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ABSTRACT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has a global mandate for the improvement of groundnut, pigeonpea and chickpea. Research is conducted into ways of alleviating the major biotic and abiotic factors that adversely affect these leguminous crops, and is largely targetted towards resource-poor farmers relying on rainfed agriculture. Genetic improvement efforts are enhanced by the establishment, characterization, evaluation and maintenance of the world germplasm collection for these crops at ICRISAT Center in India. Progress has been made in incorporating disease and pest resistance and in developing new plant types for alternative cropping systems. Improved management options have also been evolved to better exploit the genetic yield potential of traditional and improved varieties. With progress in the solution of research problems and the development of national research capabilities ICRISAT's role is changing towards an increase in strategic research in areas such as cell biology.

Introduction

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has a global mandate for the improvement of groundnut (*Arachis hypogaea* L.), pigeonpea (*Cajanus cajan* (L.) Millsp.), chickpea (*Cicer arietinum*. *L.*), sorghum (*Sorghum bicolor* (L.) Moench) and pearl millet (*Pennisetum glaucum* (L.) R. Br.). Groundnut, pigeonpea and chickpea are leguminous crops grown predominantly under rainfed conditions by resource-poor farmers in semi-arid environments. Although the major product of these legumes is the dry grain, there are circumstances where they may be used as "vegetable crops". Examples are the consumption of green pods and seeds of pigeonpea and chickpea and the use of groundnut as a boiled vegetable. Further, in areas where food habits are diversifying as a consequence of rapidly increasing per capita income, there are opportunities for developing these crops to provide high value speciality products under intensive cultivation in non-traditional areas, analogous to the situation for vegetable production.

This paper outlines the current production and utilization of these legumes and summarizes the research at ICRISAT for their improvement. More detailed information may be obtained from recent Annual Reports of ICRISAT and the following publications : Baldev *et al.* (1988), Gibbons (1986), Goldsworthy and Fisher (1984), (ICRISAT (1981), ICRISAT (1987), Pattee and Young (1982), Porter *et al.* (1984), Reddy (1988), Saxena and Singh (1987), Summerfield (1988), Summerfield and Roberts (1985), Wallis and Byth (1987), Wightman and Amin (1988).

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Table 1 Global area, production and yield of groundnut, pigeonpea and chickpea in 1987

Region/Country	Area ('000 ha)	Production ('000 t)	Yield (kg ha)
	Groundnut (in shell)[1]		
Asia	11,177	12,784	1,144
China	3,108	6,082	1,957
India[3]	6,300	4,500	714
Africa	5,721	4,696	821
Senegal	846	876	1,035
Nigeria	630	740	1,175
North and Central America	787	1,829	2,324
USA	620	1,627	2,624
South America	409	715	1,750
Argentina	185	425	2,297
World total	18,149	20,103	1,108
	Pigeonpea[2]		
South Asia	3,317	2,368	714
India[3]	3,236	2,316	716
Burma	54	36	672
East Africa	252	155	616
Malawi	134	90	672
Caribbean	41	31	751
Dominican Republic	12	11	932
World total	3,609	2,554	707
	Chickpea[1]		
South Asia	8,205	5,327	649
India[3]	6,781	4,455	657
Pakistan	1,082	583	539
Mediterranean and West Asia	1,211	1,105	912
Turkey	666	750	1,126
Iran	106	77	721
Spain	91	64	703
Morocco	85	50	588
Sub-Saharan Africa	257	163	634
Ethiopia	180	120	667
Americas	194	208	1,072
Mexico	150	180	1,200
Australia	71	67	944
World total	9,937	6,870	691

1 Data from FAO (1988).
2 Data courtesy Dr. E. A. Kueneman, FAO, Rome.
3 Values lower than in previous years due to drought (e. g. groundnut production 74% and chickpea production 77% of 1986).

Current world production

Groundnut is mainly grown in Asia under rainfed conditions (Table 1). Data for 1987 indicate considerably greater production in China than in India but in the previous year production was about equal in these two countries (FAO, 1988) : this was primarily due to the drought in India in 1987. Groundnut is also grown under high input conditions, for instance in the southeastern part of the United States of America (USA) and in Argentina, where yields of over 2 t/ha are obtained. World production has increased slightly during the 1980s but production in China has almost doubled in this period, due to increases in both area and yield. In Africa, where groundnut can be important both as a subsistence and cash crop, marked changes in production pattern have taken place during the 1980s. For example, production in Sudan has declined whereas it has increased in Senegal.

