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Technology and Product-Mix Forecast —Oils and Fats in 2000 A.D.

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Groundnut Production in The semi-arid Tropics — Problems and Progress

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Groundnut is a major oilseed and edible nut crop in many tropical, subtropical, and warm temperate regions of the world. In 1979 there was an estimated world production of 18.4 million metric tonnes of groundnuts from 18.6 million hectares (Table 1). Asia is the largest producer (10.2 million tonnes), followed by Africa (5.2 million tonnes), North America (1.9 million tonnes) and South America (0.9 million tonnes). Of the individual countries, India is the largest producer in the world (5.7 million tonnes), followed by China (2.6 million tonnes), USA (1.8 million tonnes), Sudan (1.1 million tonnes) and Senegal (0.9 million tonnes). About 80% of world production comes from developing countries and 67% of the total is produced under rainfed conditions in the semi-arid tropics (Gibbons, 1980).

Groundnut production practices around the world range from primitive farming with very little input of fertilizer and pesticides to highly mechanized farming utilizing high inputs of fertilizer and pesticides (Cummins and Jackson, 1982). Average pod yields in the semi-arid tropics (SAT) are low, around 800 kg/ha, compared to 2500 kg/ha or more in the countries with developed agriculture such as the USA. Pod yields from individual countries utilizing low level technology vary from just 400 kg/ha in Mozambique and Niger to over 800 kg/ha in Senegal, Burma and India while yields of 1250 to 2925 kg/ha have been recorded from countries such as Australia, Venezuela, Brazil and USA utilizing high levels of technology (Table 2). Australian groundnut production utilizes a high level of technology including complete mechanization and heavy capital inputs but yields are low, around 1250 kg/ha, compared to yields of over 2500 kg/ha in Brazil and U.S.A. This is mainly because the crop is grown on clay soils, rather than the sandy soils that are best suited to groundnut production, i.e. soil characters are limiting production. Also, lack of irrigation water is a limiting factor in many areas (Middleton, 1980).

Compared to other oilseed crops and grain legumes, groundnuts are relatively daylength insensitive, and well adapted and produce substantial yields under the low fertility and low input practices of the small farmers of the SAT. In many of the major groundnut-producing countries, a significant proportion of each year's crop is crushed for oil and the cake used for livestock feed. The estimated oil yields from some countries are given in Table 3. India is the largest groundnut oil-producing country followed by Brazil, Burma, Argentina and Nigeria. India was an exporter of groundnuts and groundnut products a few years ago but now imports edible oils. The present requirement of edible oils in the country is around 3.8 million tonnes and the production is 2.6 million tonnes. Thus there is a shortage of 1.2 million tonnes which is made good through imports at a cost of about Rs. 800 crores to the country's exchequer. The problem is likely to escalate further, as the edible oil requirement of India will be around 4.3 million tonnes by the end of 1983-84 (Swaminathan, 1980). Other countries that use groundnut oil for cooking are Argentina, Burma and Nigeria while Brazil exports 92% of its oil production. In Senegal, Sudan, Malawi, Australia and USA, about 70% of the groundnut production is either consumed domestically as whole groundnut products (groundnut butter, confections, etc.) or exported as kernels for similar food uses elsewhere (Cummins and Jackson, 1982). In the USA, groundnuts that contain just too high a level of aflatoxin for them to be used for human consumption are crushed for oil but the cake may not be used for human and animal food.

Table 1

Area cultivated to groundnuts and production of dried pods in 1979 for major producing countries

Country	Harvested area (1000 hectares)	Production of dried pods (1000 metric tonnes)
India	7,275	5,700
China	2,525	2,638
USA	617	1,804
Sudan	980	1,100
Senegal	975	900
Asia	11,518	10,266
Africa	5,680	5,238
South America	689	945
World Total	18,659	18,437

Source : Cummins and Jackson (1982)

CONSTRAINTS TO PRODUCTION

Diseases and pests are major constraints to groundnut production. The unreliable rainfall patterns of the SAT and recurring droughts late in the season are also important factors limiting groundnut production. Other factors that contribute to low yields are lack of high yielding adapted cultivars, poor agronomic practices, and limited use of fertilizers.

