION OF DINITROGEN FIXING-PLANT ASSOCIATIONS.
U. California Davis Agronomy	R. C. Valentine	CA-D-ARS-3447 Sept 81	GENETIC MANIPULATION OF NITROGEN FIXING BACTERIA.
U. Hawaii Honolulu Agronomy	J. Halliday W. G. Sanford	HAW175 Sept. 81	MAXIMIZING NITROGEN FIXATION BY TROPICAL AGRICULTURAL LEGUMES.
U. Hawaii Honolulu Agronomy & Soil Science	J. Halliday	HAW00183-BR Jan 83	BETTER LEGUME INOCULANTS FOR ACID, INFERTILE SOILS OF THE TROPICS
BARC Beltsville, MD. Pl. Stress Lab.	R.K. Howell	1109-20172-008 June 83	PHYSIOLOGY OF STRESS EFFECTS ON BIOLOGICAL NITROGEN FIXATION IN LEGUMES.
N.C. State Raleigh Crop Science	J. C. Wynne G. H. Elkan	NC9028 Sept 81	INCREASED EFFICIENCY OF PEANUT PRODUCTION THROUGH ENHANCED BIOLOGICAL NITROGEN FIXATION.

Texas AMU College Station S & C Sci.	R. W. Weaver	TEX3121 Sept 81	ENHANCING BIOLOGICAL DINITROGEN FIXATION IN SOYBEANS AND OTHER LEGUMES.
Texas AMU College Station Tarleton Sta	J. S. Calahan	TEX6318 July 83	SOIL FACTORS AFFECTING NODULATION AND NITROGEN FIXATION OF PEANUTS (ARACHIS HYPOGAEA L.)
Iowa SU Ames, Iowa Agronomy	T.E. Loynachan M.M. Musa	IOW2420 Jan 83	GROUNDNUT INOCULATION IN SUDAN.
U. Minnesota St. Paul Soil Sci.	E.L. Schmidt G. E. Ham J.A. E. Molina	MIN25-084 June 81	SOIL ADAPTABILITY OR RHIZOBIA FOR FOOD LEGUME PRODUCTION IN WEST AFRICA.

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SEED TECHNOLOGY			
Texas AMU Stephenville Tarleton Exp.	C. E. Simpson E. R. Howard Station	TEX00785 Aug. 80	FOUNDATION SEED OF NEW PEANUT STRAINS FOR TEXAS
N. C. State Raleigh Crop Science	R. D. Keys	NC05451 Sept. 80	SEED QUALITY MAINTENANCE AND PHYSIOLOGY OF THE MAJOR AGRONOMIC CROPS OF NORTH CAROLINA
U. Georgia Athens Agr. Eng.	R. L. Clark	GEO677 Jan 83	OPTICAL PROPERTIES OF CORN, COTTON, PEANUT AND SOYBEAN SEEDS AS RELATED TO SEED VIABILITY

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<u>NUTRITION, FOOD SCIENCE</u>			
Texas Women's University Denton NUTRITION	G. U. Liepa (J.P. Cherry)	7003-20521-036A Sept. 81	THE EFFECTS OF DIETARY VEGETABLE AND ANIMAL PROTEINS ON SERUM CHOLESTEROL LIPOPROTEINS OF RATS.
Purdue U. Lafayette, Ind. Nutrition	D. E. Pratt	IND084014 Sept 84	LIPID DEGRADATION IN FOODS DERIVED FROM Food & PLANT SOURCES.
U. Florida Gainesville	R. H. Schmidt	FLAFS1812 June 81	OILSEED PROTEIN UTILIZATION IN SUMULATED DAIRY PRODUCTS/milk, yogurt
U. Florida Gainesville	E. M. Ahmed	FLAFS1788 June 81	EXPANDING PEANUT UTILIZATION IN FOOD PRODUCTS/meat, bakery extenders-meat, dairy simulates
Fla. A & MU Tallahassee Rural Dev. Center	S. K. Pancholy	FLAX 79002 Sept. 83	AMINO ACIDS SURVEY AND PROTEIN CHARACTERIZATION OF PEANUT CULTIVARS
Fla. A & MU Tallahassee Rural Dev. Center	S.K. Pancholy	FLAX-PR- 0005-4734 April 80	SURVEY FOR AMINO ACIDS IN PEANUTS AND CHEMICAL CHARACTERIZATION OF PEANUT PROTEIN AND OIL
Fla. A & Mu Tallahassee	S.K. Pancholy	FLAX-PR 0005-4734 April 83	CHARACTERIZATION OF PEANUT SEED PROTEINS/includes tissue culture work.
Georgia Stat. Experiment Food Science	R. E. Worthington	GE01210 June 80	GLYCERIDE AND NON-GLYCERIDE STRUCTURES, PROPERTIES AND STABILITY CHARACTERISTICS OF SEED OILS.
Georgia Stat. Experiment Food Science	K. H. McWatters	GE01222-HM June 80	FACTORS INFLUENCING FUNCTIONAL CHARACTERISTICS OF VEGETABLE PROTEIN FOOD PRODUCTS
Georgia Stat. Experiment Food Science	N.P. Moon	GE01251 Sept.82	UTILIZATION OF FRUIT AND vegetable wastes/Peanut hull utilization in silage.

Nat. Peanut Lab. Dawson, GA USDA	J. L. Pearson C. E. Holaday	7704-20591-001 Aug. 80	MARKET QUALITY CHANGES IN PEANUTS AND PEANUT PRODUCTS RELATED TO STORAGE AND PROCESSING METHODS/storage at various temperatures and humidities.
Nat. Peanut Lab. Dawson, GA	C. E. Holaday	7704-20591003 April 81	DEVELOPMENT OF CHEMICAL AND PHYSICAL METHODS FOR THE EVALUATION OF PEANUT QUALITY POTENTIALS
U. Illinois Urbana Human Devel. and Family	A. K. Perry B. P. Klein F. O. Van Duyne	ILLU-60-0324  Sept. 80	UTILIZATION OF SOY AND OTHER PLANT PROTEINS FOR HUMAN CONSUMPTION/peanut flour-baking products
Southern Reg. Research Cen. New Orleans	R. O. Feuge F. L. White, Sr.	7102-20521-002 Aug 82	DETERMINATION OF RELATIONSHIP OF STEROSPECIFICS TRIGLYCERIDES OF PEANUT OIL TO ATHEROGENICITY.
Southern Reg. Res.Center New Orleans	H. P. Dupuy S. P. Fore	7102-20521-023 May 81	RAPID ASSESSMENT OF NEW PEANUT, RICE, AND COTTON-SEED GENOTYPES FOR ACCEPABLE FOOD QUALITY
Southern Reg. Res. Center New Orleans	R.L. Ory E. J. Conkerton A. A. Sekul	7102-20521-029 Feb 82	NUTRIENT COMPOSITION OF PROTEIN FLOUR FOR FOOD APPLICATIONS
Southern Reg. Res. Center New Orleans	A.J. St. Angelo	7102-20651-002 June 80	EFFECTS OF LIPID PEROXIDE-PROTEIN INTERACTION ON PEANUT QUALITY OF PEANUTS FOR THE EXPORT MARKET
Southern Reg. Res. Center New Orleans	L. Y. Yatsu J. Pominski	7102-20523-006 June 81	RELATIONSHIP OF PEANUT PRESSING OPERATIONS AND PEANUT STRUCTURE TO MECHANICAL REMOVAL OF OIL/ease of oil removal as related to seed morphology.
N. C. State Raleigh USDA-Market Qual. Res.	J. E. Pattee J. A. Singleton	7802-20590-002	FLAVOR CHEMISTRY OF RAW PEANUTS RELATED TO MARKET QUALITY
N. C. State Raleigh	M. W. Hoover	NC02109 June 82	NEW USES FOR PEANUTS, SOYBEANS, AND SWEET POTATOES/shelf stable peanut cheese product

N. C. State Raleigh Food Science	C. T. Young	NC02114 Sept. 83	IMPROVING QUALITY OF PEANUTS, PEANUT PRODUCTS & HIGH-PROTEIN FOOD PRODUCTS BY ANALYTICAL TECHNIQUES/flavor precursors identification
N. C. State Raleigh Biological and Agr. Eng.	W. F. McClure	NC02124 Sept 84	DEVELOPMENT OF INSTRUMENTATION TO MEASURE QUALITY AND COMPOSITION OF AGRICULTURAL PRODUCTS/development of mathematical models.
N. C. State Raleigh USDA-Market Qual. Res.	H. E. Pattee	7802-20590 April 80	BIOCHEMICAL CHANGES IN RAW PEANUTS RELATED TO MARKET QUALITY.
Eastern Reg. Res. Center Philadelphia	J. D. Pettinati C. E. Swift A. E. Wasserman	1402- 20530-038 Sept. 82	DEVELOPMENT OF METHODS FOR IDENTIFYING MEAT EXTENDERS IN MEAT FOOD PRODUCTS
Texas Women's Univ. Denton	B. B. Alford A. N. Milner R. L. Ory	7002- 20910-001-A Sept 81	EFFECTS OF PEANUT AND COTTONSEED MEAL NUTRIENTS ON COMPONENTS IN BLOOD OF TEST SUBJECTS
Texas AMU College Sta. Soil & Crop Sciences	L. W. Rooney M. N. Kahn	TEX01607 Jan. 82	BAKING QUALITY AND ACCEPTABILITY OF WHEAT AND FORTIFIED PRODUCTS FROM GRAIN AND OTHER OILSEED CROPS
Texas AMU College Stat. Agr. Eng.	V. E. Sweat D. A. Suter O. R. Kunze	TEX06160 Mar 80	DEVELOPMENT OF ENGINEERING PRINCIPLES FOR THE DESIGN OF FOOD PROCESSING SYSTEMS/relating physical properties of peanut pods to Pod Rot resistance.
Texas AMU College Stat. Consumer Res. Center	K. S. Rhee	TEX06162 Sept. 80	QUALITY ASPECTS OF MEAT EXTENDED WITH PLANT PROTEINS
Texas AMU College Stat. Soil & Crop Sciences	K. C. Rhee U. R. Choi	TEX06213 Nov. 84	PROCESSING, CHARACTERIZATION, MODIFICATION AND FUNCTIONALITY OF OILSEED PROTEIN INGREDIENTS/imitation milk and cheese products.
Virginia Sta. Univ.	O. Jones, Jr.	VA.X-PR-0003- 1738232 Mar. 80	SYNERGISTS FOR PHENOLIC ANTIOXIDANTS IN PEANUT OIL.

Virginia Sta. I. C. Obizoba College Res. Station	VA.X-PR-0002- 1728148 June 81	EVALUATION OF NUTRITIONAL VALUE OF COMBINATIONS OF SELECTED AND WIDELY CONSUMED PROTEIN FOODS/protein balance studies.
Michigan Sta. L. R. Dugan Univ. Food Science & Nutrition	MICL00986 June 83	COMPOSITION, STRUCTURE, FORMATION & STABILITY OF LIPIDS & LIPID DERIVED OR LIPID ASSOCIATED IN FOODS/ selection of antioxidants
Washington K. H. Koehler State Univ. Home Economics	WNPO1927 May 82	NUTRIENT COMPOSITION AND QUALITY OF CONVENIENCE FOODS MARKETED FOR INSTITUTIONAL USE
Rutgers Univ S. S. Chang Food Science	NJ00832 Oct. 80	IMPROVEMENT OF PEANUT BUTTER FLAVOR THROUGH A CHEMICAL STUDY OF ITS VOLATILE FLAVOR COMPOUNDS/collection and addition of volatile flavors lost in grinding into peanut butter.
Rutgers Univ. H. Daun Food Science	NJ10503 June 80	CHEMICAL REACTIONS INVOLVED IN THE THERMAL TREATMENT OF FOOD/ peanut roasting effects.
Rutgers Univ. S. S. Chang Food Science	NJ10503 Dec. 80	CHEMICAL REACTIONS INVOLVED IN FLAVOR AND FLAVOR STABILITY OF EDIBLE FATS AND OILS/identification of natural antioxidant.
U. Kentucky J. M. Concon Home Economics	KY00514 July 81	NUTRITIONAL QUALITIES OF COMBINING OR CO-PRECIPIATED CEREAL GRAIN AND LEGUME PROTEIN ISOLATES
Clemson U. C. V. Morr Food Science J. D. Maxwell	SC00373 June 82	DEVELOPMENT OF IMPROVED SOY AND PEANUT PROTEIN ISOLATES
Clemson U. M. G. Johnson Food Science J. J. Jen	SC00348 June 82	FERMENTED PEANUT FOODS
Clemson U. S. S. H. Rizvi Clemson S.C. J. C. Acton Food Science	SCO 0461 June 84	THERMAL PROCESSING OF FOODS PACKAGED IN RETORTABLE POUCHES.
Eastern Reg. V.H. Holsinger Res. Center H. I. Sinnamon Philadelphia	1402-20900-002 April 80	NUTRITIOUS BEVERAGE POWDERS FORMULATED FROM WHEY SOLIDS AND VEGETABLE PROTEINS AND/OR FATS

SUMMARY OF RESEARCH IN THE UNITED STATES RELATED TO PEANUTS BASED ON  
CRIS DOCUMENTATION AS OF JULY, 1981

Performing Organization:	Investigator(s)	Project Number Termination Date	TITLE/ Comments
<u>ECONOMICS</u>			
U. Georgia Experiment Agr. Econo.	J. R. Allison R. F. Anderson D. H. Carley	GEO-01-67 Oct. 81	ECONOMIC ANALYSIS OF PESTICIDE USE
U. Georgia Experiment Agr. Economics	D. H. Carley	GE01207 June 80	FACTORS AFFECTING LEASE AND TRANSFER ARRANGEMENTS, RENTAL VALUES AND ALTERNATIVES FOR PEANUTS AND FLUE-CURED TOBACCO
U. Georgia Experiment Agr. Economics	J. C. Purcell B. R. Miller	GEO 1233 Sept. 81	PRICE DISCOVERY AND INFORMATIONAL FLOWS FOR MAJOR AGRICULTURAL COMMODITIES IN THE SOUTHERN REGION
U. Georgia Athens Agr. Econ.	G. C. W. Ames	GEO 617 Sept. 80	FACTORS AFFECTING INTER- NATIONAL MARKETS FOR GEORGIA'S AGRICULTURAL COMMODITIES
U. Georgia Athens Agr. Economics	F. B. Saunders	GEO 638 Mar. 83	ECONOMIC ANALYSIS OF SELECTED ENTERPRISES AND PRODUCTION PRACTICES AT S. E. AND S. W. BRANCH STATIONS
Russell Res. Center, Athens, GA USDA	D. Burdick	7902-20540- 001 Feb. 80	NEW USES FOR PEANUT HULLS TO PRECLUDE INCINERATION AND AIR POLLUTION
U. Illinois Urbana Agr. Econ.	R. G. F. Spitze S. C. Schmidt H. D. Guither	ILLU-05-0304 Sept. 81	ALTERNATIVE PUBLIC PRICE, INCOME POLICIES FOR FUTURE AGRICULTURAL AND FOOD NEEDS
N. C. State Raleigh Economics	J. A. Seagraves	NC03567 Sept. 80	ESTIMATION OF CAPITALIZATION RATES FOR TOBACCO AND PEANUT ALLOTMENTS
Texas AMU College Stat. Agr. Econ.	R. E. Branson J. P. Nichols	TEX03192 Sept. 81	ANALYSIS OF DOMESTIC FOOD DEMAND AND CONSUMPTION BEHAVIOR
Texas AMU College Stat. Agr. Econ.	B. L. Gardner	TEX06346 Aug. 83	FARM COMMODITY PROGRAM IMPACTS ON U. S. AND TEXAS AGRICULTURE

Texas AMU College Stat. Agr. Economics	C. E. Shafer R. Knutson	TEX06173 June 80	PRICE AND DEMAND ANALYSIS FOR SELECTED AGRICULTURAL COMMODITIES PRODUCED IN TEXAS
Purdue U. Lafayette, IN. Agr. Economics	R. L. Thompson	IND045064 Sept. 80	INTERNATIONAL TRADE AND U. S. AGRICULTURE