Pigeonpea is predominantly a crop of India but it is also grown extensively in the rest of South Asia, the Caribbean region and eastern Africa (Table 1). Production data for countries other than India are likely to be underestimates. For example, we understand that Kenya is the largest producer of pigeonpea in eastern Africa but there are no data available for inclusion in Table 1 (i. e. for 1987). Most production of pigeonpea is from longer duration genotypes normally grown in intercropping or mixed cropping systems. However, in recent years, short-duration pigeonpea, grown as a monocrop in rotation with a winter crop such as wheat, has become increasingly popular in northern India.

Chickpea is also largely a crop of South Asia where "desi" types with relatively small brown seeds predominate (Table 1). West Asia and the Mediterranean region are major producers of the large, white-seeded "kabuli" types. The crop is invariably grown with minimal inputs on residual soil moisture. Over the previous decade, the production and yields in South Asia have shown large annual variations (FAO, 1988) due to the occurrence of foliar diseases and drought. In the Mediterranean countries and West Asia the area sown to chickpea, rather than the yield, has been increasing. In Australia commercial production of chickpea was virtually non-existent ten years ago.

Utilization

In India and China, groundnut is largely used for oil extraction and in China it is widely consumed as a boiled vegetable. Elsewhere it is used primarily for confectionery purposes, such as roasted snacks or peanut butter. In resource-poor rural areas it can be an important supplement to carbohydrate-rich but protein-deficient staple foods such as cereals and cassava. The haulms of groundnut, and the cake after oil extraction, are used as protein-rich animal feed.

In India, pigeonpea is consumed mostly as "dhal" (split pea). In the Caribbean and eastern Africa, and also in some regions of India such as Gujarat State, either the green whole pods or the shelled peas are eaten as a vegetable. The stems of pigeonpea are extensively used as fuel wood or as building material. The leaves, particularly of perennial plant types that can be ratooned, are used as fodder. Dry grain, and its by-products after dehulling, is also used as animal feed.

Chickpea is also mainly consumed as "dhal", or as "besan" (flour). Fresh, immature green seeds are eaten in many locations while the whole dry seed can be soaked and processed into various snacks. There is a multitude of recipes for chickpea. Both hay and dry grain are used as animal feed.

Research mandate and deployment

The research mandate of ICRISAT for groundnut, pigeonpea and chickpea is to strengthen capabilities of national programs in increasing productivity of these crops so

Table 2 Locations of ICRISAT research on legumes, where ICRISAT staff are located

Location	Groundnut	Pigeonpea	Chickpea
India			
ICRISAT Center, Patancheru (18°N)	+ + +[1]	+ + +	+ + +
Hisar (29°N)	+	+ +	+ +
Gwalior (26°N)		+ +	+
Anantapur(15°N)	+	+	–
Pakistan			
Islamabad(34°N)	–		+ +[2]
Syria			
ICARDA[3], Aleppo(36°N)			+ + +
Niger			
ICRISAT Sahelian Center, Niamey (13°N)	+ +		–
Malawi			
SADCC[4], Chitedze (14°S)	+ +		–
Zimbabwe			
SADCC, Matopos(20°S)	+	–	
Kenya			
EARCAL[5], Nairobi (1°S)	+	+ +	+

1) Activity rating : + + + major, + + moderate, + minor, – none.
2) To June 1989 (special project funding).
3) Collaboration between ICRISAT and ICARDA (International Center for Agricultural Research in Dry Areas).
4) Southern African Development Coordination Conference.
5) East African Regional Cereals and Legumes Network. Legumes staff to be appointed shortly.

as to meet national requirements. Most of ICRISAT's direct research activity is conducted at ICRISAT Center near Hyderabad in central India but there are also subcenters with important components of research (Table 2). Much experimental work is also done with national programs of collaborating countries, at their locations. Further, ICRISAT collaborates with various advanced research institutes that have capabilities in particular aspects of problems to be solved.

Overcoming constraints

Biotic

The major diseases and pests of the ICRISAT mandate legumes are summarized in Table 3.

At ICRISAT Center, field screening of groundnut germplasm and related wild species has identified sources of resistance to late leaf spot and rust. These sources have been used as parents in the breeding program and resistant lines with acceptable quality and yield are now in advanced stages of evaluation in national programs. Screening for resistance to early leaf spot is done mainly at the ICRISAT Regional Program in Malawi where this disease regularly causes severe damage. Interspecific hybridization is the most likely way to transfer resistance to this disease into cultivated groundnut.