Diseases :

The most widespread, and certainly the most important fungal diseases in the SAT, are seed and seedling diseases, leafspots, rust and pod rots (Mehan *et al.*, 1983). An economically important virus disease of restricted distribution is rosette that occurs only in Africa where it causes severe losses.

Table 2

Groundnut production in countries utilizing high and low levels of technology, 1979

Country	Level of Technology	Harvested area (1000 hectares)	Production (1000 metric tonnes)	Average pod yield ha**
Australia	High	36	51	1,250
Paraguay	High*	21	18	1,300
Venezuela	High	14		1,800
Brazil	High	290	470	2,200-2,500
USA	High	617	1,804	2,925
Mozambique	Low	200	100	400
Niger	Low	160	85	450
Malawi	Low	239	165	690
Senegal	Low	975	900	830
Burma	Low	668	450	830
India	Low	7,275	5,700	850
Indonesia	Low	530	792	975

Source : Cummins and Jackson (1982)

* 50% area (Western Region of Paraguay) is under a high level of technology.

** Dried pod yield at a shelling percentage of 70.

Table 3

Groundnut production and usage for oil extraction in some groundnut growing countries, 1979

Country	Production of dried pods (1000 metric tonnes)	Weight of dried kernels used for oil extraction* (1000 metric tonnes)	Estimated total oil yield** (1000 metric tonnes)
Argentina	400	228	72
Brazil	470	252	113
Burma	450	220	99
India	5,700	3,192	1,436
Nigeria	250	87	39

* Based on estimated shelling percentage of 70.

** Oil yield calculated on the basis of 45% oil content of kernels.

1. *Seed and seedling diseases :*

Seed rots and seedling diseases are of common occurrence in the SAT and collectively are responsible for 10-20% yield losses (McDonald, 1970). The problem is much worse in the less developed regions of the SAT than in regions where good quality seed is sown to produce optimum populations. Many farmers plant at a population level far below optimum and any emergent losses have direct effects on yield. These diseases may develop from fungi already established in the seeds before sowing, or may result from invasion of seeds and seedlings by soil fungi. Fungi commonly associated with seed rots and seedling diseases include species of *Aspergillus*, *Macrophomina phaseoline*, *Rhizoctonia solani* and *Fusarium*. Use of good quality, disease-free seed can help control seed rots and seedling diseases. Application of seed protectant fungicides such as thiram or captan has also proved effective in preventing attack on seed and seedlings by some soil fungi and has also reduced superficial seed-borne infections (McDonald, 1970 ; Garren and Jackson, 1973).

2. *Rust and Leafspots :*

Rust and leafspots are major causes of yield loss in groundnut worldwide (Subrahmanyam *et al.*, 1980). Leafspots (incited by *Cercospora arachidicola* and *Cercosporidium personatum)* often cause yield losses between 10 and 50% in many areas of the SAT (Garren and Jackson, 1973). When one, or both of the leafspot diseases are accompanied by rust (caused by *Puccinia arachidis*), yield losses of up to 70% may be recorded (Subrahmanyam *et al.*, 1980).

The diseases can be controlled by application of fungicides (benomyl and carbendazim for control of leafspots and chlorothalonil for control of both leafspots and rust) but this may not be economically feasible for small farmers of the SAT.

3. *Pod rots :*

Pod rots (caused by a complex of soil inhabiting fungi) are serious diseases of groundnut in some areas of the SAT. The disease is probably much more important than is at present realised and in addition to reducing pod yields (from 10 to 25 percent) can have a serious effect upon crop establishment and on quality of produce (Mehan *et al.*, 1983).

