An Update on Groundnut Improvement at ICRISAT Center

S.N. Nigam, D. McDonald, F. Waliyar, D.V.R. Reddy, J.A. Wightman, J.P. Moss, and J.H. Williams[1]

Since 1976, when groundnut became the fifth mandate crop of ICRISAT, research focused on major constraints to groundnut production in the semi-arid tropics. These are: diseases, insect pests, drought, poor nutrition, and lack of high yielding varieties with specific adaptation and requirements. Within these major areas, specific research goals have been identified. Genetic exploitation and improvement are considered to be an integral part of the many approaches that need to be merged into a single management package.

Diseases

Rust and late leaf spot are serious diseases of groundnut. A germplasm collection more than 11 000 accessions of cultivated groundnut and wild *Arachis* species has been screened and several sources of resistance to rust and late leaf spot have been identified. Components of resistance to rust and late leaf spot have been studied, and the inheritance of rust resistance determined. In general, the resistances have proved to be stable. Sources of rust and late leaf spot resistances have been used in a breeding program. Lines combining resistances with good agronomic characters have been developed and are now in multilocational trials in SAT countries. Two cultivars, ICG(FDRS) 4 and ICG(FDRS) 10 are likely to be released soon in India. Screening for resistance to early leaf spot has commenced and several sources of resistance have been identified in field trials in India and Nepal. This is of particular significance to southern Africa where early leaf spot is a serious problem. Wild species have shown resistance in trials in Malawi; these are being used in crosses at ICRISAT Center. Field screening of germplasm at ICRISAT Center has resulted in the identification of genotypes with moderate resistance to pod, root and stem rots caused by *Sclerotium rolfsii*. Several genotypes with resistance to pod rot caused by species of *Fusarium, Macrophomina phaseolina* and *Rhizoctonia solani* have been identified. Several of the genotypes also have resistance to preharvest seed infection by *A. flavus*. In Indonesia, collaborative research program is being initiated on screening for resistance to bacterial wilt caused by *Pseudomonas solanacearum*.

1. Principal Groundnut Breeder; Principal Groundnut Pathologist and Group Leader; Assistant Principal Groundnut Pathologist; Principal Virologist; Principal Groundnut Entomologist; Principal Cytogeneticist; and Principal Groundnut Physiologist, Legumes Program, ICRISAT Center, Patancheru, A.P. 502 324, India.

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Virus diseases cause severe losses in groundnut yield in many regions of the world. Bud necrosis disease (BND) caused by tomato spotted wilt virus (TSWV) is economically important in South and East Asia and in the USA. Several high-yielding germplasm and breeding lines with resistance to the thrips vector of BND were tested for resistance to TSWV. ICGV 86029 and 86031 were tolerant to TSWV. Peanut mottle virus (PMV) disease is of worldwide distribution and can cause significant yield losses. Several germplasm and breeding lines showing nonseed transmission and tolerance to PMV have been identified. Serological tests for the detection of groundnut clump virus have been developed. Solarization was found to be effective in controlling groundnut clump disease. Peanut stripe virus (PStV) is currently recognized as one of the most important groundnut diseases in southeast Asia. In Indonesia, screening for resistance to this disease is under way, with international cooperation. Groundnut rosette is the most important virus disease of groundnut in Africa. International research on groundnut rosette is being coordinated by ICRISAT, and research on the epidemiology of the disease and resistance breeding is being carried out at the ICRISAT Regional Groundnut Program for Southern Africa in Malawi. Wild *Arachis* species have been screened for rosette resistance and are being used in breeding programs.

Aflatoxins

Contamination of groundnut seed and products with aflatoxins is a serious quality problem in most groundnut-producing countries. Several genotypes with resistance to seed invasion by *Aspergillus flavus* and/or aflatoxin production have been identified and are being used to develop *A. flavus* -resistant cultivars with good agronomic traits. Some of the breeding lines with *A. flavus* resistance are being tested in multilocational trials. Use of these genotypes in combination with recommended crop-handling practices should help to reduce aflatoxin contamination. The interaction of *A. flavus* resistance and drought is being used to improve the efficiency of resistance-screening techniques. An enzyme-linked immunosorbent assay is being developed for estimating aflatoxin contamination in groundnuts.

Pests

ICRISAT research on the insects living on groundnut plants and stored groundnut products covers a wide spectrum of activities with emphasis on the development of pest-control strategies that include no pesticides or that include minimal pesticide application. Our prime aim is to introduce pest-resistance into zonally adapted varieties. Germplasm lines with resistance to the major pests that attack the leaves and stems (jassids, thrips, and leaf miner) and some soil insects (termites and pod borers) were identified. The breeding aspects are well advanced with many promising varieties in the pipeline. Progress has been made on defining the characteristics of pest-resistance. Investigations on combining host-plant resistance and natural control by the use of parasites and predators are under way to keep the pest populations at levels that do not reduce yields. Effects of cropping patterns—monocrops, multicrops, and intercrops—on pest populations are also under investigation. Studies are under way 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.