SUMMARY OF RESEARCH IN THE UNITED STATES RELATED TO PEANUTS BASED ON  
CRIS DOCUMENTATION AS OF JULY, 1981

Performing Organization:	Investigator(s)	Project Number Termination Date	TITLE/ Comments
<u>AFLATOXIN - MYCOTOXINS</u>			
Auburn U Auburn, Ala Bot. & Microbiol.	N. D. Davis U. L. Diener	Ala 449 Sept 82	CHEMISTRY AND PHYSIOLOGY OF MYCOTOXINS.
Nat. Peanut Lab. Dawson, GA. USDA	R. J. Cole	7704-20840-001 August 84	MYCOTOXIN-PRODUCING POTENTIALS OF MICROFLORA INVADING PEANUTS AND OTHER COMMODITIES.
Nat. Peanut Lab Dawson, GA USDA	T. H. Sanders	7704-20840--005 Jan 81	FUNGITOXIC PROPERTIES OF THE PHENOLIC COMPOUNDS IN DEVELOPING PEANUTS.
Nat. Peanut Lab Dawson, GA USDA	C. E. Holaday	7704-20840-003 June 83	SCREENING METHODS FOR MYCOTOXINS IN OILSEEDS, CEREAL GRAINS AND OTHER COMMODITIES.
N. C. State Raleigh USDA	J. W. Dickens T. B. Whitaker	7802-20840-001 January 80	IMPROVE EQUIPMENT AND PROCEDURES FOR AFLATOXIN TESTING.
S. Carolina College Orangeburg Nat. Resources	A. G. Chakrobarati J. H. Arrington	SCXPR0004PS25 March 83	DETECTION AND DETOXIFICATION OF AFLATOXINS ON SELECTED PLANT PRODUCE.
Texas AMU College Sta. Plant Sci.	R. E. Pettit J.P. Claassen H. W. Schroeder	7091-20840 -002-A Sept 80	ELECTROMAGNETIC DETECTION OF MOLD AND AFLATOXIN DAMAGED PEANUT KERNELS.
Texas AMU College Sta. Plant Sci.	R. E. Pettit R. A. Taber H. W. Schroeder	TEX06357 May 83	MYCOFLORA AND MYCOTOXIN DAMAGE OF PEANUTS, TREE NUTS, AND FRUITS

U. Georgia Tifton P. Pathology	D. M. Wilson	Geo 303 Aug. 82	DETECTION, DETERMINATION, AND REDUCTION OF AFLATOXINS IN AGRICULTURAL PRODUCTS.
U. Georgia Tifton Plant Pathology	D. M. Wilson R. J. Cole	7002-20840-007A June 81	PEANUT RHIZOSPHERE MICROFLORAS UNDER DROUGHT- STRESS AND IRRIGATION REGIMES.
U. Wisconsin Madison Plant Pathology	E. B. Smalley F. S. Chu	WIS 05110 Sept. 84	OCCURRENCE OF MYCOTOXINS IN FEEDS AND FOODS AND THEIR EFFECTS ON ANIMAL AND HUMAN HEALTH.

SUMMARY OF RESEARCH IN THE UNITED STATES RELATED TO PEANUTS BASED ON  
CRIS DOCUMENTATION AS OF SEPTEMBER, 1980

Performing Organization:	Investigator(s)	Project Number Termination Date	TITLE/ Comments
<u>SOCIO-CULTURAL FACTORS</u>			
U. Hawaii Honolulu Food & Nutritional Sciences	B. R. Standal	HAW003255 Sept. 79	FOOD CHOICE AND NUTRITIONAL STATUS OF SELECTED WOMEN ON OAHU

SUMMARY OF RESEARCH IN THE UNITED STATES RELATED TO PEANUTS BASED ON  
CRIS DOCUMENTATION AS OF JULY, 1981

Performing Organization:	Investigator(s)	Project Number Termination Date	TITLE/ Comments
STORAGE PRESERVATION			
Nat. Peanut Lab. Dawson, GA USDA	W. O. Slay C. E. Holaday	7704-20591 004 July 81	USING CARBON DIOXIDE SORPTION OF PEANUTS TO PACKAGE AND MAINTAIN QUALITY
Nat. Peanut Lab Dawson, GA USDA	C. E. Holaday T. H. Sanders	7704-20591- 002 Feb. 81	ENVIRONMENTAL AND HEREDITARY EFFECTS ON PEANUT QUALITY/ storage temperatures of shelled and in-shell peanuts
Nat. Peanut Lab Dawson, GA	J. S. Smith, Jr. J. I. Davidson, Jr.	7704-20592- 008 Aug 84	METHODS, EQUIPMENT, AND OPERATING PROCEDURES FOR MAINTAINING THE QUALITY OF STORED PEANUTS/ventilation required to minimize moisture condensation and mytoxin development

Georgia Tech Atlanta	A. P. Sheppard J. L. Butler	7097-20190- 009-A2 June 79	DESIGN OF COLLECTORS AND INSTRUMENTATION FOR SOLAR DRYING OF AGRICULTURAL CROPS
Southern Reg. Res. Center New Orleans USDA	J. Pominski J. I. Wadsworth J. J. Spadaro	7102-20522- 012 Sept. 81	REDUCING ENERGY REQUIREMENTS FOR THE OVERALL PROCESSING OF PEANUTS
Southern Reg. Research Center New Orleans USDA	A. J. Stangelo	7102-20521-035 Sept 83	INVESTIGATION OF THE BIOCHEMICAL CHANGES IN PHOSPHOLIPIDS OF PEANUTS DURING STORAGE AND PROCESSING.
Okla. State Stillwater Agr. Eng.	B. L. Claug J. L. Butler	7091-20191- 012-A(2) June 80	SOLAR ENERGY STORAGE FOR DRYING AND CURING PEANUT PODS
Texas AMU College Stat. Agr. Eng.	N. K. Person, Jr. J. W. Sorenson, Jr.	TEX01980 Sept. 80	DRYING AND STORAGE OF PEANUTS IN THE SOUTHWEST
Tetrattech, Inc. Arlington, VA. (Coop USDA, Beltsville)	R. H. Forste (H.H. Klueter)	1090-20401- 005-C Mar 80	ECONOMIC ANALYSIS OF WIND- POWERED CROP DRYING AND REFRIGERATION COOLING/WATER HEATING SYSTEMS.
Tidewater Station Suffolk, VA USDA	J. L. Steele	7812-20190- 004 Jan 82	IMPROVED DRYING AND CURING SYSTEMS FOR FRESHLY HARVESTED VIRGINIA-TYPE PEANUTS
Stored Product Insect Lab Savannah, GA USDA	E.G.Jay R. Davis	7705-20620- 045- Jan 83	MODIFIED ATMOSPHERES FOR CONTROLLING INSECTS IN MARKETING CHANNELS
Stored Product Insect Lab Savannah, GA USDA	H. B. Gillenwater L. M. Redlinger	7704-20620- 031 April 83	METHODS OF APPLICATION OF INSECTICIDES INTO COMMODITY STORAGE, PROCESSING, AND HANDLING FACILITIES
Stored Product Insect Lab. Savannah, GA USDA	R. A. Simonaitis J. M. Zehner	705-20620- 025 Sept. 82	DEVELOP/IMPROVE ANALYSIS METHODS FOR INSECTICIDE RESIDUES IN COMMODITIES IN MARKETING CHANNELS.

Stored Product Insect Lab. Savannah, GA USDA	L. M. Redlinger H. B. Gillenwater R. L. Kirkpatrick	7705-20620 016 Nov. 82	DEVELOP GRAIN AND OILSEED PROTECTANTS TO PREVENT INSECT DAMAGE IN STORAGE IN SOUTHERN U. S.
Insect Attractant Lab Gainesville, Fla. USDA	K. W. Vick J. A. Coffelt H. Oberlander	7602-20629- 001 Jan 83	INSECT CONTROL IN STORED IN-SHELL PEANUTS WITH PHEROMONES AND INSECT GROWTH REGULATORS
Insect Attractant Lab Gainesville, Fla. USDA	S. M. Ferkovich H. Oberlander	7602-20620- 010 June 80	GROWTH AND DEVELOPMENT OF STORED PRODUCT INSECTS

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT  
PROJECTS THAT RELATE TO PEANUTS 1/

<u>Country</u>	<u>Project Title</u>	<u>Project No.; Initial and Final Fiscal Year</u>	<u>Purpose</u>
Cameroon	North Cameroon Seed Multiplication Project	6310001 1976-1980	Establish and institutionalize a self-sustaining, regional system for production, distribution, and use of improved peanut and sorghum seed in North Cameroon.
Chad	Agricultural Institutional Development-Extension	6770002 1978-1983	To strengthen Chadian institutional capabilities in agricultural extension with a goal of achievement of self-sufficiency in food production (millet, sorghum, peanuts) and improvement in social and economic status for the small farmer.
Mauritana	Mauritana Rural Development	6820201 1975-1980	Develop technically and socially sound methods for increasing crop and animal yields, and to generate the necessary data required to launch an expanded extension program.

Senegal	Senegal Cereals Production Project II	6850235 1979-1984	To improve extension and research capabilities of Senegal to reach the entire farm family with improved cultural recommendations (better varieties and fertilization practices) designed to increase pod production (millet and peanuts) and farm incomes in the groundnut basin.
Upper Volta	Upper Volta Seed Multiplication	6860202 1974-1980	Establish national seed service to assure constant source of seed to farmers and to provide organizational framework for testing and multiplying seed of superior varieties as they become available. Increased domestic pod production of rice, corn, peanuts, sorghum, and millet is a primary goal.
Thailand	Seed Development	4930270 1975-1981	To develop an organization to produce, process, store, and distribute to farmers adequate supplies of quality seed of higher yielding varieties of soybean, corn, peanuts, rice, and mungbean.

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1/ It is difficult to obtain complete information on active USAID projects that are concerned in some way with peanuts, but these projects suffice to give an example of the types of country development projects that are underway.

North, Central and South America and the Caribbean

Canada - Varietal adaptation, agronomy, physiology.

CARICOM - Varietal evaluation, Agronomy.

El Salvador - Varietal and agronomic evaluation.

Nicaragua - Variety evaluation, agronomy.

Argentina - Breeding, agronomy, disease and insect control, fertility, harvesting, aflatoxin identification.

Brazil - Breeding, soil fertility, agronomy, plant pathology, soil microbiology, food science.

Bolivia - Breeding, agronomy.

Columbia - Variety evaluation.

Ecuador - Variety evaluation, agronomy.

Guyana - Variety evaluation, agronomy.

Paraguay - Variety evaluation, entomology, plant pathology.

Surinam - Production practices, mechanization.

Uruguay -

Venezuela - Breeding, plant pathology, entomology, agronomy, soil fertility, soil microbiology, economics.

#### Asia and Southeast Asia

Australia - Breeding, soil physics, plant pathology, agronomy.

Bangladesh - Breeding and variety evaluation, socioeconomics.

Burma - Variety evaluation, soil fertility, agronomy, disease and insect control.

China - Breeding.

India - A wide range of disciplines are covered in research including breeding, plant pathology, entomology, agronomy, engineering, physiology, soil, water, aflatoxin, and seed technology.

Indonesia - Breeding, agronomy, soil fertility.

Japan -

Korea - Breeding and varietal evaluation.

Malaysia - Breeding, varietal evaluation, agronomy, soil fertility, and insect, disease, and weed control.

Nepal - Germplasm and variety evaluation, agronomy.

Pakistan - Breeding, agronomy.

Philippines - Breeding, plant pathology, agronomy, food science.

Sri Lanka - Variety evaluation and improvement, agronomy.

Thailand - Breeding, agronomy, physiology, entomology, plant pathology, soil microbiology, food science.

## Africa

Botswana - Agronomy and variety evaluation, seed multiplication.

Cameroon - Seed multiplication.

Chad - Variety evaluation.

Egypt - Breeding, agronomy, plant pathology.

Ivory Coast - Variety evaluation, agronomy.

Malawi - Breeding, agronomy, soil fertility, plant pathology, physiology, soil microbiology.

Mali - Variety evaluation, agronomy.

Mozambique - Variety evaluation, agronomy.

Niger - Variety evaluation, agronomy.

Nigeria - Breeding, entomology, virology, soil science, plant pathology, agronomy, weed science, agricultural engineering, farming systems.

Rwanda - Variety evaluation.

Senegal - Breeding agronomy, entomology, aflatoxin, soil microbiology, physiology.

Sierra Leone - Physiology - production practices.

Somalia - Agronomy.

Sudan - Breeding, agronomy, entomology, plant pathology, food science, aflatoxin.

Tanzania - Breeding, plant pathology, agronomy.

Upper Volta - Variety selection, agronomy, disease and insect control.

Zaire - Agronomy.

Zambia -

Zimbabwe - Breeding, physiology, agronomy, soil fertility, disease and weed control, aflatoxins.

## ICRISAT

The Peanut program at ICRISAT (International Crops Research Institute for the Semiarid Tropics, India) has been headed by Dr. R. W. Gibbons since its inception in 1976. It has the following specific research goals.

### 1. Breeding for resistance to major diseases and pests.

The most important foliar diseases causing severe yield losses on a worldwide basis are the leafspots (Cercospora arachidicola and Cercosporidium personatum) and rust (Puccinia arachidis). Intensive programs have been started to search for resistance to these diseases, both in the cultivated and wild species of the genus, and to incorporate this resistance into high yielding and commercially accepted cultivars.

Programs are also being developed to breed for resistance to Aspergillus flavus, which produces a toxin metabolite that affects human health.

The germplasm is also being screened for sources of resistance to such commonly occurring fungi as Aspergillus niger, Fusarium sp., Pythium sp., and Rhizoctonia sp..

The major virus diseases being investigated presently are bud necrosis, caused by tomato spotted wilt virus (TSWV), and peanut mottled virus (PMV). The germplasm is being screened for resistance and other methods of control are also being investigated.

Although insect pests are often limited in their distribution, some are of worldwide distribution and importance. Among the later are species of aphids, jassids, thrips, and termites. Some of these species occur at ICRISAT and germplasm is being screened for sources of resistance.

### 2. Breeding for earliness, high yield, and for the farming systems.

High yielding ability over years is of major concern in the breeding program. Earliness is important to fit into relay or sequential cropping systems where moisture is available from the preceding crop, and for short growing seasons due to rainfall. Peanuts are commonly intercropped especially in India and Africa, therefore superior lines for intercropping are being sought.

### 3. Increasing biological nitrogen fixation.

The peanut is an efficient fixer of nitrogen and attempts are being made to manipulate both the Rhizobium and the host plant component of symbiosis to increase nitrogen fixation, and hence peanuts yields.

#### 4. Exploiting the wild species of Arachis.

A major component of the program is the utilization of genes from the wild Arachis species to improve the peanut crop. Resistance to fungal diseases, pests, viruses, and drought occur in these species but genetic manipulation is required to incorporate these characters into the cultivated peanut because of differences in ploidy levels and other barriers to interspecific hybridization.

#### 5. Exploiting physiological characters for peanut improvement.

This is the last of the programs to be staffed. The research program will be formulated in the very near future and a major part will be to study and exploit characters associated with drought resistance.

#### 6. Linkages.

Since ICRISAT is an international center, programs are linked with other international programs and with national programs in the SAT to provide germplasm and other research expertise. Research techniques and methodology are taught in training programs.

### IRHO

The Annual Oil Crops Department of IRHO which includes peanuts is directed by Dr. Pierre Gillier. IRHO works in the areas of applied agronomic research, preextension work, and seed multiplication. The latter two activities are essentially linked to applying research results. Presently, activities involve six countries: Senegal, Mali, Guinea Bissau, Upper Volta, Niger, and Chad.

Past or present activities pursued by IRHO, as part of a team undertaking with the host institutions are listed below.

#### 1. Physiology.

Since 1956, systematic work has been pursued on peanut drought resistance, its measurement, evaluation of sensitivity stages, and development of rapid tests enabling precise evaluation of the plants; reaction to water stress. This work has enabled plant breeders to develop drought tolerant varieties through proper selection of germplasm.

#### 2. Mineral Nutrition.

The first work done by IRHO on peanuts in 1948 dealt with the plants' mineral nutrition. Critical levels and response curves for several minerals, enabling the recommendation of more efficient fertilization practices.

### 3. Agricultural techniques and packaging.

Crop production practices (rotation, plant density, fertilizer application, harvesting, etc.), small equipment, and packing techniques for edible peanuts have been developed and adapted to local conditions.

### 4. Selection.

Varietal improvement through selection from a wide range of germplasm has been carried out at a number of locations. Drought and rosette resistance have been two of the major selection criteria. Other important considerations have been resistance to Aspergillus flavus, productivity, seed quality, and oil chemical composition.

### 5. Crop protection.

Control techniques for diseases and insects are being studied. Special efforts are being made to prevent, detect, and alleviate aflatoxin contamination.

### 6. Development and extension studies.

Research results are extended to the farmer through large scale demonstration tests. Seed multiplication and distribution has been a major effort.

