L.J. Haravu

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ICRISAT Asia Center

Quarterly Technical Report

July-September 1994

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International Crops Research Institute for the Semi-Arid Tropics

Patancheru 502 324, Andhra Pradesh, India

ICRISAT Asia Center
Quarterly Technical Report
July-September 1994

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics
Patancheru 502 324, Andhra Pradesh, India

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Research Activities

Genetic Resources Division

General

In accordance with an earlier decision made by CG Center Directors, ICRISAT has formally submitted the list of 94 896 "Designated Germplasm" accessions to be placed under the auspices of the Food and Agriculture Organization of the United Nations (FAO) in the framework of the "International Undertaking on Plant Genetic Resources". This action confirms that the CG Centers are trustees of the germplasm they hold in their genebanks and not the owners.

The new screenhouse for the maintenance of wild *Arachis* germplasm is nearing completion. The facility situated northeast of the Plant Quarantine Building, is being built by ICRISAT's Farm and Engineering Services Program (FESP) with the financial support of the Asian Development Bank.

As a result of an earlier discussion held between the Director General of ICRISAT and Vice President of the Chinese Academy of Agricultural Sciences (CAAS), and a follow up trip to China by Dr Melak H. Mengesha, CAAS has agreed to invite ICRISAT for joint germplasm exploration and collection in China. This is a very important development in view of the vast genetic diversity that exists in China.

Sorghum Germplasm

The new sorghum germplasm acquisitions from India (171), Mali (35), Myanmar (11), Nigeria (185), Philippines (51), Russia & CISs (44), and Uganda (197) were sown in the 1994 rainy season in Field BP 15 for evaluation. The crop establishment and growth was good. Selfing is in progress in the germplasm from Rwanda which was sown for seed increase. Apart from the above material we have also sown all the 813 landraces from Karnataka, India for evaluation. These accessions commenced flowering between 90 and 110 days after sowing and thus forms a group of medium-duration accessions.

The passport information of 4420 accessions (IS 32753 to IS 37172) was entered in computer using "System 1032" and updated the entire passport data from IS 1 to IS 37172.

A total of 317 sorghum germplasm accessions from Uganda (200) and USA (117) were sown in the Post-Entry Quarantine Isolation Area (PEQIA) on 15 Sep for seed increase and quarantine clearance.

Pearl Millet Germplasm

Crop growth of pearl millet germplasm from Mali (1), Myanmar (10), Nigeria (669), Yemen (229), and USA (88), sown for evaluation is good and observations are being recorded on different morpho-agronomic characters. Data on flowering indicates that most of the accessions from Yemen are mostly medium duration, while those from Nigeria are of long duration. Selected observations are being recorded in different random matings of early, high tillering, large spike, and bold grain genepools to assess the genetic stability of respective trait in each random mating. As a part of conversion scheme, the progenies of BC_1 F_1's derived after crossing landraces with desirable traits to elite parents were selfed to select progenies in advanced generations.

Five samples collected from Uganda were sown in PEQIA for inspection, seed increase, and subsequent release to ICRISAT. The database on passport information was updated based on the records received from the Rockefeller Foundation.

Minor Millets

A total of 1744 minor millets germplasm accessions comprising of finger millet (586), foxtail millet (115), kodo millet (111), barnyard millet (98), little millet (2), and proso millet (832) were sown for characterization and seed increase in Field RCE 23 N on 18 Jul. The seedling emergence and establishment of crops are good. As a part of multilocational evaluation trial, 500 accessions of finger millet germplasm originating from Uganda were also sown at IAC during the rainy season.

A total of 80 finger millet samples assembled from Uganda were sown in PEQIA for inspection and release by quarantine authorities.

Chickpea Germplasm

A mission to collect germplasm of chickpea was launched in Tanzania, jointly by the Plant Genetic Resources Centre (PGRC), Arusha, Tanzania and ICRISAT. A total of 87 samples were collected. Generally, desi type chickpeas that mature in about 4 months are cultivated in Tanzania. They have bright yellow seeds with a 100-seed mass of about 18 g. This crop has very bright prospects of cultivation in that country. The produce is consumed in Tanzanian homes and also exported, mainly to Kenya. With some extension education on utilization of chickpea, the crop can attain further importance. In Tanzania, without affecting any other crop, the area under chickpea can be expanded several times. Apparently there is no constraint to chickpea cultivation in Tanzania.

We rejuvenated seeds of 10 chickpeas in the greenhouse facility at IAC. The seed material from the 1993/94 crop season was cleaned, seed observations recorded, and transferred to the medium- and long-term conservation facilities.

Pigeonpea Germplasm

We registered 287 new accessions with genebank, raising the total to 12 355. The new accessions are from India (130), Indonesia (1), Myanmar (2), Nigeria (129), and Uganda (25). Passport data have been updated up to ICP 15 486.

Of the 234 accessions sown in BP 11C for characterization, 9 accessions flowered so far. A local collection (SSD 95) from Rajasthan, India completed 50% flowering in 74 days. The germplasm accessions are facing a problem of fusarium wilt in this field. We sowed 1354 accessions for rejuvenation in RP 01A field. Out of this, 200 accessions are for long-term conservation at IAC and at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi. The remaining 1154 accessions are for storage as working collection. We sowed a set of 32 elite germplasm selections for seed increase.

Sowing of 14 accessions of *Cajanus platycarpus* on 20 Jul was done for assessing the perenniality of this species. We harvested seeds of *Eriosema psoraleoides* and *Flemingia macrophylla*. We processed the seeds of 15 wild relatives for long-term conservation. These are *Cajanus acutifolius, C. albicans, C. lineatus, C. scarabaeoides, C. sericeus, Flemingia bracteata, F. macrophylla, F. semialata, F. stricta, Rhynchosia aurea, R. bracteata, R. minima, R. rothii, R. suaveolens*, and *R. sublobata*.