Surveys carried out in five countries in the SADCC region of southern Africa showed that foliage insects were not a problem, but soil pests such as termites, millipedes, wireworms, false wireworms, and ants were often causing serious yield losses.

A bruchid (*Caryedon serratus*) is a serious storage pest of groundnut throughout Africa and in peninsular India. We screen all lines that are prepared for release against this pest.

We are helping the national programs in Asia to think in terms of integrating all aspects of pest management so that insecticide application is rationalized. Similar activities will be extended throughout Africa.

Drought

Research establishing the physiological basis for genetic differences in drought response has had considerable impact on drought screening at ICRISAT Center. Lines with tolerance to drought have been identified and were used in breeding programs to improve drought resistance. Fortunately some of the lines originally identified for resistance to foliar pathogens also had drought tolerance. We found that the greatest opportunity for improving genotypes for use in drought-prone areas lies in the recovery from mid-season drought and this attribute is being used to screen breeding materials. Research is focused on root respiration and growth, mechanisms determining recovery from drought and water-use efficiency. Photoperiod was found to influence drought responses and genotypes are being screened for photoperiod insensitivity.

Nutrient Stress

Biological nitrogen fixation is usually not a limiting factor to groundnut production in locations with a long history of groundnut cultivation. We found that genotypic differences in the rate of nitrogen fixation are dominated by leaf-area effects (90% of variance) and differences attributable to genotypes are small (2-6%). Groundnut intercropped with nitrogen-fertilized millet, maize, or sorghum fixed less nitrogen than did a sole crop. It was found that application of inoculum directly into the furrow just before sowing was effective. Deep sowing resulted in the development of an elongated hypocotyl, poor nodulation, and reduced nitrogen fixation, especially in spanish cultivars. Earlier research had identified *Rhizobium* strain NC 92 as having a beneficial effect on crop growth and improving yields, but after a great deal of research we have been able to show that these benefits are probably not due to direct effects on biological nitrogen fixation, and we have now moved the resources to other areas of research.

Iron chlorosis has been shown to be caused by two mechanisms, high soil pH and periodic waterlogging. Genotypic differences exist in susceptibility to iron chlorosis and limited screening of breeding lines has been initiated.

Calcium deficiency is a major limiting factor for groundnut production in many parts of the world. Research was initiated to investigate reported genotype differences in

calcium-uptake efficiency of pods. Consistent and significant genotype × drought × gypsum interactions were demonstrated.

Breeding for Adaptation to Specific Environments and Requirements

This is the major breeding activity at the ICRISAT Center. Most of the progress so far has to do with the development of varieties under nonstress situations, or where stresses could be overcome by management practices. Using this, and other improved breeding lines with resistance/tolerance to single-stress factors as base material, we are now aiming at developing lines with multiple resistances.

Early maturing varieties are advantageous in areas where the growing season is short, or the crop is grown in a residual-moisture situation, or in multiple cropping systems. Maturity period is largely dependent on temperature regime, solar radiation, moisture and other factors during the growth period. Use of cumulative heat units (degree days) was found to be effective to determine the maturity. Several early maturing cultivars were developed and are being evaluated in many countries in the SAT.

Considerable progress has been made in the development of medium- and late-maturing cultivars. ICGS 11 (ICGV 87123) and ICGS 44 (ICGV 87128) have been released for the postrainy-season cultivation in India. Other varieties awaiting release for the rainy season cultivation are ICGS 1 (ICGV 87119), ICGS 5 (ICGV 87121), and ICGS 11 (ICGV 87123). Progress was made on development of groundnut cultivars for confectionery purposes. Several confectionery varieties showed good performance in multilocational trials in the SAT.

Utilization of Wild *Arachis* sp

About 100 accessions of wild *Arachis* species are being maintained at ICRISAT Center. All these accessions were screened for desirable characters, with particular emphasis on resistance to leaf spots and to diseases where resistance has not been found in *A. hypogaea,* so that these desirable characters could be transferred to the cultivated groundnut. Only the species in the section *Arachis* are cross-compatible with cultivated groundnut, and others cannot be crossed by conventional means. Many species have been analyzed cytologically. The sterility in crosses within the section *Arachis* has been successfully overcome by ploidy manipulations. Progress has been made in overcoming barriers to intersectional hybridization through the use of growth hormones. Tissue culture technology has been applied to the culture of young ovules from wide crosses.

International Cooperation

The ICRISAT Center program interacts with the national programs either directly or through the ICRISAT regional programs and networks. The two regional groundnut

programs in Africa have direct responsibility of West and southern Africa. The Center program largely concentrates on Asia, East and Central Africa, the Americas, and other regions. It contributes newly developed material to regional programs in the form of trials and other breeding populations. Many ICRISAT varieties have been released or identified for release in various countries. Other cooperative activities include organization of workshops, meetings, and specialized training courses.