## AGC

Research supported by the AGC (African Groundnut Council) in member countries has included breeding, agronomy, crop protection, and aflatoxin control. Locations are Bambey in Senegal, Gezira and Khashm El Girba Research Stations in Sudan, Institute for Agricultural Research in Samaru, Nigeria, the Centre National de Recherches Zootechniques in Mali, the Yundum and Sapu Research Stations in Gambia, and the Maradi Research Station in Niger. IRHO also has research and development activities at some of these locations. Research at these member countries is primarily carried out by the local institutions with support, encouragement, and coordination by the AGC.

## TPI

Since the discovery of aflatoxins in 1961, the TPI (Tropical Products Institute, near London) has developed methods for the analysis of mycotoxins, and carried out worldwide surveys of its incidence. Research and development work has also been carried out on most post-harvest aspects of the crop; e.g. shelling, oil expelling, oilcake usage and detoxification with much of the work done in collaboration with organizations in producing countries.

## II. SOCIOECONOMICS OF PEANUT PRODUCTION AND UTILIZATION

Gerald C. Wheelock

In the literature, peanuts' (*Arachis hypogaea*) role as a cash crop is found to completely dominate its role as a subsistent food crop. In spite of peanuts' importance to diets in many SAT countries, and the increasing emphasis on food self-sufficiency, studies of domestic peanut consumption in LDC's are practically nonexistent. In a review of Indian markets for four other semi-arid tropical food crops, Von Oppen et al. (1979) simply notes that market preference for peanuts has not been studied. In personal communication with Ejiga (1981), who has studied the utilization of cowpeas (1977) in Nigeria, the same research void was noted. He did estimate that peanut oil, roasted peanuts and other confections were income elastic but that other peanut products are probably not favored by higher income households. The literature's neglect of peanuts as a food crop is partly due to the fact that enough peanuts for traditional home consumption can be grown in a garden plot with traditional tools and inputs. Commercial peanut production, on the other hand, as a major source of vegetable oil and foreign exchange is favored by urban based research policy makers.

In the absence of peanut utilization studies, one can only observe aggregate production and export data available in general references and then induce an estimate of domestic consumption. Upper Volta of West Africa is one SAT country which grows peanuts everywhere but exports less than 10% of the crop. It may therefore provide a desirable case for the study of domestic consumption patterns of peanuts. Because of their lack of exports, data on Upper Volta's peanut production is not published in conventional sources such as the USDA's Agricultural Statistics - 1980. In the Atlas of Africa (Regine Van Chi-Bonnardel, 1973, Free Press), Upper Volta peanut production was estimated at 80 to 100 thousand metric tons. Assuming the lower estimate, six million persons in Upper Volta consume, feed to their animals, or lose to pests and waste an average of 13 kilograms per capita. In Senegal, where 900-1050 thousand metric tons were produced (Agricultural Statistics-1980, pp. 128) in 1978 and 1979, about 600 tons were produced for export. Thus, Senegal's 1978 estimated 5.8 million population had more than 50 kilograms per capita available for domestic consumption.

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For several hours of discussion and encouragement, the author is indebted to Virginia Caples, Home Economist; Hezekiah Jones, Ag. Economist; and S. K. Reddy, Rural Sociologist. They have contributed literature references and reviewed earlier drafts of the SOTA documents. Cheryl Davis very diligently processed the several drafts of this and the three Food Science sections of the SOTA.

About 10 kilograms per capita are available for domestic consumption in India, the world's largest producer of peanuts. In a country where oil and fat consumption averages less than five kilograms per capita, peanuts are perhaps the single most important oil food.

These estimates of peanut consumption in SAT countries with marginal nutritional adequacy compare with an average of about seven kilograms per capita in the United States. Considering the dramatically greater range of food choice available in the U. S., it would appear that the rough estimates of LDC peanut consumption are reasonable ones. The Senegal estimate of 50 kilograms per capita are perhaps not high in a country which enjoys a climate and soil uniquely suited to peanuts. Supportative of this estimate, J. Y. Weigel (1978) has reported an estimate of monthly expenditures for families in the Senegal River Valley. In a relatively poor crop year (1977-78), over 7% of all expenditure was spent on cooking oil (probably peanut oil) and about 6% was spent on peanuts. The expenditure on peanuts exclusive of vegetable oil represents about one U. S. dollar per month per person. At the government market price this would represent more than 10 kilograms of peanuts, in times of food shortages it may represent no more than three or four kilograms per capita. At this rate one person would consume over 35 kilograms of peanuts plus about that many more in the form of peanut cooking oil. This sketchy data suggests that the potential for increased consumption of peanuts by SAT populations is considerable.

If the potential for increased peanut production and consumption by SAT populations is significant, there are several questions that should be researched regarding the impacts on human populations.

For many SAT populations, peanuts provide the major source of vegetable oil. Is this demand being adequately met? If not, is there a critical need to research new products? If it is, is the export market an elastic market that could absorb both additional peanut oil and cake without depressing prices. If the export market is viable, does it make more sense to increase specialization in peanut production and trade for needed food commodities or try to produce the other food commodities domestically? If the decision is to substitute for imports, development of a wide range of peanut products that meet consumer cost and preference standards may be needed. Alternately, other SAT food grains and pulses may be more cost effective in meeting protein and carbohydrate needs of the poor majority (e.g. see Ryan and Asokan, 1977). Are there metabolic reasons that peanuts should remain primarily an oil food? Tolman et al. (1981) observed that fats from peanut oil are more readily absorbed than from whole peanuts or peanut butter. Also aflatoxins are not a problem in peanut oil but they may be a significant health problem in peanut and peanut meal products.

For the consumer, research must show new peanut products to be both comparatively inexpensive and healthful. For the producer, research must be demonstrated that incremental peanut yields and new food products will be profitable and competitive. Positive results of pre-investment (ex ante) research must be readily apparent to the small farmer through on-farm and market-place demonstrations before the agronomist, food scientists, and social scientists have completed their job. If, through ex ante research, multidisciplinary teams see these economic tendencies to be present and socially desirable, it behooves them to do their part to enhance those tendencies through applied research. Some of the ways in which socioeconomic research may enhance the effort to bring agricultural research to fruition are reflected in the literature.

To the extent its disease resistance and drought tolerance can be enhanced in other SAT countries, the peanut promises to be a comparatively more efficient and preferred domestic source of oil and protein. Some of the ways in which socioeconomic research may enhance the effort to bring this promise to fruition are reflected in the literature.

#### Literature Overview

The socioeconomic literature as it relates to production and utilization of peanuts is very sparse. Most of the literature relates to peanut production and marketing as a cash crop, its first order effect. The first major work outside the French literature (Franke and Chasin, 1980) to address explicitly the ecology, food and development issues in Sudano-Sahelian West Africa dwells heavily upon the second order impacts of expanded peanut production. Feedback of second-order effects upon production has also been researched. Colvin et al. (1981) examine cash crop (peanuts) induced migration patterns in West Africa and how they, in turn, impact agricultural productivity, positively and negatively. Left alone, studies of either first order or second order effects lack balance. Farming systems research placed in a macro-regional context could serve to temper the radical conclusion of this and other works regarding wholesale "ecological degradation" of the Sahel while enhancing both productivity and quality-of-life. Domestic market and consumption research methods could also have impact on the local utility of the major SAT oil crop.

#### Comparative Advantage in Peanut Production:

While much of SAT Africa and Asia appears to be well suited to peanut production, i.e. they have a comparative advantage, new technologies and world markets may alter the situation. Methodologies to study comparative advantage of producing selected crops are available (e.g., Pearson, et al. 1976 and Jabara and Thompson, 1980). Implications for government policies and international trade may be drawn from such studies, and to the extent production inputs are to be imported such studies become critical.

As population pressures grow on SAT lands and as energy prices rise, ex ante rather than ex post facto evaluation of new peanut varieties and their associate technologies is increasingly critical. The ICRISAT Economics program is bringing focus to the (ex ante) decision-making process involved in allocating research resources to SAT agricultural needs (Walker, 1981). Peanut CRSP activities should relate to their efforts.

#### ICRISAT Economic Studies:

The International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) Economics Program has been engaged in Village Level Agricultural studies in India since 1975 (Jodha et al., 1977) More recently in West Africa, two ICRISAT economists, Dr. P. Matlon and J. McIntyre, and an anthropologist, Dr. Helga Veirich, are initiating long-term village level studies in the millet/peanut zone of Upper Volta and Niger (Peter Matlon, 1980).

Two published proceedings of ICRISAT conferences are particularly relevant to cropping systems including peanuts. Proceedings of the International Workshop on Socioeconomic Constraints to Development of SAT Agriculture (Ryan and Thompson, 1979) covered issues on the socioeconomics of 1) existing farming systems; 2) prospective technologies for SAT regions and 3) their field assessment; 4) food grain marketing; 5) improved animal drawn mechanization; 6) literature on SAT of West Africa; 7) risk; and 8) rural labor markets. A major objective of this socioeconomic workshop was to enhance the relevance of biological science research work.

The proceedings on the International symposium, Development and Transfer of Technology for Rainfed Agriculture and the SAT Farmer (Kumble, 1979) highlights the mission of ICRISAT; research for development of agriculture's technology and its transfer in the SAT; and SAT experiences and linkages in research, development and technology transfer. These two proceedings are referred to below in brief overviews of the literature on farming and marketing systems as they relate to the socioeconomics of peanut production and utilization.

#### Farming Systems and Peanut Production:

Farming Systems Research (FSR) has gained attention in recent years as an important ex ante tool to link farmers and researchers (Norman, 1980; Hobgood, et al., 1980). It is contended that this partnership is needed because much of the "top down" research in experiment stations has not given sufficient attention to the relevance of a technology in terms of the goals and resources of small farmers (Norman, 1980). While small holders are producing the majority of Third World nations' food crops, their traditional farming practices have been little affected by improvements in agricultural technology. Strategies to benefit small holder farmers should also mean more work opportunities for growing members of underemployed rural poor (Hobgood et al., 1980).

FSR may be a particularly important tool to enhance the relevance of research on peanut production and utilization in the semi-arid tropics. On the face of it, peanuts as a cash-food crop should blend well into drought tolerant food production systems and adaptive strategies. When prices are right, more peanuts can be grown for sale--allowing the purchase of food requirements--or when peanuts are in less demand, they fit well into nutritious subsistent food production systems. In either instance, intercropping peanuts with corn, sorghum or millet, and thus economizing on labor and water has often served the small-holder well.

Studies of mixed cropping under indigenous conditions in northern Nigeria found average gross returns per acre to be about 62% higher than mono-cropping (Norman, 1975). Analysis of mixed cropping systems indicated that they reflect a risk aversion strategy to minimize income variability as well. Peanuts, more than sorghum, millet, or cowpeas, however, reached optimum output as a mono-crop.

One investigation of subsistent food production strategies indicate that a land constraint of three acres or less makes meeting protein and calorie requirements infeasible. Instead these small-holders tended to grow peanuts as a cash crop and then buy their food. Otherwise, peanuts were not found to be part of an optimum solution unless a farmer had at least 10 acres for food production (Abalu and D'Silva, 1979). For the nuclear family, two to three acres of peanuts would be sufficient for traditional consumption levels, while six or seven acres would fully extend traditional hand labor.

#### Labor Constraints:

Labor, and its division by sex mechanization and energy issues pose an interrelated set of constraints to peanut production and utilization in SAT regions. From land preparation until peanuts are shelled and marketed, traditional hand labor requirements are about 2000 hours per hectare. Assuming a maximum of about 4000 hours of labor inputs by a nuclear family with two older children (Byerlee, 1979), three hectares of food grains, vegetables and cash crops (peanuts) would fully extend the labor force. Mechanization appropriately applied to operations where labor constraints are most severe, would enhance per capita and total productivity if not yields. First, the seasonality of peak labor demands vary widely. Timing of production operations is particularly critical in the shorter 90 to 100 day rainy season regions of SAT Africa. Moisture is rapidly lost from hot sandy soils, and planting of peanuts must be accomplished within 24-48 hours of the first significant rain. Also, weeding must be timely and complete to conserve all available moisture. Finally, lifting of the peanut must take place when the majority of the peanuts are

mature but before their pegs soften and break, leaving the peanuts in the soil. When rainy seasons are 120 days or longer there is more flexibility to rotate these operations among other crops, larger acreages or even off-farm jobs. Consequently, mechanization benefits and priorities will differ.

Division of labor by sex and a greater flexibility in the male role to allocate their labor depending on rates-of-return hold a different set of implications for the assessment of mechanization impacts. To the extent that women are charged first with the responsibility of feeding and raising the children while men grow cash crops, conduct other business, or sell their labor, men are more financially able to invest in mechanization of cash crop production. Accordingly, mechanization has tended to focus on the tasks traditionally performed by men (land clearing, preparation and planting) rather than those tasks traditionally done by women (weeding, food preparation, and drawing of water for the household). Consequently, the burden on women has grown and may continue to grow substantially. Alternately, if focused on weeding and the use of herbicides, cottage industries to make peanut products for the market and water pumps and wheel barrows to facilitate household chores and food processing, mechanization could increase the marginal product of women's labor in SAT regions as well (Lele, 1975; Fisher, 1979).

Research to date has provided much of the basic data needed to understand labor constraints by sex, season, peak demand over a wide range of labor market situations. Because of the variation, Byerlee (1979) emphasizes that the design of agricultural research programs must take account of the local labor situation. While the "cost route" studies that he reviews are useful in obtaining detailed daily labor allocations, they are too expensive for wide replication. Byerlee suggests that it may be more practical to take focused one-contact surveys based on prior familiarization with farming systems in the area.

Regarding research on mechanization per se, H. P. Binswanger, et al. (1979), M. LeMaigne (1979) and Johnson (1979) review the economics of tractors and animal drawn mechanization in India, West Africa and East Africa, respectively. Three issues are dominant: mechanization research has been inconsistent with both government goals and real needs of farmer communities; appropriate interdisciplinary methodologies for designing technologies that bridge the gap between the objectives of research stations and farmer needs or government goals; and structures and incentives to change the research station based approach to a farming community based approach and from an ex post to an ex ante methodology.

The mismatch between research and needs appear to center on a lack of attention to major labor constraint operations such as weeding, particularly in the dominant intercrop farming system. Johnson (1979) cites the FAO/UNDP Agricultural Improvement Project in Kenya as one of the most serious efforts to conduct equipment trials under semi-arid farm conditions. Particular attention is paid to "suitability for local manufacture".

#### Culture and Farm Household Decisions:

Beyond micro-economic concerns, Barlett (1980) reviews 198 anthropological studies of peasant agricultural production. She finds that the vast majority of these studies have focused inquiry and conclusions at the cultural level, foregoing the opportunity to relate cultural and individual determinates to choices at the household level. While the range of individual household behavior may have been very narrow in traditional cultures, modernizing environments allow for more variation and experimentation in decision making. Not only would the inclusion of the FSR approach guard against the danger of explaining household or farm level decisions on the basis of impressions and intuitions gained at the cultural level, but she expects that an anthropologist would be better equipped to diagnose constraints and predict production and consumption behavior in a modernizing cultural environment.

Technical efficiency of small farmers, and the influence of education, has been the subject of 18 studies reviewed by Lockheed, Jamison and Lau (1980). By regressing across studies, they found farm production to increase an average of 7.4% as a result of a farmer completing four years of elementary education rather than none. A modernizing environment improved the effect, reinforcing the importance of adapting anthropological methods to study household level variation. One study found non-formal education (extension) to substitute elementary education, but not to supplement it (Moock, 1981). Again, this finding suggests that the traditional, less educated society may be approached from a generalized cultural perspective with a focused set of extension recommendations, while the modernizing influence of formal education sensitizes the farmer to a range of alternatives from which he must choose to fit his farm conditions. For the literate farmer, the non-formal extension program is only one alternate source of information, and often it is less specialized source than he thinks is needed to deal effectively with his set of production constraints.

Consistent with this emerging view is the work of Doherty and Miranda (1980) at ICRISAT on social organization and small watershed development. Their work suggests that if extension activities can be integrated into and legitimized by the decision-based activity of "centrally managed" traditional communities, rule-based activities such as a set of scientifically and economically sound agricultural practices could be implemented on a community wide basis. As communities modernize and more

educated individuals find access to a range of information, decision based activity may become more individualized and agricultural practices less subject to a generalized set of recommendations or cultural rules. This will be particularly true in heterogeneous agricultural regions. If extension services grow with their clientele, however, they can still accommodate and utilize existing social organizational processes to promote agricultural development.