Much needs to be learnt about factors affecting pod rots before effective disease management can be advised. Much effort has been expended in recent years in screening germplasm lines for resistance to pod rots in several parts of the world.

4. *Rosette disease :*

Rosette is the most important virus disease of groundnuts in Africa south of the Sahara. In 1975 the disease appeared on one million hectares of groundnuts in Nigeria causing yield losses estimated at around 325,500 tonnes

(Yayock *et al.*, 1976). The disease also caused severe damage to the crop in Niger Republic in the same year.

High seed rates and early planting have been recommended for reducing rosette disease incidence. Considerable success has been achieved in producing rosette resistant cultivars (Gibbons *et al.*, 1977).

Pests :

Although insect pests are often limited in their distribution, some are of worldwide occurrence and importance. Among the latter are species of aphids, jassids, thrips and termites.

The groundnut aphid *(Aphis craccivora)* is the most widely distributed pest in the SAT. This sap feeder, when present in large numbers, can cause severe damage or even kill plants but, of greater general importance, is that it acts as a vector of rosette virus (McDonald and Raheja, 1980) Several species of jassids (genus *Empoasca*) attack groundnuts but *E. dolichi* and *E. kerri* are the most common in the SAT areas (Feakin, 1973).

Thrips damage can be important, especially when young plants are attacked and the leaflets become scarred or deformed. Several species of thrips attack groundnuts but only a few are pests of economic importance. These include species of *Caliothrips*, *Scirtothrips dorsalis* and *Frankliniella schultzei*. In India, the latter species is more important as vector of tomato spotted wilt virus causing bud necrosis than as a direct pest. (Amin *et al.*, 1981, Ghanekar *et al.*, 1979).

Leaf miner *(Aproaerema modicella)* is the most widespread and specific pest of groundnuts in India and in southeast Asian countries. It causes particularly severe damage under drought conditions. Damage at the seedling stage can kill the plants. Yield losses vary from 30-55% (Mohammad, 1981).

Termites belonging to the genera *Microtermes* and *Odontotermes* are the most important soil pests in India and Africa. Although *Microtermes* spp. are established pests of groundnuts in the tropics (Feakin, 1973), there are few estimates of damage. In Nigeria, yield losses of 10-15% have been recorded, and this may prove to be an underestimate. Termites *(Odontotermes spp.)* also feed on pods, scarifying shells and rendering them more susceptible to invasion by soil fungi including toxigenic species. The level of aflatoxin in seeds from termite-damaged pods is higher than that from undamaged pods (McDonald, 1970).

Pest control in groundnuts is at present largely dependent on use of chemicals. There are only a few reported instances of varietal resistance to pests in groundnuts (McDonald and Raheja, 1980).

STRATEGIES TO INCREASE GROUNDNUT YIELDS

1 Farmers should use cultivars well adapted to their specific environments, e.g. to utilize to best effect the available growing season and avoid pests and diseases.

To obtain optimum plant stands only good quality seed should be used and this should be treated with an effective protectant chemical.

Where the growing season is of limited duration the choice of cultivars is largely restricted to Spanish or Valencia types. Under longer season conditions, higher yields can be obtained by growing high yielding Virginia type cultivars.

2. Large Increases in yield (upto 70%) can be obtained by fungicidal control of rust and leafspots diseases. This strategy should vary with the risk factors involved in the crop production, with more costly inputs possible where adequate moisture is assured in the growing season. The yield response to fungicide application varies with the variety. Some cultivars can tolerate relatively large loss of leaf area through disease attack, but they usually have low yield potential. The released high yielding but foliar diseases-susceptible Indian coltivar Robut 33-1 responds very well to fungicide application.

Yield increases of 38 to 105% can be obtained when the foliar diseases and insect pests are controlled by combined applications of fungicides and insecticides, where insect pest alone is not economical (Schiller *et al.*, 1982).

High yielding lines can be used in areas where pests and diseases are not very serious or where the crop can be protected against these stress factors.