Invasion of groundnuts by *Aspergillus flavus* and subsequent production of aflatoxins is a serious problem in many countries, especially where groundnuts are exported. Several genotypes with resistance to pre- and post-harvest invasion of seed by *A. flavus* have been identified and are being used in breeding programs. Use of resistant genotypes,

Table 3 Major biotic constraints to ICRISAT's mandate legumes

Name Disease	Distribution	Name Pest	Distribution
	Groundnut		
Rust (*Puccinia arachidis*)	Pandemic	Virus vectors (e. g. *Aphis craccivora*)	Pandemic
Early leaf spot (*Cercospora arachidicola*)	Pandemic	Leaf miner (*Aproaerema modicella*)	Asia
Late leaf spot (*Phaeoisariopsis personata*)	Pandemic	Tobacco catapillar (*Spodoptora litura*)	Asia
Web blotch (*Didymella arachidicola*)	Southern Africa, North America	Termites (e. g. *Microtermes* spp.)	Pandemic
Collar rot (*Sclerotium rolfsii*)	Pandemic	White grubs (e. g. *Holotrichia* spp.)	Africa and Asia
Aflatoxins (*Aspergillus flavus*)	Pandemic	Millepedes (e. g. *Peridontopyge* spp.)	West Africa
Bacterial wilt	Mainly East and Southeast Asia		
Virus diseases			
mottle	Pandemic		
rosette	Sub-Saharan Africa		
clump	West Africa, South Asia		
stripe	S. E. Asia, North America		
bud necrosis	South Asia, Australasia, North America		
Nematodes	Pandemic		
	Pigeonpea		
Fusarium wilt (*Fusarium udum*)	Pandemic	Pod borer (*Helicoverpa armigera*)	Pandemic
Phytophthora blight (*Phytophthora drechsleri* f. sp. *cajani*)	South Asia	Podfly (*Melanagromyza obtusa*)	South Asia
Alternaria blight (*Alternaria alternata*)	South Asia	Leaf webber (*Cydia critica*)	Asia
Cercospora leaf spot (*Cercospora* spp.)	Pandemic	Spotted borer (*Maruca testulalis*)	Pandemic
Macrophomina blight (*Macrophomina phaseolina*)	Pandemic	Blister beetle (*Mylabris pustulata*)	South Asia, Africa
Stem canker (*Xanthomonas cajani*)	Pandemic	Bruchids (e. g. *Callosobruchus* spp.)	Pandemic
Sterility mosaic disease	South Asia		
Witches, broom	Caribbean		
Nematodes	Pandemic		
	Chickpea		
Fusarium wilt (*Fusarium oxysporum* f. spp. *ciceri*)	Pandemic	Pod borer (*Helicoverpa armigera*)	Pandemic
Ascochyta blight (*Ascochyta rabiei*)	Higher latitudes	Leaf miner (*Liriomyza cicerina*)	Mediterranean region, West Asia
Botrytis gray mould (*Botrytis cinerea*)	Sub-tropics to higher latitudes	Bruchids (e. g. *Callosobruchus* spp.)	Pandemic
Dry root rot (*Rhizoctonia bataticola*)	Pandemic		
Collar rot (*Sclerotium rolfsii*)	Pandemic		
Stunt (Bean Leaf Roll Virus)	Pandemic		
Nematodes	Pandemic		

in combination with crop handling methods, hold promise to minimize risk of aflatoxin contamination.

Groundnut virus characterization and detection methods developed at ICRISAT are now being used in disease surveys and should provide more reliable data on global incidence and importance of virus diseases. For peanut mottle and rosette virus diseases, sources of host-plant resistance have been found and these are being used in breeding programs. International working groups have been set up to coordinate research on groundnut rosette and peanut stripe virus diseases.

Some insects of groundnut, such as *Aphis craccivora* and thrips, are important because of both the direct damage they do to the plant and their role as virus vectors. Research emphasis is on finding suitable combinations of cultural practices and host-plant resistance to develop integrated pest management (IPM) systems. Intensive studies have been made on the defoliators, *Spodoptera litura* and leaf miner, to establish population-yield loss relationships, identify host-plant resistance and develop IPM schemes. Research on termites, which can cause pod losses exceeding 30% in Africa and encourage aflatoxin contamination by scarifying pods, is carried out in collaboration with the Overseas Development National Resources Institute (ODNRI) of the United Kingdom (UK).