#### Marketing and Peanut Utilization:

Little if any research attention has been devoted to domestic peanut markets and consumption. Of 189 dissertations from 1969 to 1979 identified as dealing with "food and agricultural marketing in developing countries" (58 African, 63 Asian, 62 Latin American, and 6 general), only seven, as indicated in the titles and abstracts, deal with peanut marketing (Riley, and Weber, 1979).

Four of these investigate state interests and actions in peanut markets of Nigeria and Niger (Collins, 1974; Idachaba, 1972; Ihimodu, 1977; and Osayimwese, 1971). With little or no state involvement, Thailand oil seed markets were found to converge on Bangkok (Pollok, 1974). The world market (Jellema, 1972) and India's position in the world market (Mehta, 1970) are subjects of two other dissertations. All seven of these studies portray the dominance of export objectives, but only one dissertation was completed since 1974. The role of peanuts in LDC food self-sufficiency programs and import substitution policies of recent years does not receive attention in the dissertation literature.

There are, however, several recent studies that do analyze the role of single commodities or groups of commodities in the self-sufficiency effort. They provide a diversity of models which should be useful in assessing peanut utilization. Two recent dissertations on sub-Saharan Africa provide broad based economic analyses of domestic cowpeas (Ejiga, 1977) and food grain (Wilcock, 1977) marketing and consumption impacts. Five other studies focus on animal protein markets and their socioeconomic impacts (Billings, 1971; Obot, 1977; Okrah, 1975; Ruigu, 1978; and Thiuri, 1974). Other studies include all food commodities. They use data ranging from household budget surveys (Acquah, 1977), to anthropological field studies (Tripp, 1978), to macromarketing studies of food systems linked to anthropometric and infant nutritional status measures (Dahinger, 1978). In contrast with the peanut market studies all but one of these LDC domestic food marketing system studies are dated 1974 or later.

Zalla (1979) also provides a methodological model to initiate such an inquiry. With both historic and contemporary data on food consumption in Kilimanjaro District of Tanzania, this paper investigates the possibility of a conflict between cash income and nutrition objectives in peasant societies. Data were collected from a single 24 hours recall interview of 480 randomly selected families. Calorie and protein adequacy ratios were useful guidelines for future research predicting nutritional adequacy.

Regarding the potential contribution of improved systems for peanut production to consumption patterns and rural development generally, international development agencies are just beginning to recognize the gap in the literature. In Senegal for example, promising initial efforts have been sponsored. One multidisciplinary effort focuses on policy implications of rural migrants quest for cash, principally through peanut production (Colvin et al., 1981). Also the detrimental effects in a too rapidly expanding government bureaucracy upon peanut production and rural quality of life is chronicled by Carvin (1981).

Peanuts, in sum, have not been studied as an LDC food commodity, but suitable methods of demonstrated utility are available. Most of the studies cited in this review lend themselves to an applied research setting such as an LDC College of Agriculture or Agricultural Research Corporation. To be of greatest benefit to the LDC economy under study, it seems appropriate that applied research questions be addressed within applied multidisciplinary programs of appropriate LDC research institutions. This is the aim of the proposed Peanut Collaborative Research Support Program.

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Acquah, Benjamin Kojo. 1977. "An Analysis of the Demand for Food Commodities in the Eastern Region of Ghana." University of Wisconsin at Madison. DAI 38/10:5607-A, Order #7723696.

Main objective is to estimate expenditure elasticities of demand for food commodities in rural and urban households. Also considers non-food commodities, effects of household size, composition and geographical location on consumption, existence of economies of scale in on cross-sectional data from 1967/68 Eastern Region Household Budget Survey conducted by Institute of Statistical, Social and Economic Research, University of Ghana.

Amegashie, Austin Kwaku. 1978. "Liberian Agricultural Programs: The Theory and Practice of Marketing and Food Distribution System." University of Florida. DAI 39/07: 4493-A, Order # 790031.

Failure to develop an adequate domestic food production system and discussed with attention to historical, socioeconomic and cultural factors. Studies three regional marketing centers--Monrovia, Gbarnga and Voinjama--in some detail for direction of crop flows, their effects on crop production, labor migration, transportation networks and other elements. Stresses vital role of women in marketing, linking urban consumer population and rural food-producing regions.

Bartlett, Peggy F. 1980. "Adoptive Strategies in Peasant Agricultural Production." Annual review of Anthropology 9:545-73.

This anthropological review cites 198 peasant agricultural production articles. The emphasis is toward an improved methodology that would relate patterns of household choice or strategies to patterns of variation in determinant variables. Anthropological methods have focused on descriptions of both the presumed determinants and the choices on a cultural level, but have forgone the opportunity to relate determinates to choices at the household level, thus moving away from possible distortions of impressions and intuition. The discipline should then be better equipped to aid in diagnosing constraints and predict outcomes in modernizing environments.

Billings, Martin Hewett. 1971. "Economics of Commercial Egg Production in Eastern Nigeria." Michigan State University. DAI 32/03: 1147-A, Order # 71-32,162.

Describes and analyzes problems of commercial egg operations in the region. Research included 6-month study of 21 farms and consumer survey in 4 cities. The causes of problems are limitations in the market for eggs, shortages of chicks and feed, common use of dual purpose birds, and mainly, poor management. Suggestions for improvements are made, recognizing the potential importance of eggs for urban consumers.

Binswanger, H. P., R. D. Ghodake and G. E. Thierstein 1979. "Observations on the Economics of tractors, bullocks, and wheeled tool carriers in the semi-arid tropics of India." pp. 199-212; In J. G. Ryan, ed., Socioeconomic Constraints to Development of Semi-Arid Tropical Agriculture. 19-23 February, 1979. Hyderabad, India.

Byerlee, Derek, 1979. Rural labor markets in West Africa with emphasis on the semi-arid tropics. In J. G. Ryan, ed., Proceedings of the International Workshop on Socioeconomic Constraints to Development of Semi-Arid Tropical Agriculture. 19-23 February, 1979. Hyderabad, India. ICRISAT.

Carvin, Joe. 1981. Senegal's cooperative movement: Seventy years of movement without the cooperatives. Dakar, Senegal (unpublished manuscript through AID).

Documents the history of peanut cooperatives and subordination of their goals and objectives to national goals, government bureaucracy and foreign exchange earnings. Suggests how agricultural productivity could be revived through cooperatives if they were to concentrate on development of client participation.

Chodak, Simon 1972. "Brotherhood or otherhood? Some aspects of societal change in modernizing rural Africa." Sociologia Rualis XII:3/4: 302-314.

In modern Africa tribal brotherhoods remain intact, though battered both from inside and outside by the forces of otherhood. The contradiction of these two forces are discussed in terms of kinship relations, the local market place, the nation and universal African brotherhood.

Collins, John Davison. 1974. "Government and Groundnut Marketing in Rural Hausa Niger: The 1930s to the 1970s in Magaria." Johns Hopkins University, 1974. DAI 39/08:7973-A, Order # 75-12,942.

Continuous state interest and action in the local groundnut markets since the 1930s provides a context for assessing the cumulative impact of state intervention of the local socioeconomic system. Analyzes important developments in the precooperative period, partial nationalization in the early 1960s, and cooperative reform after 1965.

Colvin, Lucie Gallistel, Cheikh Ba, Boubacar Barry, Jacques Faye, Alice Hamer, Moussa Soumah and Fatou Sow. 1981. The Uprooted of the Western Sahel: Migrants' Quest for Cash in the Senegambia. Praeger: New York. pp. 385.

Historical background, country studies and policy implications of migration patterns for Senegambia - Senegal, Mali, Mauritania, and the Gambia. In addition to the trend of rapid urbanization, the migratory trends of farmers from hinterland areas to the frontiers of cash-crop zones, migrant labor to cash-crop zones, and sedentarization of nomadic herders are studied.

Dahringer, Lee Douglas. 1978. "Strategies for Food System Enhancement in Lesotho Through New Developments in the Market Process Concept." University of Colorado at Boulder. DAI 39/08: 5111-A, Order # 7903034

Prior macro-marketing studies of food systems are used to examine the food marketing system, developing new linkages with performance measures, including anthropometric child assessment and infant nutritional status. Applicability of market process theories is explored. Examines problems of potential programs dealing with food output and distribution.

Doherty, Victor S. and Senen M. Miranda. 1981. Personal Communication. ICRISAT, Patancheru P. O., Andhra Pradesh, 502324, India.

Ejiga, Nathaniel O. 1981. Personal Communication. Department of Agricultural Economics, Ahmadu Bello University, Zaria, Nigeria.

Ejiga, Nathaniel Omatai Okliko. 1977. "Economic Analysis of Storage, Distribution and Consumption of Cow Peas in Northern Nigeria." Cornell University. DAI 38/12: 7459-A, Order # 7807746.

Studies the two main ecological zones of Northern Nigeria. Administered questionnaires to farmers and traders in rural areas and to households and traders in urban areas. Gives detailed description of cowpea distribution system, found to be quite organized. Calculates bi-variable correlation coefficients of prices to indicate level of market integration. Analyzes relationships between transport costs and price differences and between average seasonal price rises and storage costs. Estimates gross marketing margins. Analyzes consumption in terms of food habits, regional preferences and income.

Fisher, John J. 1978. Summary Report on the Conference on Women and Food.

Consortium for International Development (CID), Executive Office, Utah State University, UMC 35, Logan, Utah 84322, USA.

Presents issues and recommendations discussed at a three-day conference on the role of women in meeting basic food needs in developing countries. Includes proposals for enhancing women's participation in projects and suggestions about ways in which private and international agencies can redesign technical assistance programs to better achieve this goal. 32pp.

Franke, R. and B. Chasin. 1980. Seeds of Famine: Ecological Destruction and the Development Dilemma in the West African Sahel. Allanheld, Osmun/University Books: Montclair/New York. 266pp.

With the exception of the French literature, this is the first major work to address ecology food and development issues in Sudano-Sahelian West Africa. The first part examines the relationship between food, ecology, and underdevelopment in the Sahel from a historical perspective "to explain how and why this major famine took place (and) why major ecological destruction occurred". The second part examines the linkage of the Sahel with the global economy through French-USA competition in development assistance and multinational corporations in agricultural development.

Gilbert, E. H., D. W. Norman and F. E. Winch. 1980. Farming Systems Research: A Critical Appraisal. MSU Rural Development Paper No. 6. Department of Agricultural Economics, Michigan State University, East Lansing, Michigan.

Idachaba, Francis Sulemanu. 1972. "Marketing Board Taxation of Nigerian Agriculture Some Implications". Michigan State University. DAI 33/11: 5931-A, Order #73-12,741.

Provides a framework for analysis of the effects of taxes on marketing board crops and of subsidies on input use. Develops model for period 1930-66. Examines quantitative impact on tax revenue from cotton and groundnuts if farmers had been paid higher prices than those actually received. The ordinary least squares method is used to estimate sales supply equations. Discusses the problem of relying on revenue contributions from these boards to stabilize state government revenues, using evidence from the Northern States Marketing Board.

Ihimodu, Isaih Ifeyori. 1977. "The Impact of Government Taxation and Control of Marketing of Five Major Agricultural Exports of Nigeria." University of Pennsylvania. DAI 38/03: 1545-A, Order # 77-19,864.

Study of effects of government marketing monopoly on price responsiveness of producers, prices and incomes, and government revenues for the major agricultural exports: groundnuts, cotton, palm oil, palm kernels and cocoa. Comparisons to other major producing and exporting countries reveal a significantly negative relation between performance indices and the "degree of control". Results of analysis suggest domestic stabilization scheme itself might have introduced instability into the system.

Jabara, C. L. and R. L. Thompson. 1980. An Agricultural Sector Model for Senegal. Station Bulletin No. 278. Dept. of Ag. Econ. Purdue University: West Lafayette, Indiana.

Jellema, Bouwo Marcus. 1972. "Analysis of the World Market for Groundnuts and Groundnut Products". North Carolina State University at Raleigh. DAI 33/12: 6551-A, Order # 73-13,100.

Treats groundnuts, groundnut oil, and groundnut meal independently in a market simulation model. Uses average export and import data for years 1966 to 1968 combined with transportation and storage costs to identify the seasonal pattern of commodity flows and most profitable markets for each exporter. Considers effects of various tariff policies and analysis of income transfers involved.

Jodha, N. S., M. Asokan, J. G. Ryan. 1977. Village Study Methodology and Resource Endowments of the Selected Villages in ICRISAT's Village Level Studies. Occasional Paper 16. ICRISAT: India.

Johnson, Bruce R. 1979. "Socioeconomic aspects of improved animal drawn implements and mechanization in semi-arid East Africa." pp. 221-233. In J. G. Ryan, ed., Proceedings of the International Workshop on Socioeconomic Constraints to Development of Semi-Arid Tropical Agriculture. 19-23 February, 1979. Hyderabad, India. ICRISAT.

Johnson, Eleanor Jean. 1973. "Marketwomen and Capitalist Adaptation: A Case Study in Rural Benin, Nigeria". Michigan State University. DAI 34/12: 5794-B, Order # 74-13,915.

Investigates trading activities of marketplace traders and analyzes process in which petty traders evolve into capitalist traders. Based on participant observation, survey questionnaires to large samples and intensive work with small samples in and around the Nigerian Institute for Oil Palm Research, 20 miles north of Benin City. Conceptualizes adaptive process and raises hypothesis concerning the roles of female traders and emerging capitalist modes.

Kumble, Vrinda. 1979. Development and Transfer of Technology for Rainfed Agriculture and the SAT Farmer. Proceedings of the International Symposium. ICRISAT Center, Patancheru, India, 28 August - 1 September, 1979. Vrinda Kumble, Editor. 324 pp.

This symposium in eight sessions highlighted the mission of ICRISAT; researches for development of agriculture's technology and its transfer in the SAT; and SAT experiences and linkages in research, development and technology transfer.

Lele, Uma, 1975. The Design of Rural Development: Lessons from Africa. John Hopkins University Press Baltimore. pp. 276.

Based on the results of a major study of rural development policies and programs in sub-Saharan Africa, the author makes recommendations concerning the design and operation of future development projects to raise the productivity of the rural poor. Throughout the book, she emphasizes the need for an overall policy and an institutional framework conducive to the objectives of rural development. Lele also notes that one of the reasons associated with the failure of many programs is the tendency for agricultural extension services to neglect the key role women play as contributors to the farm labor supply and as generators of family income. Project reviews on agricultural credit, marketing, and training in seven nations provide useful insights for those interested in helping small groups generate income in rural areas. 246 pp.

Lockheed, Marlaine, Dean T. Jamison and Lawrence J. Lau, 1980. "Farmer Education and Farm Efficiency: A Survey". Economic Development and Cultural Change, 29-1:37-76.

This paper surveys the findings of 18 studies conducted in low income countries concerning the extent to which the education level of small farmers affects their production efficiency. Positive and usually significant results were shown in 31 of 37 sets of farm data. By inspection and regression across studies, farm production was estimated to increase on the average by 7.4% as a result of a farmer's completing 4 additional years of elementary education rather than none. A modernizing environment improved the effect. One study found non-formal education (extension) to substitute for elementary education but not supplement it.

Matlon, Peter J. 1980. "Profile of Farm Units in Two Villages of Central Upper Volta". Progress Report West African Economics Program 1. ICRISAT, Ouagadougua, Upper Volta.

Mehta, Vasantkumar Mansukhlal. 1970. "India's Position in the World Peanut and Peanut Oil Markets." North Carolina State University at Raleigh.

Quantitative analysis of recent changes in trade patterns for peanuts and peanut oil among the main producing and consuming countries. Flows are studied for 1955, when Indian exports were at record level, and 1965 when they were small. Long-run projections are made for 1975. Data from UN, Government of India, various US government agencies, and Commonwealth Economic Committee. Conclusions about India's export potential incomplete due to author's death.

Moock, Peter R. 1981. "Education and Technical Efficiency in Small Farm Production." Economic Development and Cultural Change.

Focus on a single aspect of production efficiency: the effect of education on the utilization of inputs, input levels held constant. This study of a sample of 101 male farm managers on farms of 1 to 20 acres finds farmers with four or more years of education to obtain higher yields than unschooled farmers. However, the difference declines with increased exposure to extension. Extension appears to substitute for formal education but not supplement it.

Norman, David W. 1980. The Farming Systems Approach: Relevancy for the Small Farmer. MSU Rural Development Paper No. 5. Department of Agricultural Economics, Michigan State University. East Lansing, Michigan.

Norman, David W. 1975. Rationalizing mixed cropping under indigenous conditions: the example of northern Nigeria. *Journal of Development Studies*, 11:1.