3 Greater attention should be paid to evolving high yielding cultivars with resistance to major yield reducers and these cultivars should be made available to the small farmers of the SAT — as rapidly as possible.

Rust and late leafspot resistant lines have been used in the breeding programme at ICRISAT and a number of advanced lines with high resistance to the diseases and with good agronomic characters have now been developed. These lines have significantly outyielded susceptible high yielding released cultivars under both high and low fertility conditions.

4 There is an interaction between season and cultivar and high yielding cultivars do not behave similarly in both rainy season and irrigated postrainy season. Yields of groundnuts in the irrigated postrainy season are greater (1.5 to 2.5 times) than those detained in the rainy season, primarily because of assured moisture supply and reduced or altered disease and pest situations. There has until recently been little effort to identify or develop suitable cultivars specifically for the postrainy season. This is of obvious significance in India and several other regions where areas under postrainy season groundnut are steadily increasing as irrigation facilities are extended.

STRATEGIES TO INCREASE GROUNDNUT OIL PRODUCTIVITY

1. High oil yield can be obtained through increased kernel yield per unit area.

2 High oil yield can also be achieved by developing cultivars with increased oil content

The range of oil content in the cultivated groundnut types is around 45-55% and therefore there is scope for breeding groundnuts for relatively higher oil content. Little effort in the past has been made for breeding high-yielding lines with high oil content. In some early attempts selection pressure was exerted initially for yield and subsequent selection was for oil content (Hammons, 1981). The nuclea.

magnetic resonance (NMR) spectrometer provides a simple, effective, rapid and non-destructive method for determining oil content in planting seed, permiting simultaneous selection for oil content and seed yield at each step in the breeding programme. It also facilitates screening very large numbers of genotypes from the world germplasm pool for high oil content.

3. Harvesting the crop at proper maturity would increase oil productivity.

RESEARCH AT ICRISAT

ICRISAT has been designated as a world center for the collection, maintenance and distribution of germplasm of the cultivated groundnut and its wild species relatives in the genus *Arachis*. The Groundnut Programme of ICRISAT is responsible for the improvement of yield and quality of groundnut in the SAT, and its objective is to produce high yielding breeding lines with resistance to major pests and diseases and with tolerance to drought stress.

The most important foliar diseases are the leafspots and rust. Considerable amount of effort has gone into the search for resistance to these diseases, both in the cultivated and wild species of the genus *Arachis*, and to incorporate this resistance into high yielding and commercially acceptable cultivars.

Field screening of the world germplasm collection was started in 1977 and 10,000 lines have now been tested. Of these, 34 genotypes have been found to have high level of resistance to rust, 24 have resistance to late leafspot and 17 of the genotypes have resistance to both these diseases (ICRISAT 1982). Fourteen breeding lines with rust resistance have been jointly registered by ICRISAT and USDA (Subramanyam and McDonald, 1983).

Most of the rust and late leafspot resistant lines are low yielding and have undesirable pod and seed characteristics. Breeders have been crossing them with high yielding but disease susceptible cultivars and are now well on the way to developing rust and late leafspot resistant cultivars with good agronomic characters.

Pod rots have been found to cause serious reduction in both yield and quality of groundnuts in a number of countries. Several fungal species such as *Fusarium, Macrophomina phaseolina* and *Rhizoctonia solani* have been found associated with pod rots in different areas. Field screening for resistance has been complicated by uneven disease incidence between and within fields but 11 genotypes have been found to have significantly lower incidence of rotted pods than susceptible check cultivars (ICRISAT, 1981).