Recently, a structured research program has begun on the nematode diseases of the three mandate legumes, involving surveys, estimates of yield loss and identification of host-plant resistance.

In pigeonpea, the major disease constraint worldwide in Fusarium wilt and extensive field screening of the germplasm collection has revealed many sources of resistance. Resistance genes have been incorporated into otherwise desirable plant types. A particular problem of short-duration pigeonpea is Phytophthora blight which strikes when there is standing water in the field. Stable and usable resistance has not been found yet. Cultural control methods, such as good drainage of fields and the use of foliar fungicides, offer better prospects at present than host plant resistance. Another major yield-reducer of pigeonpea is mite-transmitted sterility mosaic disease, against which stable sources of host-plant resistance have been found and incorporated into high-yielding lines.

Fusarium wilt is the major soil-borne disease of chickpea and, as for pigeonpea, many sources of resistance have been found and wilt-resistant varieties have been developed. Sources of resistance have also been found for some of the root rots, such as dry root rot, but for others, such as collar rot, no well expressed resistance has yet been identified despite extensive screening. Chickpea stunt incidence seems to be increasing. Field screening has revealed sources of resistance, which are used in breeding programs.

Outside of the tropics the foliar diseases, ascochyta blight and botrytis gray mold, can be devastating to chickpea. Despite extensive screening at ICARDA and in northern India and Pakistan, sources of strong and stable host-plant resistance have not been found for ascochyta blight, possibly because of the occurrence of different pathotypes. Nevertheless, varieties have been selected and bred that give a fair protection to the crop. This has enabled the development of winter planting systems for chickpea in the Mediterranean region. Screening for sources of resistance to botrytis gray mold is in progress.

Pod borer, *Helicoverpa armigera* (= *Heliothis armigera*), is a potentially devastating insect pest of both pigeonpea and chickpea and for its control ICRISAT's emphasis has been on screening for host-plant resistance. Less susceptible genotypes have been found and these are being used in breeding programs. A particular challenge is to combine *Helicoverpa* and wilt resistance as these traits are negatively linked. Collaborative studies with the Max Planck Institute for Biochemistry at Munich in West Germany on mechanisms of host-plant resistance and with ODNRI on ecology of *Helicoverpa* are continuing.

Podfly is another major pest of pigeonpea particularly in sub-tropical regions. Sources of host-plant resistance have been found and are being used in breeding programs.

In the West Asia and Mediterranean region, leaf miner is the most serious insect pest of chickpea : at ICARDA host-plant resistance has been identified.

Abiotic

A summary of the major abiotic stresses faced by the ICRISAT mandate legumes, and our current research emphasis on them, is given in Table 4.

For groundnut, drought has received the greatest attention and initial studies characterized the types of drought stress faced as mainly mid-season and terminal drought. Drought-resistant genotypes were identified and are being used in breeding programs. Interactions of drought with other stresses, such as calcium deficiency and *A. flavus* infection, have also been examined in multidisciplinary studies.

Research at ICRISAT Center has shown that photoperiod does not affect time to flowering in groundnut but does influence partitioning between vegetative and reproductive parts. Some genotypes have lower harvest indices under long-day conditions than in short days. These studies have contributed to our understanding of the adaptation of groundnut on a global basis, and have shown that genotypes adapted to short-day locations may not fit long-day environments.

Extensive studies on the nitrogen fixation of groundnut have shown that this is not a serious yield limitation in most circumstances and that little can be done to enhance the process. Therefore research emphasis on this topic has been curtailed. Studies are in progress on other economically significant nutritional limitations of groundnut such as phosphorus, iron and calcium.

At ICRISAT Center, we screen medium-duration pigeonpea for terminal drought stress and have found genotypic differences for reproductive growth under conditions of receding soil moisture. We have also screened short-duration pigeonpea under line-source sprinklers and found large differences in drought response. These findings have implications for the conduct of breeding programs, with respect to choice of selection environments and selection of genotypes to match probable moisture environments. Pigeonpea is very sensitive to waterlogging and screening has revealed genotypic differences in this regard.

We did not find much difference in salinity response among pigeonpea genotypes, but some related wild species, such as *Atylosia platycarpa* and *A. albicans*, showed substantial tolerance. This possibly opens a way for enhancing the salinity tolerance of cultivated pigeonpea.