Obot, Johnson Udo. 1977. "Movement and the Removal of Nutritional Deficiencies: The Case of Beef in Nigeria". University of Oklahoma. DAI 38/04: 2344-A, Order # 77-21,391.

Discusses the problems of shipping and distributing high protein foodstuffs from production areas to deficit areas. The shipment of live cattle from the Tsetse free northern Sahel zone of Nigeria to the south is investigated. Recommends that the government initially subsidize and supervise cattle transportation and distribution and then allow private enterprise to take over. Taxation of hoarded herds, food science education, and wider use of refrigerated meat are also favored.

Okrah, Alexander Magotey. 1975. "An Institutional Case Study of the Commercial Fishing Industry of Ghana:." University of North Carolina at Chapel Hill. DAI 35/10:6813-A, Order #76-9277.

Investigation of the role of physical distribution and marketing in economic development. Primary data based on 761 interviews conducted in 30 towns. Fish consumption patterns analyzed by income and region. Physical distribution system is found inefficient due to poor transportation, inventory fluctuations, very long distribution channels, inadequate storage, and other difficulties.

Osayimwese, Ghatekha Izevbuwa. 1971. "A Transportation-Distribution Problem: An Application to the Groundnut Industry in Nigeria." Northwestern University. DAI 32/09: 4793-A, Order # 72-7831.

Discusses the problems of transporting an important export crop. Transportation from the hinterland to ports is the largest single marketing expense. Linear programming is used to minimize transport expenses and thereby maximize net financial surplus. Model considers disaggregation of supply regions.

Pearson, Scott R., ed. 1976. "Comparative advantages in rice production." Food Research Studies XV: 2:131-282: Food Research Institute Stanford University, Stanford, California.

Presents methodology for determining comparative advantage, net social profitability and the domestic resource cost of foreign exchange earned or saved. While the methodology could be adopted to peanut production, rice is the example presented. Four countries, Thailand, Taiwan, Philippines and USA, studied by four separate investigators. Their results are compared and implications for government policies and international trade are drawn.

Pollak, Peter Karl. 1974. "Economic Analysis of Oilseed Markets in Thailand." University of Minnesota. DAI 35/12: 7499-A, Order # 75-12,142.

Considers the four major oilseed crops: soybeans, peanuts, sesame and castor beans. Statistically analyzes supply response. Discusses marketing patterns: at farm level, heavily influenced by farmers' relationship to landlords, merchants and money lenders; at local markets; at the Bangkok wholesale market which receives most of the harvest. Uses market surveys in analysis of prices. Finds markets to be competitive in general.

Riley, Harold M. and Michael T. Weber. 1979. "Marketing in developing countries". MSU Rural Development Series. Working Paper No. 6. Department of Agricultural Economics, Michigan State University. East Lansing, Michigan.

This chapter emphasizes market incentives and constraints whether they come from rural or urban demand sources, as they key to agricultural development. The conceptual model outlines potential points of public sector intervention in regional or national food system processes, possibly acting to bring about desired changes, and expected effects on economic growth and development. Proposed diagnostic research is aimed at identifying current market efficiencies as well as needed structural transformation which may be unprofitable or unavailable to individual market participants, but if adopted by all participants, could yield substantial system improvement. Organization approaches to the recommended research agenda are discussed.

Riley, Peter, and Michael T. Weber. 1979. "Food and agricultural marketing in developing countries: An annotated bibliography of doctoral research in the Social Science, 1969-1979." MSU Rural Development Series, Working Paper No. 6, Department of Agricultural Economics. Michigan State University, East Lansing, Michigan.

This annotated bibliography of 198 dissertations (58 African, 63 Asian, 62 Latin American, 6 general) highlights a current major concern to discuss how changes in marketing institutions can improve the economic and social conditions of small farmers, while meeting the larger goal of holding down food prices for other low income consumers. This paper brings together diverse approaches to market problem solving.

As indicated in the titles and abstracts, only seven dissertations deal with peanut marketing. Four of these investigate state interest actions in groundnut markets of Nigeria and Niger. With little or no state involvement, Thailand oil seed markets were found to converge on Bangkok. The world market and India's position in the world market are subjects of two other dissertations. All seven of these studies portray the dominance of export objectives. Only one dissertation was completed since 1974. The role of peanuts in LDC food self-sufficiency programs and import substitution policies of recent years does not receive attention in the dissertation literature.

Ruigu, George Munice. 1978. "An Economic Analysis of the Kenya Milk Subsystem". Michigan State University.  
DAI 39/10: 6521-A, Order # 7907392

The study analyzes supply and demand, making future projections, determines income and price elasticities, determines optional pricing policies based on results of supply and demand projections, and determines export levels of milk products assessing future export abilities. Data sources include various government agency cooperatives, the Kenya Dairy Board, publications and personal interviews. Descriptive, regression and parametric linear programming methods are employed.

Ryan, J. G. and M. Asokan. 1977. Effect of Green Revolution in wheat on production of pulses nutrients in India. Occasional Paper 18, ICRISAT Economics Program. Hyderabad, India.  
(Reprinted from Indian Journal of Agricultural Economics. 32:3. 1977).

Using data on six major wheat-growing states of India, it was clear that the net nutritional impact of the new HYV's of wheat was both positive and substantial. This was found to be true in spite of the fact that 22 % of the expansion in wheat hectareage was at the expense of pulses and 8% at the expense of winter wheat and rye. For the rainfed SAT areas, however, substantial increases in yield of coarse grains and pulses are required if the nutritionally most vulnerable groups are to be made better off.

Ryan, J. G. and H. L. Thompson, eds. 1979. Socioeconomic Constraints to Development of Semi-Arid Tropical Agriculture: Proceedings of an International Workshop, Hyderabad, India, 19-23 February. 434 pp.

Sessions covered issues on socioeconomics of 1) existing farming systems; 2) prospective technologies for SAT regions and 3) their field assessment; 4) food grain marketing; 5) improved animal drawn mechanization; 6) literature on SAT of West Africa, 7) risk; and 8) rural labor markets. A major objective of this socioeconomic workshop was to enhance the relevance of biological science research work.

Thiuri, Philip John. 1974. "The Dairy Industry in Spatial Perspective With a Focus on Recommendations for Development in Kenya as Drawn From the New York State Case". Syracuse University. DAI 36/10: 6962-A, Order #76-7945.

Spatial structure and interaction patterns of a dairy industry are discussed and modeled. Examines the structure and behavior of producers, processing plants, distributors and consumers for the New York State and Kenya dairy industries. Considers policies and aspatial features. Finds the processing plant to be the central element of the dairy industry. Technology transfer and short-run planning guidelines are also discussed.

Tolman, R. R., J. D. Miller, A. S. Levine, and S. E. Silvis. 1981. Absorption of peanuts: Correspondence. New England Journal of Medicine. 304:359. February 5, 1981.

Tripp, Robert Burnet. 1978. "Economic Strategies and Nutritional Status in compound Farming Settlement of Northern Ghana". Columbia University. DAI 39/08: 5020-A, Order #7904132.

Examination of the economic organization of a Nankane-speaking settlement in the Upper Region, focusing on agricultural practices but also covering trading activities and labor migration. Based on 20 months of anthropological research in the field. The most successful traders deal in export of animals, poultry and eggs to southern Ghana or import of kola nuts or manufactured items from the south. Notes strong relationship between women who are active in trade and nutritional well-being of their children.

Von Oppen, M., V. T. Raju, and S. L. Bapna. 1979. Food grain marketing and agricultural development in J. G. Ryan, ed., Socioeconomic Constraints to Development of Semi-Arid Tropical Agriculture. ICRISAT, Hyderabad.

Walker, Tom. 1981. Personal Communication and Peanut CRSP site visits to ICRISAT. February 1981. Hyderabad, India.

Weigel, J. Y. 1978. Economies Rurales et Migrations dans la Region de Yaounde (Vallee de Senegal). Dakar, Senegal: ORSTOM.

Monthly expenditure data for 1977 to 1978, a relatively poor crop year, find that over 70 percent of per person expenditures (3110 CFA or \$15.00 per month) were spent for food. Of the 2235 CFA spent on food 10.2 percent was reportedly spent on cooking oil (probably peanut oil) and 8.7 percent on peanuts. Sample size was not reported in the USAID/Senegal document from which this abstract derives: John M. O'Sullivan and Charles Morgan. 1981. Bakel Small irrigated perimeter production economics study. Tuskegee Institute.

Wilcox, David Carrington. 1977. "The Political Economy of Grain Marketing and Storage in the Sahel". Michigan State University. DAI 39/03: 1730-A, Order # 7815181.

Investigates the problems of weather-induced instability in domestic food grain supplies. The political economy framework stresses the structural underdevelopment of the region. Analyzes trends in regional grain production, consumption and food imports. Reviews traditional systems of grain marketing in Sahel and discusses policy and institutional issues. A reform proposal based on a village stock system is outlined in a case study of Upper Volta.

Zalla, Tom. 1979. "The relative importance of money and subsistence incomes in explaining dietary intake in Kilimanjaro: Some preliminary results". Paper prepared for the Midwest Conference on Economic Development. Ann Arbor, Michigan, November 9-10. Department of Agricultural Economics, Michigan State University, East Lansing, Michigan.

With both historic and contemporary data on food consumption in Kilimanjaro District of Tanzania this paper investigates the possibility of a conflict between cash income and nutrition objectives in peasant societies. Data were collected from a single 24 hour recall interview of 480 randomly selected families. Calorie and protein adequacy ratios were computed and analyzed in a multiple regression model, and for future research predicting nutritional adequacy.

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Dissertation Abstract International (DAI) entries include vol. and no., page, and order no. for University Micro films International, i.e., DAI 39/07:4493-A, Order #77-8875.

### III. PRE-AND POST-HARVEST HANDLING OF PEANUTS

Dr. Bharat Singh

The quality of peanuts depends on curing, shelling, and storing. In the U. S., through mechanical harvesting and improved methods of transportation, it has been possible to reduce losses due to humidity, temperature, air-flow, mold growth and insects. Practically all commercially grown peanuts are now mechanically harvested, artificially cured and automatically handled and shelled (Woodroof, 1973). By contrast, in most less developed countries, peanuts are handled manually and stored in unfavorable environments (Misaw et al., 1980).

#### Maturity

The timing of harvest and maturity of peanuts are important criteria for determining nut quality. If the peanuts are harvested too early, many of the pods may be lost. The optimum maturity is important to the sheller, because quality grades are dependent upon factors related to maturity; and it is important to the end-users because kernel size, flavor, texture and color are influenced by kernel maturity.

A common method to determine maturity of peanuts is to observe the internal surface color of the shell. As the kernels mature the inner shell becomes gray and finally almost brown with distinct markings of vascular strands of the seed coat on the shell.

Several objective methods have been suggested in recent years. A suitable method to determine the optimum time to harvest peanuts has definite economic benefits. Sanders et al. (1978) calculated the dollar return per acre and found that digging 7 days before or 7 days after the optimum yield period resulted in respective losses of approximately \$50 and \$110 per acre. The late harvest may result in more infestation of Aspergillus flavus and hence more aflatoxin in peanuts under late season drought. Miller and Burns (1971) developed a nonsacrificial index of peanut kernel maturity based on objective color measurement of the internal shell color, which was then related to other indices of maturity and quality. Kernel density and light transmittance of peanut oil at

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480 mu were found as good indices of quality. Three additional methods of predicting and/or estimating peanut crop maturity were developed including the arginine maturity index (Young, 1973; Young and Hammons, 1974; Young and Mason, 1972); methanol extract (Holaday et al., 1979) and seed hull maturity index methods (Pattee et al., 1974; Patee et al., 1980). Sanders et al. (1980) compared arginine maturity index, methanol extract, shell out, and seed-hull maturity index methods of determining peanut maturity. Under the conditions of the test, the seed-hull maturity index and shell out (subjective method) were the most consistent indicators of the optimum yield period in 1978.

In the United States, peanut harvesting begins with Southeastern Spanish in August, which reaches a peak in September. Stock piling of runners reach a peak in October, Southeastern Spanish and Virginias reach a peak in December. Due to susceptibility of farmers stock peanuts to rancidity, insect infestation and molding, there is no carry-over from one season to the next. Mechanical harvesting using a cylinder-type combine has been practiced since 1951 (Baker et al., 1951). Baker (1951) pointed out that roasted peanuts and peanut butter of excellent quality and stability could be made from mechanically harvested and artificially cured peanuts.

Bailey et al. (1954) observed two general types of flavor problems when green mature peanuts were cured in less than three days or cured rapidly in windrows. One was an obvious bitter-off flavor, encountered when green pods were dried in ten days at temperature up to 120F and in windrows in the hot sun. The other was a blandness or lack of capacity to develop a desirable flavor on roasting. Peanuts cured in forced air at 110F did not have off-flavor, but were bland, had loose seed coats and were susceptible to more splitting during shelling than those cured more slowly. The adverse effects due to improper drying and curing were cumulative and irreversible.

### Moisture Content

Moisture is the most critical factor affecting the quality of peanuts during processing or storage. In general peanuts are picked at an average kernel moisture content of 18.25% and artificially dried to a moisture content of approximately 10%. For marketing the desired moisture content of shelled peanuts is about 7.5%. Any deviations from the above acceptable moisture criteria usually result in a loss of milling or market quality (Woodroof, 1973). Growth of the fungus, Aspergillus flavus and the usual subsequent formation of aflatoxin in peanuts presents a major problem in storage. Diener and Davis (1970) demonstrated that the optimal conditions for the growth of Aspergillus flavus are temperatures between 25C and 35C and relative humidities of 85% or higher, or peanut kernel moisture contents in excess of 10%. They also reported that relative humidity less than 83% (peanut kernel moisture content of less than 10%), and temperatures less than 12C or more than 41C will limit aflatoxin production by the fungus.

Excessive kernel damage occurs when peanuts are stored at temperatures less than 7C or at kernel moisture contents less than 6% (Smith and Davidson, 1980; Dickens and Hutchinson, 1976).

Peanuts in the United States are harvested by farmers and are sold and held as farmers' stock until shelled, graded, and bagged. Approximately 7% of the peanut crop in the U. S. is retailed in the shell. Peanuts to be roasted in-shell and eaten from the hand are cleaned in ten steps using mechanical devices and screens. A peanut shelling plant for edible purposes or for oil stock includes silos or warehouses for storing farmers' stock peanuts; screens for separation; shellers and separators; and automatic filling, weighing, and sewing bags of peanuts.

### Storage of peanuts

Requirements for successful storage of peanuts are: (1) they should have high initial quality; (2) the temperature should be low; (3) the relative humidity should be low; and (4) the atmosphere should be free of odors and well circulated. The storage life of peanuts begins in the field, including the degree of maturity, time and temperature of curing, and method of cleaning.

During the early part of the storage season, the air temperatures and relative humidities surrounding the peanuts are much higher than ideal. The greatest potential for production of aflatoxin exists at the early part of the season when excess heat and moisture are present (Smith and Davidson, 1980). The following are listed as sources of heat and moisture by Smith and Davidson (1980): heat of respiration, heat capacity, solar heat, conductive heat, convective heat, peanut moisture, foreign material moisture, insecticide solution moisture, leaks, and condensation. Adequate air flow over and through the peanut during the first part of the season is needed to remove excess moisture and to reduce temperature to prevent mold growth. During the mid-part of the storage season, temperatures lower than ideal are desirable if the peanuts are not to be shelled until the last part of the storage season. Storage conditions during the last part of the storage season are usually similar to those during mid-season with some exceptions.

At an average temperature of 70F, unshelled peanuts may be expected to retain edible quality for 6 months; when shelled the time is reduced to about 4 months. At 47F unshelled peanuts may be held for 9 months and shelled nuts for 6 months. The storage life of shelled peanuts may be extended for 2 years at 32-36F, it may be 5 years, at 25F, and it may be 10 years at 10F. Storage of unshelled peanuts may be 50% longer.

Controlled atmosphere using a higher concentration of carbon dioxide and a lower concentration of oxygen has been found useful in extending the shelf-life of peanuts (Slay, 1980; Marzke et al., 1976). Holaday et al. (1979) used pouches comprised of a laminate of nylon and ethyl-vinyl acetate to store peanuts. The initial gas composition was CO<sub>2</sub>-91.8%, O<sub>2</sub>-1.5%, N<sub>2</sub> - 6.0%. Raw and shelled, roasted and blanched peanuts were protected from any significant deterioration of flavor and other quality factors for 12 months; roasted salted-in-the shell peanuts were protected for 4 months. The carbon dioxide storage also inhibited growth of fungus, Aspergillus flavus (Sanders et al., 1978).

