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Production Aspects of Groundnut and Future Prospects

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Abstract. *Groundnut seeds are rich in oil (36-54%), and protein (21-36%), and have a high energy value 2363 KJ(100g)$^{-1}$ of seed. They are used for oil extraction, as food, and in confectionery products. The cake remaining after extraction is processed for animal feed and human consumption. The haulms are valued as fodder. Cultivated groundnut, a native of South America, is grown on 20 million ha in about 80 countries, with a total production of 21.5 million t. The approximate geographic limits of present commercial production are between latitudes 40°N and 40°S. Groundnut is mostly grown in Asia followed by Africa, North, and Central, and South America. Groundnut crops are found on farms at all levels of development - from bush clearings in Africa to the highly mechanized high-input farms of North Carolina and Georgia in the USA. Productivity varies accordingly - from 300 kg ha^{-1} to 10 t ha^{-1}. The key to high yields is identifying and overcoming the constraints to production.*

Introduction

Groundnut is a native of Bolivia and northeast Argentina on the eastern slopes of the Andes mountains in South America. The crop is now grown throughout the tropical and warm temperate regions of the world. Although groundnut is predominantly a crop of the tropics, the approximate limits of present commercial production lie between lattitudes 40° N and 40° S.

Groundnut is rich in oil (36-54%) and protein (21-36%) and has a high energy value of 2363 KJ.100 g^{-1}. Seeds are used for oil extraction, as food, and as an ingredient in confectionery products. After extraction, the residual cake is processed largely for use as animal feed, but also for human consumption. The haulms are valued as fodder.

Groundnut Production

Production of groundnut in the semi-arid tropics (SAT) exceeds that of any other legume and comprises 70% of the world production. It is grown on an average 18.8 million ha in

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about 103 countries with a total production of 18.5 million t (Various issues of FAO Production Year Book from 1974 to 1986). The crop is mainly grown in Asia followed by Africa, North, Central, and South America. Average crop yields are highest in North and Central America (2.5 t ha^{-1}) and lowest in Africa (0.8 t ha^{-1}). Average yields in Asia are 1 t ha^{-1}. Except for Europe, average yields in other regions are low in comparison with those from the USA (3.3 t ha^{-1}) and much lower than the potential yields of over 10 t ha^{-1} reported from research farms in Zimbabwe.

Groundnut is cultivated on farms at all levels of development - from bush clearings to the highly mechanized high-input farms of North Carolina and Georgia in the USA. The crop is also grown in different cropping patterns, i.e., as a mono-crop, mixed- or inter-crop.

In the rainfed SAT early- and medium-duration varieties are grown mainly for oil, but also for use as food and fodder. Where supplemental irrigation is available or the growing season is long, medium- and long-duration varieties are grown for oil and confectionery uses. Under a high-input system, confectionery types are normally preferred; the early types are grown in a residual moisture situation. The productivity of the crop varies with the farming system. There is need for research to identify and overcome the factors responsible for low yields.

Constraints to Production

Major constraints to groundnut production are:
- damage by diseases and pests;
- unreliable rainfall patterns, with recurring drought;
- nutritional stresses;
- poor agronomic practices with limited use of fertilizers; and
- lack of high-yielding adapted cultivars.

Groundnut Research at ICRISAT Center

At ICRISAT we are integrating plant breeding, plant pathology, entomology, microbiology, physiology, and cytogenetics research to produce high-yielding adapted cultivars with stable resistance or tolerance to the major stresses presently limiting production. Our groundnut scientists cooperate with economists, cropping systems specialists, and agronomists to develop crop management systems applicable to the small farmer. The world collection of groundnut and wild *Arachis* germplasm provides the basis for crop improvement efforts.

The problems of growing groundnut all over the world are studied intensively at ICRISAT Center. Problems more specific to particular regions are worked on in ICRISAT regional programs or through cooperative research with national programs. The program at ICRISAT Center works closely with the ICRISAT Regional Groundnut Program for Southern Africa, set up in Malawi in 1982, and the West African Program based at the ICRISAT Sahelian Center in Niger that started in 1986. There is regular flow of improved germplasm between the Center and regional programs, and networks have been established for effective evaluation of cultivars.