Studies on nitrogen fixation of pigeonpea have also demonstrated that, in many situations, symbiosis with native *Rhizobium* supplies enough nitrogen for satisfactory

Table 4 Abiotic constraints of the ICRISAT mandate legumes that have received research attention at ICRISAT

Abiotic constraint	Groundnut	Pigeonpea	Chickpea
Photoperiod	+++[1]	+++	+
High temperature	+	+	+++
Low temperature	+	++	++
Humidity	++	–	+
Drought	+++	+++	+++
Waterlogging	–	++	–
Nitrogen fixation	+	++	++
P deficiency	+	+++	+++
Fe deficiency	++	–	+
Ca deficiency	++	–	–
Salinity	–	++	+
Acidity	+	–	–

1) Current research priority : +++high, ++intermediate, +low, –none.

plant performance. However, in soils of high clay content this is not the case as poor aeration limits nodule development and larvae of the insect *Rivellia angulata* damage nodules. Nitrogen contributions of pigeonpea to the total cropping system are under study and have been estimated at up to 40 kg/ha N.

Studies of a Special Project at ICRISAT Center funded by the Government of Japan have revealed that pigeonpea root exudates contain substances with special ability to solubilize phosphorus from an iron-bound form, which is normally not available to other plants. This explains the particular ability of pigeonpea to grow well on soils of high iron content but low apparent available phosphorus status, such as Alfisols.

We have done little research on photoperiod and temperature responses of pigeonpea and chickpea, although these factors are important is understanding the adaptation of these crops. However, we have worked collaboratively with appropriately equipped institutes elsewhere, such as the University of Reading, UK, in attempting to unravel these relationships. We have established that low temperatures delay pod set of chickpea during sub-tropical winters of South Asia, with consequent effects on yield stability. We have identified genotypes that can initiate pod set at 5 C and this may lead to the development of genotypes that, is this environment, can escape terminal drought and heat stress, avoid excessive vegetative growth and lodging and escape foliar diseases and *Helicoverpa* damage. At ICARDA, identification of cold tolerance in the early vegetative stage, in combination with resistance to ascochyta blight, has allowed the development of winter planted chickpea cropping systems for this region, with resultant higher yields and reduced terminal drought stress, compared with traditional spring-sown chickpea.

In most environments where chickpea is grown, terminal drought stress is a major constraint. We are trying to match growth durations of genotypes to environments with particular periods of soil moisture availability. However, within a maturity group genotypes have been identified which can avoid drought by developing a more extensive root system. These are candidates for use in further genetic improvement.

Methods of multiplication and inoculation of chickpea rhizobia for tropical environments have been improved. Genotypic differences in nitrogen fixation of chickpea have been identified and, more recently, non-nodulating genotypes have been found. These are of value as non-fixing controls in quantification of nitrogen fixation.

Detailed studies of phosphorus nutrition of chickpea, also under the Government of Japan Special Project, have led to recommendations of optimum methods of application of phosphorus fertilizer and shown that chickpea root acid exudates are effective in solubilizing calcium-bound soil phosphorus, which is the main form of phosphorus in Vertisols.

Genetic improvement

The basis of genetic improvement efforts on groundnut, pigeonpea and chickpea at ICRISAT is the world germplasm collection of these crops, and related wild species, collected, characterized, evaluated and maintained by the Genetic Resources Unit (GRU). As of May 1989, the collection stood at 12,160 groundnut, 11,171 pigeonpea and 15,948 chickpea accessions. Seed samples and associated information from this collection are available to anyone on request.

Breeding programs at ICRISAT attempt to incorporate resistances to constraints as referred to above, to raise yield potential in specific environments and to develop cultivars of wider adaptation, while maintaining or improving quality characteristics. Some examples of successful varieties so developed are listed in Table 5. It should be emphasized that the multilocation testing of advanced material is carried out within national programs and they decide on their release or otherwise.

In some cases, new plant types have been evolved in breeding programs, which has opened the way for the development of new cropping systems. An example is short-

Table 5 Some legume cultivars developed by ICRISAT's genetic improvement efforts that have been accepted for release in national programs