Major problems in the storage include mold growth and storage insects (Thompson et al., 1951); and rodents. The data on pre- and post-harvest storage of peanuts in under developed countries are not available. The data on temperature, humidity, and method of packaging during transportation and storage are necessary to improve shelf-life of peanuts in most LDC's. It is also desirable to collect data on aflatoxin contamination and monitoring programs; insect damage, and other contaminants. Misari et al. (1980) have pointed out that a groundnut producer experiences 5-35% damage to his crop annually from insect pest attacks during post-harvest periods in Nigeria. At present, it is unrealistic economically to recommend the routine use of pesticides. In Senegal, the main problems being studied during post-harvest period are: grading of edible and confectionery peanuts; electronic screening of seeds contaminated with Aspergillus flavus; detoxification of peanut meal with gaseous ammonia; and studies on both cold or vacuum packs storage methods (Gautreau and DePins, 1980). In Zimbabwe, a monitoring procedure for aflatoxin for use by the grain marketing board has been established since the early seventies (DuToit, 1971).

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#### IV. FOOD SCIENCE CONSIDERATIONS: PEANUT PROCESSING AND PRODUCT DEVELOPMENT

Dr. John C. Anderson

It was previously indicated that approximately 18.4 million metric tons of peanuts are annually harvested worldwide. It is evident that potentials of several millions of metric tons of peanut protein could conceivably be used as direct human food; nevertheless in many of the largest peanut-producing regions, substantial proportions of each year's crop is crushed for its oil content and the residue is used for livestock feed. Lusas (1979) cited examples of nations where 75 to nearly 100% of the production was so disposed to provide oil for domestic and international consumption and often exportable feed grade peanut meal. In contrast, in the U. S., about 70% of the peanut crop is either consumed domestically as whole peanut products (peanut butter, confections, etc.) or exported as peanut kernels for similar food uses elsewhere. Portions that are crushed for oil in the U. S. are frequently so processed to salvage kernels that are culled or have aflatoxin levels sufficient to divert from direct food uses. This review will attempt to identify the constraints to more widespread use of the peanut resources as human foods and outline quality and functional attributes of these resources as they might be included in products affording greater utilization of the peanut material.

George Washington Carver is credited with developing some 300 food and industrial uses of peanuts prior to World War I (Woodroof, 1973; Elliot, 1956). Since that time, numerous investigators and entrepreneurs have considered and employed additional innovations, some of which have gained commercial significance in forms of peanut food products. For this food product review, discussion will first focus on a variety of products and ingredients demonstrating current success in the marketplace (particularly as it reflects the U. S. condition where substantial whole peanut products are consumed) and proceed to other promising alternatives and processes.

Recently Lusas (1979) reviewed food uses of peanuts in which he indicated a substantial advantage of peanut-based foods is that it needs minimal preparation to produce pleasant and acceptable products. As the peanut is endowed naturally with appropriate constituents to be readily nutritious as well as satisfying, extractions and purifications (which require more energy and may result in pollution of the environment) may be bypassed by simple processes of roasting and grinding.

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Lusas identified whole peanut products including:

1. Boiled peanuts in which unshelled immature nuts are boiled in a medium brine and eaten fresh or alternately canned and frozen and marketed commercially (Woodroof and McWatters, 1972).

2. Roasted peanuts in the shell in which mature nuts are soaked in a brine and subsequently roasted to a dry stable standard American food (Woodroof, 1972).

3. Roasted shelled peanuts are used as snacks and garnishes to a variety of food products and may take the form of whole, split kernel and chopped nut products. Considerable sophistication in preserving these products involved dry and wet blanching operations to remove testa (red skins) (Woodroof, 1972), applications of antioxidants, and protective packaging including vacuum and nitrogen flush packaging (Pominaki, et al, 1975). Some success has been achieved in using a hydraulic press to remove 50-60% of the oil, reforming the nut shape by soaking in a brine followed by deep fat frying to dehydrate and give a roasted flavor. Such processes of preparing peanut items with 1/3 less calories than their counterparts (Vix et al., 1967, a,b,c).

4. Peanut candies of more than 50 types make peanuts the most popular nut ingredient in American candies (Woodroof, 1972).

5. Peanut butters of three nominal forms are formulated with at least 90% peanuts and about 2% salt. The types include "old fashioned" in which no stabilizer are added to minimize oil separation from the product, "smooth" in which stabilizer ingredients (any one or emoriation of partially hydrogenated vegetable oils mono- and dio-glycerides of vegetable oils) are included, and "chunky" which incorporates pieces of nuts often 1/16 inch in diameter and larger to enhance mouth feel. Variations in "smoothness" can be obtained by adjusting the degree of grinding from one with no preceotible graininess of peanut particles (smooth) to a definite graininess (preceptible) but less than 1/16 inch diameter pieces (regular texture). Manufacture of peanut butter involves roasting to a controlled brownness (320 F for 40 to 60 minutes); cooling to stop the cooking process of roasting; a dry blanching operation to remove the skins (testa); and a grading or sorting operation to remove light, scorched or discolored nuts. Several vrieties of roasted peanuts may be optionally combined and ground to a paste or butter according to the form of product desired. Additions of salt, stabilizers, and other optional ingredients including sweeteners are metered and blended with the butter prior to cooling and packaging. Woodroof (1972) has devoted a complete chapter to this most prominent of American peanut food products.

6. Precooked full-fat peanut flakes are prepared from unroasted peanut cotyledons (hearts and skins removed) by first drying to 2-4% moisture content and grinding to a fine consistency. Water is added with heating and the slurry dried to a flaked product on a drum drier (Mitchell 1972, Mitchell and Malphrus 1968). Flakes have high-keeping quality and find applications in formulated food where high fat and protein contents are desired. The ingredient is a bland product as a consequence of no roasting operations and removal of hearts (McWatters 1973).

In considering peanut-based ingredients involving some extraction processed, Lusas (1979) describes a commercial process of partially defatting peanuts with hydraulic processing to remove 55% of the original oil. The defatted material is marketed as a flour (Seabrook Blanching Corporation). Another extraction process leaving oil intact involves a saline washing in which the full-fat flour is said to be free of peanut flavor and objectionable compounds including tannins (Matsunaga, 1974). Fully-defatted peanut grits, meals, and flours are typically prepared by a pressing or expelling operations followed by hexane solvent extraction of most of the last 9 to 12% oil not mechanically released (Lusas, 1979; Ayres et al., 1974 and Harris et al. 1972). By modifying the heat processes in preparation of the defatted materials, protein solubility as monitored by NSI (Nitrogen Solubility Index) and other functional properties can be modified. Peanut protein concentrates are prepared by processes that insolubilize the protein and permit by leaching with aqueous washes extraction of compounds contributing to peanutty flavor, bitter accents, flatulence and by appropriate oxidizing agents, even destroy aflatoxins (Rhee et al., 1977). While the detoxification of aflatoxin is yet to be approved for food and feed use, employing aqueous alcohol or dilute acid to insolubilize proteins are fairly standard processes (Nagaraj and Subramanian, 1974). Peanut protein isolates are akin to soy protein isolates in that defatted materials from oil extraction processes are solubilized in neutral to basic reaction washes to extract much of the protein which is subsequently separated from the whey formed by reducing the pH to isoelectric levels. Isolates once separated are neutralized with alkali and may be spray dried (Bhatia et al., 1966) or incorporated wet into products as illustrated by the Miltone peanut extended "milk" beverage (Chanrasekkhara et al., 1971). Additional dairy-like products of peanut origin including a yogurt derivative (of the Miltone, a curd-type derivative (Krishnaswamy et al., 1971) and a cheese-like (Krishnaswamy, 1971). McWatters (1973) reported other efforts by Indian and other investigators in similar efforts. More recently investigators have attempted formulation of peanut-based milk-like beverages to improve their acceptability by additions of fruit flavors (Schmidt and Bates, 1976; Schmidt et al., 1978) and lectin fermentation (Beuchat and Mail, 1978; Bucker et al., 1979) and addition of dairy milk (Schmidt et al., 1980). Similarly, Chen et al. (1979) have shown approaches to utilize peanut protein

isolates and oil in combination with milk protein (caseinates) to prepare cheese analogs believed to be of marketable quality. Lusas (1979) has reported analogs of peanut-based curd products including "tofu" used in Japan and miso- and koji-like products in India. Mention must be given at this time to the traditional Indonesian oncom (ontjom) prepared by fermentation of Nemrospora sitophilia and Rhizopus Oligosporus molds innoculated on peanut press cake (Beuchat, 1976). The molds are credited with effecting a proteolysis of the peanut substrate (Beuchat and Basha, 1976) and degradation of phytic acid to enable more pretitious absorption of dietary minerals present in the peanut product (Fardiaz and Markakis, 1981).

Innovative peanut production formulations have been recently noted from Indian scientists, particularly several from the Central Food Technological Research Institute, Mysore. Among them Parpia (1969) and Chandrasekhara and Ramanna (1969) have noted peanuts materials incorporated into a variety of pilot scale and commercial scale products including (1) Bal-Ahar vitamin-fortified flour composed of wheat (65%), peanut (25%) and chickpea (10%); (2) a precooked (roller dried) dehydrated weaning food of peanut cake, chickpea, green grain and wheat or corn; (3) an infant food as a spray dried product composed of peanut and wheat flours and skim milk powders; (4) high (25-28%) protein biscuits supplemental with peanut flour and lysine; and (5) Indian Multipurpose Food Supplement composed of 75% peanut and 25% chickpea flours and vitamin-mineral fortified. Recently at a U. S. university, Indian investigators with adult Indian student evaluators prepared chapatis of commercial whole wheat flour fortified with 10 and 20% levels of commercial peanut flour found the peanut-fortified products of equal acceptable quality including color, appearance, texture, and flavor as nonfortified chapatis (Bhat and Vivian, 1980).

Peanut products of a variety of forms have been included in extended meat products in similar approaches as other legume preparations, and a variety of underutilized protein resources. Perkins and Toledo (1981, to be published) have used levels of retention of trypsin inhibitor activity to monitor the extent of heat treatment of reorted whole peanuts to correlate quality of meatloaf preparations in retaining water and fat. In addition, they found a correspondence of trypsin inhibitor activity with functional factors of protein solubility, but less predictable relations of gelation capacity and water absorption capacity. Other have contrasted peanut preparations (isolates, concentrates and flours) with other oilseeds (glandless cottonseed and soybean material) with particular reference to the oilseeds improved antioxidant benefits and better cooked patty yield (Aiprin et al., 1981). Similarly, McWatters and Heaton (1979) have shown improved effectiveness using heated meals (peanuts, soybeans, pecans and field peas) in terms of aroma and flavor qualities while contrasting physical and sensory qualities of most heated and unheated materials. Cross and Nichols (1979) compared the

palatability of ground beef patties extended with precooked peanut flakes to mechanically processed beef extended with structured soy protein. They found similar increases in tenderness and cohesiveness with the peanut and beef materials compared to the soy, but less cooking losses with the structured soy protein extender. Aguilera et al. (1980) have demonstrated an effective means of extrusion-texturization of defatted peanut flour into structured peanut protein of similar quality and function as the more abundant soy product.

Another effort undertaken by the Food Protein Research Development Center at Texas A & M University has been reported using aqueous extraction to obtain soluble full fat and low fat fractions that are subsequently processed through ultrafiltration and reverse osmosis membranes to yield peanut preparations (Lawhon et al., 1981). Specific applications of these products having high nitrogen solubilities and bland characteristics will probably be reserved for premium speciality products.

While few explicit formulations of commercial food products involving peanut flours and meals are published in the literature (presumably because of the proprietary interests of the food formulators), several investigators have attempted to show examples of product ideas. McWatters and Cherry (1982) are preparing to update product options in a forthcoming revision of Peanut Science and Technology. In addition, Parker and Sexton (1982) will cover products of commercial interest in a chapter entitled "Commercial Manufacturing of Peanuts and Peanut Products" in the same volume. Several examples of uses both potential and commercial include snack-type chips from whole peanuts (McWatters and Heaton, 1972); peanut pie mixes similar to pecan pies with roasted split peanuts and syrup filling mix (McWatters et al., 1971); fortified cookie recipes using defatted peanut flour (McWatters, 1978); and moist heat-treated peanuts converted to a paste to substitute for almond pastes in Macaroon cookie recipe (McWatters and Heaton, 1974). Several products using defatted peanut flour or grits have been described (Ayres and Davenport, 1977). These include extrusion formed protein-fortified breakfast cereals, extrusion formed protein-fortified corn and peanut snack chips, or extruder processed texturized vegetable protein as hamburger patty extenders, peanut protein fortified white and whole wheat bread formulations, and raised doughnut formulations in which peanut flour replaced nonfat milk solids and part of the egg requirements.

Cookie formulations fortified with defatted peanut flour to contain approximately twice the protein level of nonfortified counterparts were reported to be rated with similar sensory quality as the nonfortified cookies (Ahmed and Heister, 1981). Other suggestions for incorporating peanut flour and other legume flours in formulations of family and institutional food uses in developing countries have been proposed (USAID-AID, 1969). McWatters (1973 in Woodroof) reported uses of half-roasted peanut

paste as a shortening substitute requiring 2-1/3 to 2-1/2 times replacement of the usual shortening in a variety of baked items. Such levels of substitution not only improved the protein content of the baked food item, but increased the energy density by replacing more than proportional amounts of fat within the peanut pastes.

Until now in this review only a passing notice has been afforded to the differences in product characteristics that can be exhibited with various peanut flours and extracts. It should not be assumed apart from composition that different preparations of peanut ingredients will behave in similar manners. Functionality of an ingredient, particularly with respect to its protein contribution, will be markedly different depending upon contents of oil present and levels of heat treatment. McWatters and Cherry (1980) compared full fat peanut flour with partially defatted flours having no toasting and three levels of toasty heat treatments in preparation of snack-type chips. Differences were noted in stickiness of doughs and other handling characteristics, durability of chips, frying times, toughness of products, sensory quality, and in various additional chemical and physical parameters. Ahmed and Schmidt (1979) observed differences in solubility, emulsification capacity, foaming stability and capacity of peanut and soybean isolates prepared by freeze drying, spray drying and drum drying processes that included different heat treatments and time of ingredient storage.

Substantial heat treatments, usually in the presence of moist environments, are employed in the preparation of edible peanut flour and grits (Ayres et al., 1974) and in water blanching to remove skins (Woodroof, 1973). Several investigators have characterized the effects of such moist heat treatments on peanut ingredients ranging from sensory qualities of the kernels (Beuchat and Koehler, 1979), to baking quality and functional properties of peanut pastes (McWatters and Heaton, 1974); McWatters and Cherry, 1975), to solubility and emulsification properties and protein structural changes of full fat peanut preparations (McWatters and Holmes, 1979); Cherry and McWatters, 1975; and Cherry et al., 1975). Effects of salt concentration and pH adjustments have been reported in terms of functional properties of partially defatted peanut flour preparations (McWatters et al., 1976); McWatters and Holmes, 1979). Proteolysis, either by additions of enzyme preparations or as a consequence of fungal inoculations, have been instruments of modifying peanut flours functional properties (Beuchat, 1977a; Beuchat et al., 1975; Quinn and Beuchat, 1975). Substantial benefits in baked cookie quality are claimed for formulations fortified with enzyme modified peanut flours (Beuchat, 1977b). Hydrolysis of peanut protein by fungal fermentation results in reduced cystine fractions and free amino acids with the electrophoretic patterns demonstrating greater mobility (Beuchat et al., 1975b). In contrast, modification of peanut flour by succinylation processes reduces electrophoretic mobility, and effects other substantial changes of functionality including increases in water absorbing and retaining capacity,

emulsion capacity, and apparent viscosity (Beuchat, 1977c). Fungal modification of peanut products are also identified with efforts to reduce oligosaccharide levels and thus potentially alleviate flatulence problems encountered with this and other legumes (Worthington and Beuchat, 1974). It seems evident that modifying and assessing the functional properties of peanut materials will continue as with similar ingredients from other legumes. In that light it is possible to indicate that among other material, the functional behavior of the peanut is demonstrably different and thus offers opportunities and challenges (McWatters and Cherry, 1977).