Diseases

Foliar diseases. The world collection of over 12 000 accessions has been screened for resistance to rust (*Puccinia arachidis* Speg.) and late leaf spot [*Phaeoisariopsis personata* (Berk. & Curt.) v. Arx] diseases at ICRISAT Center. There are 78 lines with good resistance to rust, 34 with resistance to late leaf spot, and 31 combining resistance to both diseases (Branch and Csinos 1987). Interspecific hybrid derivatives with high levels of resistance to rust and/or late leaf spot have also been bred. The sources of rust and late leaf spot resistances have been used in a breeding program, and lines combining these resistances with good agronomic characters are now in international trials. A groundnut variety, ICCV 87160, with resistance to rust and tolerant to late leafspot has been released in 1990 for rainy-season cultivation in India.

An epidemic of early leaf spot at ICRISAT Center in 1987, and establishment of a collaborative field resistance screening project at Pantnagar in northern India, have accelerated the work on this disease. During 1987, 33 out of 618 germplasm lines, 3 out of 641 breeding lines, and 5 out of 1665 interspecific hybrid derivatives showed satisfactory levels of resistance to early leaf spot at ICRISAT Center. Of these promising lines, 13 genotypes were found to be resistant even at Pantnagar during 1988 (Waliyar et al. 1990). Some of these lines are also resistant to rust and late leaf spot.

Studies continue on the influence of environmental factors and agronomic practices on development of foliar diseases.

Diseases caused by soil fungi. Field screening of germplasm lines under naturally occurring outbreaks of a pod rot complex caused by *Fusarium* spp, *Macrophomia phaseolina* and *Rhizoctonia solani* has identified several resistant lines, some of which are also resistant to pod and seed invasion by *Aspergillus flavus*.

More recently, field screening of germplasm and breeding lines against *Sclerotium rolfsii* with artificially enhanced inoculum levels has identified susceptible and moderately resistant material (Branch and Esinos 1987). Stem and pod rots caused by *S. rolfsii* are most serious in groundnut grown on Vertisols, and it is important that advanced breeding lines be screened to eliminate unduly susceptible material before release.

Aflatoxin contamination. Factors influencing the invasion of groundnut pods and seeds by the aflatoxigenic *Aspergillus flavus* have been studied in relation to genetic resistance and cultural control measures. The importance of drought in relation to pre-harvest contamination has been confirmed, and drought stress used to enhance resistance screening methods (Mehan et al. 1988). Several germplasm lines with resistance to seed invasion by *A. flavus* have been identified (Mehan 1989) and used in a breeding program, and some breeding lines have good levels of resistance (Rao et al. 1988). Crosses have been made to combine seed coat resistance to *A. flavus* infection with low capacity to support aflatoxin production. A data base on published information on aflatoxin in groundnut is in preparation.

Virus diseases. Bud necrosis disease (BND) caused by tomato spotted wilt virus (TSWW) affects the groundnut and is economically important in South and Southeast Asia. Several high-yielding germplasm and breeding lines with resistance to the thrips (latin name) vector of BND (ICRISAT 1987) have been tested for resistance to TSWW, and ICGV 86029 and ICGV 86031 have been found tolerant (ICRISAT 1988). Peanut mottle virus (PMV) disease is of worldwide distribution and can cause significant yield losses (Demski et al. 1975). Several germplasm and breeding lines showing non-seed transmission and tolerance to PMV have been identified (ICRISAT 1988). Serological tests have been developed for the detection of peanut clump virus. Soil solarization was found to be effective in controlling this disease (ICRISAT 1987). Peanut stripe virus is currently recognized as one of the most important diseases affecting the groundnut crop in Southeast Asia (Rao et al. 1988). Screening for resistance to this disease through international cooperation is in progress in Indonesia.

Pests

Particular emphasis has been placed on the development of pest control strategies that do not involve the use of pesticides, or that rationalize their use. The prime aim is to introduce pest resistance into zonally adapted varieties. Germplasm lines with resistance to major pests that attack the leaves and stems of groundnut plants (jassids, thrips, leaf miner and *Spodoptera litura*) and to some soil insects that attack below-ground parts (termites and pod borers) have been identified, and are being used in breeding programs (Amin et al. 1985, ICRISAT 1988, ICRISAT 1989). Progress has been made in defining the mechanisms of pest resistance. The feasibility of combining host-plant resistance and natural control by the use of parasites and predators are being investigated, their aim being to keep pest populations down to levels that do not reduce yields. Effects of cropping patterns—monocrop, multicrop, intercrop—on pest populations are also being investigated. Studies are being conducted to determine the damage thresholds of *Spodoptera litura*. Collaboration between entomologists and virologists has led to an increased understanding of the role of thrips as the vector of TSWV.