Cultivar name	Distinguishing features	Environment best suited for
	Groundnut	
ICGS 11 (ICGV 87123)	15-69% pod yield advantage, tolerant to bud necrosis disease (BND) and terminal drought stress.	Post-rainy season, peninsular and central India.
ICGS 44 (ICGV 87128)	16-105% pod/yield advantage, tolerant to BND, good recovery from mid-season drought, wide adaptability.	Post-rainy season, western India and Pakistan.
ICG 7886 (Cardi Payne)	75% pod yield advantage, excellent eating and roasting qualities	Jamaica
ICGS 1 (ICGV 87119)	10-36% pod yield advantage and less susceptible to diseases and insect pests.	Rainy season in northern India.
ICG (FDRS) 10 (ICGV 87160)	78-92% pod yield advantage, highly resistant to rust, tolerant to late leaf spot and BND.	Rainy season in peninsular India.
	Pigeonpea	
ICP 8863 (Maruti)	Wilt-resistant, medium-duration.	Central and southern India.
ICP 7035 (Kamika)	Medium-duration vegetable type, wilt and sterility mosaic (SM) resistant	Fiji (as Kamika), Zambia, Burma.
ICPL 87 (Pragati)	Short-duration, high-yielding, ratoon-harvestable, wilt and SM-tolerant.	Multiple harvesting in tropics, rotation with winter crop in sub-tropics.
ICPL 151 (Jagriti)	Short-duration, high-yielding, wilt and SM-tolerant, white-seeded.	Rotation with winter crop in sub-tropics.
ICP 9145	Long-duration, high-yielding, wilt-resistant.	Malawi
	Chickpea	
ICCV 1 (ICCC 4)	High yield potential	Gujarat, India.
ICCV 2	Extra-short-duration, wilt-resistant, kabuli.	Short growing season environments.
ICCV 6 (ICCC 32)	Medium-duration, wilt-resistant, kabuli.	Sub-tropics with mild winters.
ILC 482 (Ghab 1)	Ascochyta blight and cold-tolerant	For winter sowing in West Asia and Mediterranean region.
ICCL 81248 (Nabin)	High yield potential	Bangladesh

duration determinate pigeonpea which is grown as a monocrop, as distinct from the traditional, long-duration, indeterminate, intercropped pigeonpea. Such new plant types require a different set of management practices and thus genetic and management improvement efforts merge.

Management improvement

In the harsh conditions of the semi-arid tropics, it is necessary to assess carefully what is likely to be achieved by genetic and management innovations. Scientists of the Legumes Program collaborate with those in the Resource Management Program (RMP) in this exercise. Examples of improved cropping packages developed at ICRISAT for Indian conditions include summer groundnut, short-duration pigeonpea in rotation with winter crops in northern India or for multiple harvests in central and southern India, and irrigated chickpea in peninsular India. Recently, ICRISAT has been requested to demonstrate these packages at many locations in India in collaboration with the national program. This activity may soon be extended to other countries.

Future research thrusts

Progress in some fields of research and improvement of indigenous research capability in some countries have caused realignment of our research efforts. Globally, there will be a further strengthening of our research effort in Africa.

There will be less emphasis on producing finished varieties and greater emphasis will be given to enhancement of germplasm for resistance or tolerance traits to stress factors. Greater use will be made of agro-ecological zoning in designing breeding strategies. In particular, there will be more detailed study of how best to elicit improved genetic recombinants in drought-prone environments.

In collaboration with national programs, attempts will be made to develop alternative cropping systems for the mandate legumes, utilizing some of the new plant types evolved in the breeding programs and keeping in view the sustainability of the total production system. Increased emphasis will also be given to utilization analysis and research.

In pest and disease research we will give special attention to problems arising in newly evolving cropping systems. More in-depth research will be done on ecology and epidemiology of the important pests and diseases. Attempts will be made to establish reliable host-plant resistance screening techniques in glasshouse and laboratory, so that more material can be screened more reliably than is possible with current field techniques.

In line with a greater emphasis on strategic research, new techniques in cell biology will be applied, such as the use of monoclonal antibodies, tissue culture techniques for making wide crosses so as to access potentially useful genes in wild species, and developing transgenic plants with desirable characters.

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Discussion

Nkansah, G. O. (Ghana) : I would like to suggest that ICRISAT extend its activities to the humid tropics (HT) where the present shifting cultivation system is being replaced by farming/cropping systems since these legumes, for example pigeonpea, could be incorporated to contribute to soil enrichment, or provide a source of food and nutrition or serve as windbreaks.

Answer : IITA which is located in Nigeria is the CGIAR institute with the mandate for improving cropping systems in the humid tropics (HT). Chickpea would not be suitable for the HT except at high altitudes. However, pigeonpea with disease resistance has a good potential for the HT, both as perennial types (e. g. ratoon harvest systems for vegetable-green pod-production). Closer cooperation between ICRISAT and IITA is needed in this regard, and also for comparing data on suitable, sustainable cropping systems for HT and SAT environments.