The major virus diseases now being investigated at ICRISAT are bud necrosis and peanut mottle. Bud necrosis can cause yield losses of over 50% and it occurs in all major groundnut growing areas of India (Ghanekar *et al*., 1979). Seven thousand lines have been screened under high natural disease pressure in the field but none showed resistance to the disease. However, the cultivar Robut 33-1 has consistently given lower than average field incidence of the disease. Five hundred germplasm lines have been screened for resistance to peanut mottle using a field mechanical inoculation technique. All proved susceptible but 4 lines showed less than 5% yield loss compared with 12 to 60% losses from infected plants of other lines. Two genotypes were found to have no seed transmission of peanut mottle virus from infected mother plants.

Aflatoxin contamination of groundnut is a serious quality problem. Research at ICRISAT has concentrated on finding genetic resistance to invasion of pods and seeds by *A. flavus* and/or to production of aflatoxin in the event of seeds becoming infected by a toxigenic strain of the fungus. Breeding lines with testa resistance to invasion of rehydrated dried seeds were reported by Mixon and Rogers (1973) from the USA. This resistance was confirmed at ICRISAT and several more genotypes were identified one of which is the commercial Indian cultivar J 11 (Mehan and McDonald, 1983). Several of the *A. flavus* resistant genotypes have been entered in breeding trials to combine the testa resistance factor with acceptable levels of yield.

A number of germplasm lines have also been tested for resistance to aflatoxin production following invasion of seeds by toxigenic strains of *A. flavus*. All genotypes supported aflatoxin production but significant varietal differences in rate of accumulation and total toxin produced were found (Mehan and McDonald, 1981).

Germplasm is being screened for resistance to thrips, jassids, leafminer and termites and several sources of resistance have been identified to thrips, jassids and termites. No high level resistance has yet been found to leafminer. Sources of resistance to jassids and thrips are now being utilized by breeders to develop high yielding cultivars with resistance to these pests.

Quality of Groundnuts :

The acceptance of the groundnut and groundnut products as food is unique among major oilseeds. Groundnuts are pleasantly flavoured and can be prepared into various food forms. Groundnuts have about 50% oil and 25% protein content. They have more than twice the oil content of soybeans and groundnut oil is easily extracted and may be used directly without further processing (Rao, 1982). However, groundnuts do have some undesirable traits e.g., poor quality of protein, presence of antinutritional factors and high susceptibility to aflatoxin contamination. Groundnuts show deficiency in at least three essential amino acids — lysine, threonine, methionine. Recently, observations on atherogenesis induced by groundnut oil in animal has also raised concern (Rao, 1982).

At ICRISAT we have recently initiated a project to improve the oil and protein quality of groundnuts. A considerable variability in germplasm for oil and protein has been found and breeders will utilise this in developing high yielding lines with superior protein and oil quality. Triglycerides are the major components of groundnut oil and have been reported to be responsible for atherogenesis in animals. There is thought to be genetic potential to develop a nonatherogenic groundnut (Hokes and Worthington, 1979).

A project has just started on investigating marketing of groundnuts. It is intended to describe marketing channels in India and worldwide, to assess relative preferences for quality attributes as expressed in market price in India, and to assess relative world markets for confectionary versus high oil cultivars.

The Problem of Aflatoxin Contamination of Groundnut :

Aflatoxin contamination of groundnut is a serious quality problem in the SAT. Groundnuts may be invaded by toxigenic strains of *Aspergillus flavus* group fungi and aflatoxins ground, during post-harvest drying and in storage. Factors such as damage to pods by parasitic fungi, perforation of shells by termites and other soil fauna, and late season drought stress have been shown to predispose groundnuts to fungal invasion and aflatoxin contamination (Mehan and McDonald, 1983). Crop handling and storage methods have been evolved that could greatly reduce aflatoxin contâmination. However, these approaches have had little success in the SAT. Research has shown that some cultivars are highly resistant to seed invasion by toxigenic *A. flavus*. Th3 best approach to prevention of aflatoxin contamination of groundnuts would be the utilization of genetic resistance either to invasion of pods and seeds by *A. flavus*, or to production of aflatoxin. Both of these approaches are currently under investigation at ICRISAT (Mehan and McDonald, 1983).

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