Drought

Research on the physiological basis for genetic differences in drought response has had considerable impact on drought screening at ICRISAT Center. Drought-tolerant lines have been identified and used in breeding for improved drought resistance. Some lines with resistance to foliar diseases have also shown drought tolerance. The greatest opportunity for improving genotypes for use in drought-prone areas lies in capitalizing on the ability of some cultivars to recover from mid-season drought. This attribute is therefore being used in screening breeding materials. Research is focussed on root respiration and growth, the mechanisms determining recovery from drought, and on water use efficiency. Photoperiod also influences drought responses (ICRISAT 1988), and genotypes are being screened for photoperiod insensitivity (ICRISAT 1989).

Nutrient Stresses

Biological nitrogen fixation is not usually a limiting factor to groundnut production in locations with a history of groundnut cultivation. Genotypic differences in the rate of nitrogen fixation are dominated by leaf area effects (90% of variance), and the differences directly attributable to genotypes are small (2-6%) (Nigam et al. 1990).

Iron chlorosis has been shown to be caused by two mechanisms, high soil pH and periodic waterlogging. Genotypic differences in susceptibility to iron deficiency exist in groundnut (Hartzook et al. 1974, Hartzook et al. 1972), and limited screening of breeding lines has been initiated at ICRISAT Center.

Calcium deficiency is a major limiting factor for groundnut production in some countries. Research is in progress to investigate reported genotypic differences in the calcium uptake efficiency of pods. Consistent and significant genotype × drought × gypsum interactions have been demonstrated (Rajendrudu and Williams 1987).

Plant Improvement

Major thrust areas in the groundnut breeding at ICRISAT Center have been identified.

Zonalization of groundnut growing environments. Based on biotic and abiotic stresses and agroclimatological data bases our investigations include identification of the important combinations of stresses and the required maturity duration in different regions. This exercise is undertaken in collaboration with the Agroclimatology Unit of the Resource Management Program.

Development of varieties/populations adapted to specific environments and requirements. Early-, medium-, and long-duration varieties with resistance to relevant combinations of stress factors that will fit well into existing farming systems, and that are attuned to consumer preferences are being developed.

Most of the progress so far has been made in breeding cultivars which are high yielding under no-stress situations, or which have resistance/tolerance to single stress factors. It is now intended to develop varieties with multiple resistances.

In addition to supplying early-generation populations, ICRISAT also offers international trials of advanced generation breeding lines to cooperators. Several ICRISAT-bred lines are in the advanced stage of testing in various national programs or have been released by them. Jamaica has released one of improved germplasm line Tifrust 2 (ICG 7886) as 'Cardi-Payne'. The Republic of South Korea has released ICGV 87127 as 'Jinbungtangkong'. Pakistan has released 'BARD699', a composite of ICGV 87187 and ICGV 27128). Releases in Malawi, Zambia, and Nepal are awaited.

In India (ICGV 87123) and ICGV 87128 have been released and are increasingly becoming popular with Indian farmers. More recently ICGV 87141, 87119 and 87160 for rainy season cultivation and ICGV 87187 for postrainy season cultivation have been released for various groundnut zones in India. The variety ICGV 87121 has been released in Uttar Pradesh state of India for rainy season cultivation. Progress has also been made in developing cultivars for confectionery purposes, and several lines have shown good performance in international trials (ICRISAT 1989).

Agronomy and Crop Production

ICRISAT groundnut scientists cooperate with those of the Resource Management Program in providing cultivars and advice to enable national program scientists/extension workers to put together management systems appropriate to local conditions.

The Legumes On-Farm Testing and Nursery Unit (LEGOFTEN) of the Legumes Program actively cooperates with the scientists and extension workers in India to demonstrate the potential of improved technology and varieties of groundnut in farmers' fields. The results of the past two seasons have been highly encouraging. They have clearly shown that the potential of high-yielding varieties and improved technology is within the farmer's reach.

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