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## V. PEANUTS IN HUMAN NUTRITION

D. Ramkishan Rao

### Introduction:

Of the major food legumes, peanuts (Arachis Hypogaea) offer important advantages to help offset the current worldwide shortage of vegetable protein and oil. The ubiquitous acceptance of the peanut and peanut products as food is unique among major oil seeds. Peanuts are pleasantly flavored and can be prepared into various food forms. From the agronomic view point, the peanut plant is relatively day-length insensitive, so that varieties may be developed world wide or planted at any season of the year. Peanuts are relatively well adapted, and produce higher yields under the low fertility and low technology practices of the small farmer. Peanuts have more than twice the oil content of soybeans, and peanut oil is easily extracted and used directly without processing. However, peanuts have been criticized variously for their poorer protein quality, potential danger of aflatoxicosis and atherogenesis due to their consumption and to some extent the presence of some antinutritional factors. Peanuts have been reported to be deficient in at least three essential amino acids -lysine, threonine, methionine, and possibly tryptophan. Similarly, there are epidemiological data linking aflatoxin consumption and hepatic carcinoma in humans. Recently, observations on atherogenesis induced by peanut oil in animals has also raised some concern in the peanut industry. These topics and antinutritional factors in peanuts and their implications in peanut consumption are reviewed in this article.

### Peanut Consumption:

It has been estimated that in 1978, approximately 18.4 million metric tons of peanuts were produced in the world of which 5.1 million metric tons were produced in Africa, 6.2 in India, 2.8 in China, 1.8 in the USA and the rest in other developing countries (USDA, Agricultural Statistics, Various Sources). Production is concentrated in South Asia and West Africa where peanuts are grown as a cash crop. Protein calorie malnutrition (PCM) is a problem in the developing world. It is ironic that PCM exists in areas where most of the peanuts are produced. Peanuts are an excellent source of both calories and protein (585 kcal/100 g full fat peanut kernels and about 25% protein). Assuming a level of production of 19 million metric tons of peanuts, there would be about 3.5 million tons of peanut protein available (after correcting for the kernel yield). Thus, there should be about 2.4 to 2.5 g of peanut protein available per caput per day in the world. This translates into approximately 5% of the total protein requirements of the world.

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However, even in the USA, the peanuts contribute not more than 4% of the total protein requirements. The situation is even worse in the developing countries. For example, in India 4.47 million metric tons of peanut kernels were produced during the year 1978-79 (Potty, 1981). This should amount almost to 5 g protein per caput per day or about 10% of the protein requirements (assuming a population of 660 million). Yet, only about 15,000 tons of edible groundnut flour and edible peanut protein which is used to make up some 3.6 million liters of Miltone (blend of buffalo milk with peanut protein isolate) are produced from peanuts (Potty, 1981). This would then translate into a fraction of 1% of the protein requirements. The obvious reason for this low consumption is that out of 4.47 million tons of kernels produced, 78% was utilized for oil extraction, 11% for seeds, 6% for exports, and the remaining (most likely unaccountable) for edible purposes (Potty, 1981). The protein rich cake resulting from oil extraction is fed to the animals as a protein supplement. Similarly in other developing countries, the peanuts are either used for extraction of oil to be exported later or directly exported. For example, Sudan accounted for 17% of world peanut export trade. Abulu (1978) estimated that 5% of the estimated 58.9 g of crude protein available per head per day in Nigeria, is contributed by peanuts. According to Futrell (1981), peanuts are used almost daily in Nigerian diets. Notable peanut products which are practically daily staples in Nigeria are groundnut stew and kuli kuli (Vincent, 1962). On the other hand, recent site visits (Okezie, 1981) indicated that there is little or no demonstrable direct human food use of peanuts other than as a snack item. Likewise, the consumption patterns in many countries are unknown. For example, in Senegal, half of the peanuts (0.6 million tons) retained for consumption within the country are not accountable as to the form of consumption (Wheelock, 1981). Similarly, peanut production in Upper Volta is extensive but the consumption mode, except as peanut paste (butter), is largely unknown (Reddy, 1981). Thus, the consumption patterns of peanuts in the world are not documented, and available figures, are at best, estimates. However, in the U. S., figures are available on the consumption pattern of peanuts. About 55% of the shelled peanuts are used to make about 250,000 tons of peanut butter; the rest of the peanuts are used as salted peanuts (about 85,000 tons) and confectionery uses (about 70,000 tons) (Mottern, 1972). Lusas (1979) has summarized the disposition of the total U. S. peanut crop during the periods of 1971-1975.

### Protein Quality

Amino acid composition: The protein content of peanuts ranges from a low of 22% to a high of 30% depending upon the cultivar, location, and year (Young and Hammons, 1973; Pancholy et al., 1978). According to FAO (1970), the limiting amino acids in peanuts are lysine and methionine, but there are reports which indicate that lysine, methionine, and threonine are equally

limiting (Miller and Young, 1977). Tryptophan has also been included as a possible limiting amino acid in peanuts (Milner, 1962). Much published information is available on the amino acid composition of peanuts and some excellent sources of information are publications by FAO (1970), Mottern (1972), McWatters (1979), Young (1979), Cater and Rhee (1975), Young and Hammons (1978), Lusas (1979), Pancholy et al (1978), Hovis et al. (1979), and Young (1980). The ranges reported for the amino acids, lysine, methionine, and threonine (as % of protein) are 2.1 to 3.9, 0.35 to 1.0 and 2.3 to 2.7, respectively. These ranges indicate that selective breeding might result in a peanut of superior protein quality. Nevertheless, even the highest values in the above ranges are still lower than FAO (1970) reference protein indicating the limits of increasing the amino acid content.

Biological value (BV): The chemical score for peanut protein calculated by using amino acid compositions tabulated by FAO (1970) is 65 with first and second limiting amino acids being lysine and threonine (Hackler, 1977), while the essential amino acid index is 69. The protein efficiency ratio (PER) of edible cake protein and a protein isolate prepared from this cake was 1.60 and 1.53 respectively (Anatharaman et al., 1959). Supplementation of the protein with methionine at 0.6% level in the diet of rats increased the values to 1.84 and 1.63, respectively. The digestibility coefficient of the isolate was found to be slightly higher than that of the protein in the cake. In later studies, Anatharaman et al. (1962) reported that the biological value of the peanut protein isolate in young rats increased from 60% to 69% when supplemented with 0.31% DL-methionine, 0.37% L-lysine and 0.15% DL-threonine, and further supplementation with 0.10% DL-tryptophan resulted in a biological value of 82%. This is one of the few studies that indicate a marginal deficiency of tryptophan in peanut protein. Also, the available lysine content of the peanut cake and the corresponding peanut protein isolates were reported to be 3.34 and 3.20 g/16 gN, respectively.

Estimates of the BV of peanut protein relative to that of a reference protein ranged from 50 to 75% (Hegsted et al., 1968; Neucere et al., 1972). The BV, PER, and NPU (net protein utilization) for peanut protein have been calculated to be 55, 1.65, and 43%, respectively (FAO, 1970). In some studies with humans and other animals, lysine, and sulfur containing amino acids were found to be the most limiting amino acids. McOsker (1962) evaluated the limiting amino acids in raw and roasted peanuts using rats. In unroasted peanut paste, lysine, methionine, and threonine were equally limiting, while in paste from roasted nuts the order of the limiting magnitude of the amino acids was lysine, threonine, and methionine. Calculations based on the amino acid content of the peanut protein and the amino acid requirements of the rat (NRC, 1972) indicated that threonine should not be limiting and thus, McOsker concluded that about 30% of the threonine in peanut protein was not biologically available

to the rat. FAO (1965) considers lysine and methionine (or total sulfur containing amino acids) to be the most limiting in peanut protein for humans. Carpenter and Anantharaman (1968), Spreadbury (1974), and Wethli et al. (1975) also reported that lysine and methionine were the most limiting in peanut protein for rats, rabbits and chicks, respectively. Rao et al (1963) reported that there is no demonstrable amino acid imbalance in peanut proteins, and it has been shown that when fed at 20% protein level, peanut protein promotes good growth in albino rats. Long term feeding studies carried with albino rats for a period of 48 weeks have shown that peanut flour, when providing 20% protein in an otherwise adequate diet, promotes good growth with no histological changes in the liver structure. At lower levels (10%) intake, however, peanut proteins were inferior to milk proteins. In similar studies, Miller and Young (1977) reported the maximum growth rate of weanling rats was obtained with diet containing peanut meal as the sole source of dietary protein. Growth of rats fed 16.7 and 20% peanut protein was essentially equivalent to that of animals fed 12 to 24% casein protein. With 13.3% peanut protein in the diet, methionine, lysine, and threonine were equally limiting in the peanut meal by rat growth and PER. However, Wethli et al fed different levels of peanut protein to chicks and from growth data concluded that amino acids supplied by peanut protein were so disproportionate with respect to chicks requirement that increasing the levels of peanut protein in the diet did not offset the poor quality of the peanut protein.

In other studies, Chopora and Sidhu (1967) tested the protein quality in 9 different peanut varieties grown in Punjab, India. Biological values were not significantly different among varieties and ranged from a low of 50.9% to a high of 52.8%. Likewise, the digestibility of protein ranged from 81.9 to 83.2%, while PER values were between 1.56 and 1.58. In comparing the body water and nitrogen balance-sheet methods for determining the nutritive value of protein, Henry and Toothill (1962) reported biological values of 56.5 to 62.7%, protein digestibilities of about 92%, and NPU values from 37.8 to 47.1% for peanuts.

Unfortunately, in all these studies, the source, variety, and maturity of the peanut and the method of preparation of the peanut meal and protein isolate either were not mentioned or different. These conflicting reports strongly point to the need for standardized procedures in protein quality evaluation and nitrogen balance studies in humans to find out the biological value of peanut protein.

Supplementary effect: Several combinations of peanuts with other legumes and cereals have been tried to achieve complementary effect on the protein quality including amino acid fortification. Indian Multipurpose Food (MPF), which is a blend of peanut flour and chick-pea flour (3:1) fortified with calcium, vitamins A, D, B<sub>1</sub>, and B<sub>2</sub>, when incorporated at 12.5% level in poor Indian diets based on cereals and millets showed significant supplementary effect as judged by the growth of albino rats compared to that of

American multipurpose food based on soya flour (Kuppuswamy et al., 1957). Joseph et al. (1960) prepared various combinations of protein blends using peanut, free amino acids (lysine, methionine and threonine), soybean flour, Bengal Gram flour, sesame flour, and skim milk powder to simulate the amino acid composition of FAO reference protein. In all cases, the PER values were higher than the PER value of peanut alone. Peanut supplementation with the three amino acids gave the highest PER (2.59) followed by a mixture which provided 33% protein from peanut flour, 33% protein from soybean flour, 15% from Bengal Gram flour, 19% from skim milk (2.36). Similarly, Lal and Rajagopalan (1953) found that, among several vegetable protein mixtures, a mixture of peanut, soybean, and sesame, providing 60, 20, and 20% respectively of the protein gave the highest biological value of 72.5% followed by a mixture of peanut (55%), wheat (25%), and cotton seed (20%) proteins. Howe et al. (1965) reported the effect of adding lysine, methionine, and threonine to peanut flour (PF) on the protein quality. The PER values for PF, PF + lysine, PF + methionine, PF + threonine, and PF + lysine + methionine + threonine were: 1.72, 1.35, 1.66, 1.34, 1.70, and 2.2, respectively. Peanut flour fortified with calcium salts and essential vitamins when incorporated to provide 5% extra protein to rice diets and 15% extra protein to maize-tapioca diet made up the deficiencies in the diet and promoted good growth of rats Rao et al., (1963). Bressani (1977) has fed mixtures of corn flour and peanut flour to rats progressively replacing corn flour with peanut flour from 0 to 100% at 8.5% protein level. Neither weight gains nor PER was improved by the additional peanut flour to the corn flour at any level. This may be due to the fact that both corn and peanuts are deficient in lysine. More studies on complementary effects of peanut protein with other protein sources are needed. Particularly, the combinations should involve at least one other legume to compensate for methionine deficiency. Ahmed and Araujo (1977, 1978) demonstrated that peanut protein supplementation of corn muffin allowed weanling mice to sustain a maximal growth rate on a smaller dietary intake.

The nutritional value of Miltone (milk toned with peanut proteins) was studied by Chandrasekhara et al. (1972). Compared to FAO reference protein, Miltone was slightly deficient in sulfur containing amino acids. The PER values for Miltone, sterilized Miltone, and lactic fermented Miltone were 2.5, 2.3 and 2.7 respectively as opposed to a PER value of 3.0 for the control milk group. The net protein utilization (NPU) from Miltone and Miltone curd was 67 and 76%. Thus, lactic acid fermentation of peanut products seems to improve the protein nutritive value, and therefore, further work is recommended in this area. On infant feeding experiments, Chandrasekhara et al. (1972) also found that there were no significant differences in weight gain between groups supplemented with Miltone and Toned Milk. Other studies on peanut protein evaluation also tested supplementary effect of various vegetable proteins with or without added amino acids (Chandrasekhara et al., 1962; Tasker et al., 1960 and 1963;

Guttikar et al., 1965, Daniel et al., 1972). Over all, it appears that supplementing of peanuts with both legumes and cereals will slightly improve the lysine and methionine deficiencies. A combination of peanut and cow milk seem to offer a very nutritive product.

Effect of processing on protein quality: Prasannappa et al. (1972) studied the effect of extrusion cooking on two Indian blended foods, Bal-Ahar and Indian Multipurpose Food. Extrusion cooking slightly improved the PER value of both products. Carpenter (1973) has reviewed the literature concerning the effects of processing on amino acid content of peanuts and concluded that severe protein damage was specific to lysine; availability of other limiting essential amino acids, methionine, and threonine of peanuts was little affected. Similarly, in a recent study (McWatters and Cherry, 1981), preparation of peanut chips from full-fat or partially defatted peanut flour resulted in an appreciable loss of lysine, but the variation in the other amino acids was not statistically significant.

During isolation of peanut protein, the majority of aflatoxins originally present in the peanut meal is precipitated with the protein fraction. Several chemical and physical approaches have been suggested for the destruction of aflatoxin. However, the effect of such treatment on the nutritive value of the peanut protein has not been studied to any appreciable extent. For example, hydrogen peroxide treatment of the peanut to destroy aflatoxin, reduces the methionine content by as much as 64%, and the available lysine is also reduced from 2.51 g/16 g N to 1.97 g/16 g N (Sreedhara and Subramanian, 1981). More research is needed on the effects of chemical and physical destruction of aflatoxins in peanut products on its protein nutritive value.

(Rhee and Rhee, 1981) tested the nutritional quality of the protein in oil seed products, including peanut heated with glucose and sucrose. In vitro protein digestibility, total amino acids, available lysine and computed protein efficiency ration decreased substantially when glucose was the sugar source. Sucrose had little or no effect on these parameters. Both defatted peanut flour and peanut protein isolate appeared to show less protein quality damage due to the reactions of sugars than protein sources from cotton seed and soybean.

It has been demonstrated that texturization of defatted peanut flour (DPF) does not result in loss of protein nutritional quality of the peanut flour. The adjusted protein efficiency ratio (PER) of the DPF was 1.57 while that of the texturized DPF was 1.54. Supplementation of DPF and texturized DPF with 0.3% DL-threonine, 0.2% L-lysine and 0.2% DL-methionine resulted in a significant increase in PER value of 2.18 (Yanex et al., 1981). These results confirm the previous work that peanut protein is deficient in threonine, lysine, and sulfur containing amino acids.

Human feeding studies: Feeding of Indian multipurpose food (MPF) to school children showed that supplementing their diets with 2 ounces of MPF/day/subject brought about a highly significant improvement, in their height, weight, red blood cell count, hemoglobin, and their general nutritional status as compared to the control group with significant increases in N, Ca and P retention (Subramanyan et al., 1957; Joseph et al., 1957). Similarly, low fat peanut flour has been shown to have a marked supplementary value when incorporated at 20% level in poor Indian diets based on certain tubers and cereals. Feeding trials carried out on school children have shown that supplementation of their diets with 50g of peanut flour fortified with vitamins and minerals daily, resulted in significant increases in their height, weight and hemoglobin content and marked improvement in their nutritional status as compared with the control group not receiving the supplement (Doraiswamy et al., 1962). Likewise, peanut flour enriched products such as tapioca-macaroni blend (Rao et al., 1961); (Doraiswamy et al., 1961) balanced malt foods (Subramanyan et al., 1959); Korula et al., 1961) have been shown to be of high nutritional value both in rats and humans. Edwards et al, (1971) reported that addition of peanut butter to wheat bread in the diet of young adult humans improved the nitrogen balance although the lysine intake remained the same. Other human nutritional work with peanut protein is scanty and has been a part of some studies evaluating different methods for protein quality (Murlin et al., 1948). A few other human feeding studies have been reported by Voris (1961).

Kwashiorkor studies: Srikantia and Gopalan (1960) conducted clinical trials with various vegetable proteins, including peanut protein, in patients with kwashiorkor. Peanut protein in combination with other proteins from Bengal gram, sesame seed and/or lucerne (alfalfa) was very effective in alleviating the clinical symptoms of kwashiorkor. However, peanut protein alone was somewhat inferior to Bengal gram.

Rao et al., (1963) prepared five different protein blends based on peanut protein, soy protein, casein, and skim milk powder with or without lysine and methionine supplementation. Fifty four cases of kwashiorkor were treated with different blends. The results indicated that peanut protein along with some skim milk powder or casein could effectively raise the serum albumin levels comparable to skim milk powder controls, and kwashiorkor was cured by peanut protein blends. It is unfortunate that protein-calorie malnutrition still exists in those developing parts of the world where most of some 19 million metric tons of peanuts are produced.

Nutritive value of fermented peanut products: Ontjom (lontjom) is a fermented peanut press cake very popular in Indonesia. Two different fungi, Neurospora sitophila or Rhizopus oligosporous are commonly used to ferment the peanut press cake (van Veen et al. 1968). Beuchat (1976) reviewed the literature on the nutritive value of ontjom. The overall nutritive value of protein and lipid appear to be unchanged. Increases in riboflavin, niacin, and possibly thiamin have been reported. Fardiaz and Markakis (1981) reported that the phytic acid content of the uninoculated peanut press cake (1.37% on a dry basis) decreases rapidly after fermentation with Rhizopus oligosporous (0.05%) after 72 hours of fermentation. Quinn et al (1975) observed that fermentation of peanut flour by various fungal cultures including those used for ontjom preparation results in an increase of thiamin, riboflavin and niacin. Pantothenate did not increase, and the PER remained essentially unchanged.

Swaminathan and Parpia (1967) reported the lactic fermentation of peanut milk. More recently, Schmidt and Bates (1976) reported the use of natural fruit flavorings to improve the acceptability of yogurt-like product made from peanut milk. Similarly, Beuchat and Nail (1978) fermented peanut milk and subsequently used it for corn muffin preparation. In all of these studies no attempts were made to evaluate the nutritional quality of the product.

Peanut oil and atherosclerosis: In 1960, Gresham and Howard serendipitously discovered that peanut oil was more atherogenic than the other unsaturated oils in rats. Scott et al. (1964) confirmed these results in rats. Later, Wissler et al. (1967) produced similar atherogenic lesions in Rhesus monkeys fed peanut oil. Also Kritchevsky et al. (1971, 1973) were able to induce atheromatous plaques in rabbits by feeding peanut oil. The type of atheromatous plaque on different fats were, however, found to be different in subsequent studies. Vesselinovitch et al. (1974) examined the pathogenesis of atherosclerosis in Rhesus monkeys fed peanut oil, corn oil, and butter fat. After 50 weeks of feeding at 25% level with 2% cholesterol, all the lipids produced atheromatous plaques in the aorta. In the butter fat group, the lesions were characterized by abundant lipid deposition and relatively little cell proliferation or collagen deposition. On the contrary, the aortic lesions in the peanut oil fed animals were characterized by thick fibrous plaques which were elevated to the point of apparent narrowing of the ostia of various vessels. The apparent intimal cell proliferation associated with high collagen content resulted in severe coronary artery narrowing. These findings and interpretations were substantiated in a later study (Vesselinovitch et al., 1980) in which it was demonstrated that peanut oil "contaminated" at 5ppb with aflatoxin was no more atherogenic than aflatoxin-free peanut oil. Increased rate of collagen synthesis in the aorta of peanut oil fed rabbits confirmed the fibrotic nature of lesions produced by peanut oil (Ehrhart and Holderbaum, 1980). There is, however, one conflicting report in which arachis oil has been found to be no more atherogenic than the other unsaturated fats (Funch et al., 1960).

The mechanism by which peanut oil induces severe atherogenesis has not been substantiated to any significant extent so far. In several studies it was observed that the degree of unsaturation of peanut oil was not related to atherogenicity (Kritechevsky et al., 1971, 1973, and 1976). However some studies suggest that the atherogenic potency of peanut oils may be determined by their triacylglycerol structure (Kritchevsky et al., 1971). Randomized or racemic synthetic peanut oils (in which the position of fatty acids on glycerol are changed) were shown to possess marginal atherogenic activity when tested in animals (Kritchevsky et al., 1973). Myner et al. (1977) analyzed the structure of peanut oil triacylglycerols and found that the native oils were characterized by a specific confinement of the long chain saturated fatty acids to the sn-3 position and a much greater relative preponderance of linoleic acid in the sn-2 position, when compared to the artificial oils. Based on the acylglycerol structure of some genetic varieties of peanut oils of varying atherogenic potential, Manganaro et al. (1980) hypothesized that the atherogenic potential is generated during the metabolic utilization of the products of hydrolysis or resynthesis of the peanut oil triacylglycerols. Since both atherogenic and nonatherogenic oils contain all their long chain fatty acids in sn-3 position, they differ largely from each other only in the nature of the sn-1,2 diacylglycerol moieties. The hypothesis states that it is possible that higher proportion of linoleic acid in sn-1,2 diacylglycerol moieties of the more atherogenic oils may contribute to more efficient hydrolysis of these long chain triacylglycerols to the resulting sn-3 monoacylglycerols. These sn-3 long chain monoacylglycerols could then become absorbed, reesterified and eventually transferred to any other tissues, where they resist hydrolysis by tissue lipases. Should these triacylglycerols accumulate, they produce lesions by their detergent-like activity. In the author's opinion, this hypothesis suffers from at least three weaknesses. 1) The preferential hydrolysis of triacylglycerols by pancreatic lipase usually results in sn-2 monoacylglycerols (Raghavan and Ganguly, 1969; Kayden, 1967); 2) it is assumed that these triacylglycerols are absorbed intact by the tissues; and 3) in peanut oil feeding studies, the lesions are of more fibrous type than of lipid type. Peanut oil varietal differences have been demonstrated with regard to their atherogenic potential (Kritchevsky et al., 1981). Hokes and Worthington, (1979) suggested that other active compounds may be present in the non-triacylglycerol fraction of peanut oil, and it is possible that these compounds would be inactivated or removed under conditions employed in the randomization of the oil. It is not known whether peanut oil would have similar effects in humans. Moreover, in most of the studies cited the fats were incorporated into the diets at about 25% level with 2% supplemental cholesterol. These levels are unrealistic and long term feeding studies with lower levels of peanut oil and other peanut foods should be conducted to substantiate the atherogenicity of peanut oil. If, indeed, the peanut oil and other peanut products are atherogenic due to their triacylglycerol structure there seems to exist some genetic potential among cultivars for development of nonatherogenic line of peanuts (Hokes and Worthington, 1979).

## Aflatoxicosis in humans:

Interest in mycotoxicoses was stimulated by the discovery that the death of 100,000 turkey poults in England in 1960 was caused by a toxic and carcinogenic metabolite of Aspergillus flavus which contaminated the Brazilian peanut meal fed to these turkeys as a protein supplement. Since then many research papers have been published on aflatoxicosis in animals and some epidemiological studies have been conducted in humans. A detailed discussion of the toxicity of aflatoxin in animals is beyond the scope of the review. Excellent reviews on the toxicological effects of aflatoxins have been published. Some recent articles of interest are those by Rodricks (1976), Rodricks et al., (1977), Uraguchi and Yamazaki (1978), Wyllie and Morehouse (1978), CAST (1979), Bullerman (1979) and Diener (1981). One fact may be underscored in most of these reviews. The most common biological effect of aflatoxin in animals is a reduced growth rate at levels of toxin below those required to induce any diagnosable clinical disorder. Further, carcinogenesis has not been reported (or was not part of toxicological studies) as a common sequelae to aflatoxin consumption in livestock and poultry. Therefore in humans, low levels of aflatoxins may cause various nutritional interactions resulting in suboptimal growth. Mostly, as reviewed below, data were collected on acute toxicosis and hepatic carcinogenesis in humans without much attention to long term chronic effects of low level aflatoxin consumption which might exist particularly in developing countries. In fact, there are indications that aflatoxins might interact with nutrients at biochemical level (Voight et al., 1980). Apparently, more work is needed in the area of nutritional interactions that may result due to aflatoxicosis.

Any doubts that remained as to whether aflatoxin is hazardous to human health have been cleared by the unfortunate aflatoxin-related episode in India. In 1974, people of a corn-eating ethnic group in India who reportedly consumed 0.25 to 15.6 ppm (2 to 6mg) aflatoxin along with the contaminated corn developed acute toxicoses with 106 deaths (Van Rensburg, 1977; Jukes, 1978). On most of the recovered people (including those who did not show overt clinical symptoms), there is follow-up actually to determine possible development of liver cancer and other pathological abnormalities. The epidemiological data linking a relationship between the ingestion of aflatoxin contaminated food and the incidence of human liver disorders have been reviewed recently. Campbell and Stoloff, 1974; Van Rensburg, 1977; Shank, 1978; Wilson, 1978; Nizami and Zuberi, 1977; Brudzynski et al., 1977). Countries where the surveys have been done include Uganda, Zaire, Swaziland, Mozambique, India, Pakistan, Taiwan, Kenya, Philippines, and Thailand. The most common liver disorders noted in these countries were hepatoma and cirrhosis of the liver. The common staple foods analyzed for aflatoxin (B<sub>1</sub>) in these countries showed both very high frequency and levels of contamination (Campbell and Stoloff, 1974). As mentioned earlier, more epidemiological studies on the

effect of prolonged consumption of aflatoxin at very low levels by humans on their metabolism are needed. Meanwhile, some animal experimentation to test the interaction between subchronic aflatoxicosis and nutrition may be helpful.

#### Antinutritional and other factors in peanuts:

Lusas (1979) has briefly reviewed various antinutritional factors present in peanuts. Trypsin inhibitor activity in peanuts has been reported to be about one half (Borchers et al., 1947a) to approximately one fifth (Anantharaman and Carpenter, (1969) of the activity found in soybeans. Anantharaman and Carpenter (1969) reported that this trypsin inhibitor activity in peanuts is significant enough to cause pancreatic hypertrophy in rats receiving 15% of protein intake from peanuts. Earlier studies (Borchers et al., 1947b) indicated that the trypsin inhibitor(s) in peanuts were heat-resistant, but later studies showed that the trypsin inhibitory activity could be destroyed by heat treatment although the results from various laboratories were not consistent with respect to the degree of inactivation (Woodham and Dawson, 1968; Anantharaman and Carpenter, 1969; Rakeis, 1966; Perkins and Toledo, 1981). These differences may have been due to procedural differences.

Lectins (also known as phytohemagglutinins or hemagglutinins) shown to possess a remarkable array of biological activities, have been found in peanuts (Liener, 1979). An interesting aspect of the lectins in peanuts is that, roasting of peanuts does not destroy the lectins (Nachbar and Oppenheim, 1980). Enterokinase, which initiates a cascade of reactions resulting in the activation of digestive proteases in animals, has been shown to be inhibited by protein fractions isolated from various plant sources with peanut seeds showing the highest enterokinase inhibitor activity (Lau et al., 1980). If indeed, high amounts of enterokinase inhibitors are present in peanuts, the implications are obvious and more work is needed to confirm the presence of enterokinase inhibitors, and ways to destroy this inhibitory activity should be explored.

A number of other pharmacologically and toxicologically important compounds have been reported to be present in peanuts. The presence of hemostatic agents in peanuts has been reported by Frampton et al. (1966) and Jackson et al. (1966). The bleeding time of transected arterioles in the cheek pouch of hamsters ingesting an alcohol extract of defatted peanuts was shortened to about 3/4 that observed for the control animals. Sreenivasan et al., (1957) have reported the presence of a goitrogenic glycoside,

arachidoside, in peanuts. Oil seed proteins constitute the most highly allergenic food groups. Peanuts also have been shown to be highly allergenic. For example, May (1976) observed that in 11 children in whom food allergy symptoms could be evoked with food challenges, peanuts were responsible for 8 hypersensitivity reactions. In this connection, an empirical observation of the author and the others has been that many people complain untoward effects of peanut consumption, especially new peanuts. Reportedly, the untoward effects range from plain nausea and head-aches to total unconsciousness. Such claims may be related to hypersensitivity reactions and idiosyncrasies and merit scientific investigation. Phytic acid and oxalates are also commonly found in peanuts (Lusas, 1979). Arachis oil has been attributed to contain potent anti-inflammatory compounds (Outram, 1975). Calloway et al., (1971) observed that peanuts are absolutely nonflatulent, while Rackis et al., (1970) found that the amount and composition of gas produced from cotton seed and peanut meal were comparable to those from soybean meal. Later, Hymowitz et al., (1972) reported that varietal differences exist in peanuts in their ability to cause flatulence. Recently, the oligosaccharide content of the peanuts has been reviewed by Tharanthan et al., (1979).

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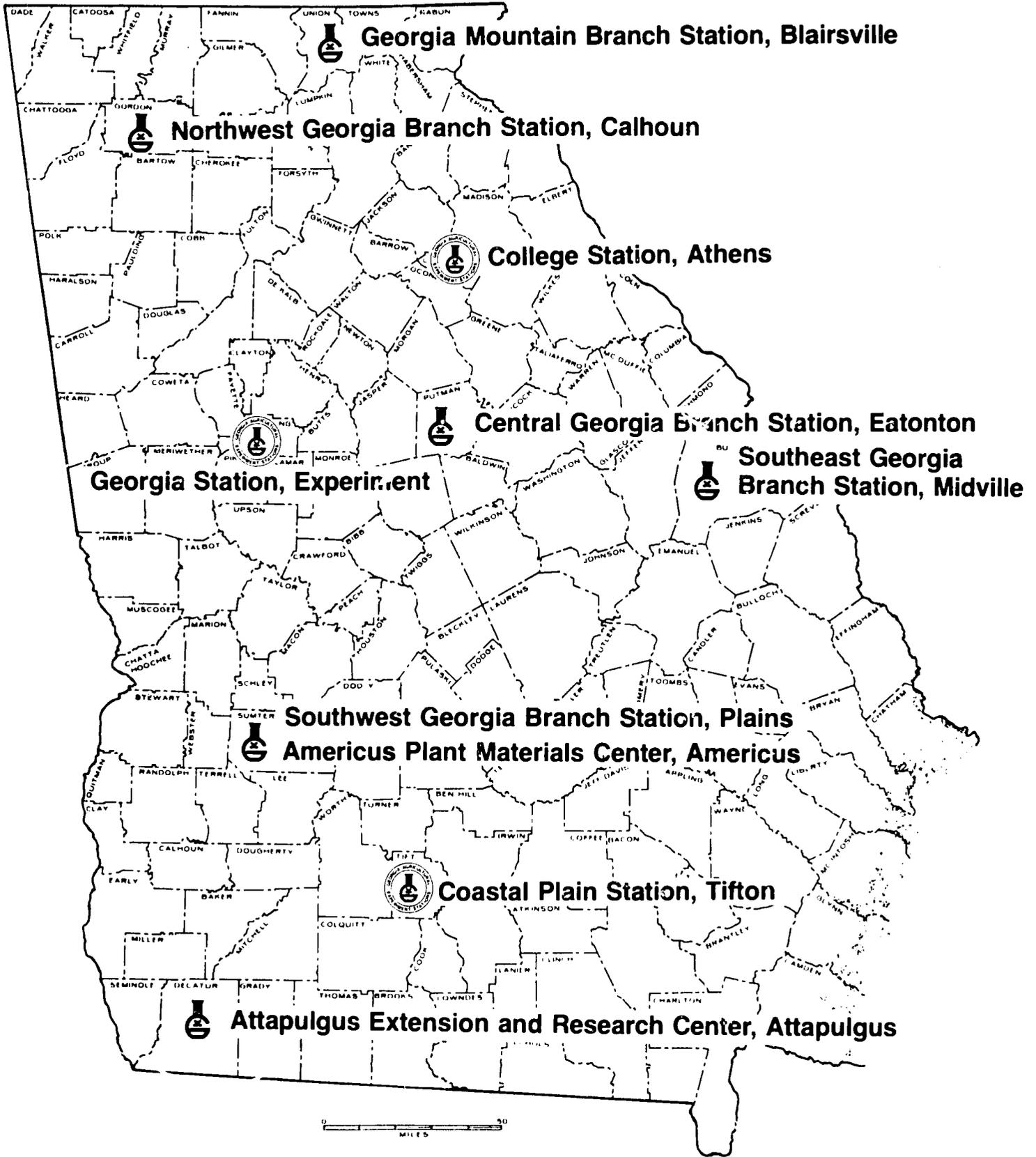
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main station



branch station