A total of 53 exotic accessions of pigeonpea from South Africa (22), and Uganda (31) were sown in PEQIA for quarantine inspection and release. The world collection of *Rhynchosia* received from Australia was also sown in the same area on 15 Sep.

Groundnut Germplasm

Despite the initial leaf-miner damage, the crop stand is good. Preharvest observations were recorded on 547 accessions sown for seed increase and 380 accessions for characterization. One hundred and fifteen new cultivars with less seed stock were also sown in pots for seed increase.

NBPGR released 102 samples of wild *Arachis* which were collected from Brazil. Further, seeds of these samples were plated on agar medium after ethrel treatment. The germinated seedlings were transferred to 4" pots. These seedlings, after 6 weeks of age were transferred to 12" pots as suggested by NBPGR. These pots are placed in bay no. 3 of greenhouse no. VI, instead of PEQIA, for further inspection by NBPGR.

NBPGR also released 119 lines obtained from Brazil (111), Malaysia (1), Niger (3), and Vietnam (4) which were sown in PEQIA for observations and seed increase. Nine cultivars obtained from Pakistan (2), Uganda (2), and USA (5) sown in PEQIA were cleared by NBPGR and the material was harvested.

The produce of the 1993/94 postrainy-season crop was cleaned and transferred to containers for medium-term storage. One hundred and sixty samples were shelled and processed for long-term conservation.

Dr A.K. Singh, who is presently on a study leave, joined the Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA) scientists for a joint groundnut germplasm collection in Brazil. Over 100 samples of cultivated and wild *Arachis* germplasm were collected.

Genebank and Seed Laboratory

The environment control systems were monitored regularly and fluctuations due to power failures and high atmospheric humidity were attended on priority basis. Few modifications in the power supply system to the dehumidifiers of the medium-term cold rooms were done to improve the safety and efficiency of the dehumidifiers. Additional storage systems were ordered to accommodate more accessions in two medium-term cold rooms of the genebank.

For long-term conservation as base collection, freshly harvested seeds of 364 accessions of chickpea and 415 pigeonpea including 54 accessions of related wild species were processed after drying to about 6% seed moisture content and testing the initial viability. We are processing about 402 chickpea for duplicate base conservation at the International Center for Agricultural Research in the Dry Areas (ICARDA), Syria and 400 accessions of pigeonpea germplasm at NBPGR, New Delhi, India.

During the quarter we tested the viability of 637 pearl millet and 1708 chickpea accessions that were conserved for over 5 years in medium-term facilities and identified 62 pearl millet and 200 chickpea accessions with <85% germination for immediate rejuvenation.

From our germplasm conservation studies under different conditions, we observed a significant loss in the viability of sorghum (within 6 months) and pearl millet (within 9 months) seeds stored in aluminum foil packets under ambient conditions at 13% seed moisture content, whereas, the loss in viability under short-term storage conditions was significant within 15 months for sorghum and 21-24 months for pearl millet. We also observed a gradual decrease in viability of sorghum and pearl millet seeds stored in cloth bags and aluminum foil packets under ambient conditions at 10% seed moisture content in 24 and 27 months, respectively.

After 24 months of storage under ambient and short-term conditions, the loss in viability was significant at 10% seed moisture content for chickpea and 13% for pigeonpea.

Seed Exchange

During the quarter, 7236 germplasm samples were supplied to scientists on request at IAC and institutes in India and abroad (**Table 1**).

Table 1. Germplasm samples of ICRISAT crops supplied on request to several scientists and organizations during Jul-Sep 1994.

	Number of samples									
	IAC			India			Abroad			
Crop	Jul	Aug	Sep	Jul	Aug	Sep	Jul	Aug	Sep	Total
Sorghum	4	205	1	668	21	276	0	15	70	1260
Pearl millet	545	3	2	623	15	55	5	0	39	1287
Chickpea	4	0	4	2	3	488	3	0	0	504
Pigeonpea	465	1320	142	445	790	60	3	0	0	3225
Groundnut	19	107	103	423	0	0	308	0	0	960
Total	1037	1635	252	2161	829	879	319	15	109	7236

Staffing

N. Kameswara Rao, Sr. Research Associate, after spending 2 years of postdoctoral research work at the International Rice Research Institute (IRRI), Philippines, returned to IAC on 16 Sep.

Staff Travel

Travel Outside India

Period	Staff name(s)	Organization[1]/ Location	Country(s)	Purpose
4-9 Jul	Mengesha, M.H.	FAO/CFC Rome	Italy	Groundnut germplasm activities for West Africa-CFC fund
13-25 Jul	Mengesha, M.H.	ISC, Niamey	Niger	RPRC meetings
2-5 Aug	Pundir, R.P.S.	PGRC Arusha	Tanzania	Chickpea germplasm collection
11-19 Sep	Mengesha, M.H.	CAAS	China	ICRISAT/CAAS collaboration

1. CAAS = Chinese Academy for Agricultural Sciences, CFC = Common Fund for Commodities, FAO = Food and Agriculture Organization of the United Nations, PGRC = Plant Genetic Resources Centre.

Visitors

Period	Name of visitor(s)	Organization[1]/ Location	Country(s)	Purpose/Interest
26 Aug	45 students and teachers of botany	Osmania University, Hyderabad	India	General interest
2 Sep	19 B.Sc. students	Kranti Degree College, Ameerpet, Hyderabad	India	General interest
5 Sep	25 post-graduate students	APAU Rajendranagar	India	General interest
8 Sep	40 M.Sc. students	Holy Cross College, Trichy	India	General interest
18 Sep	Lenné, Jillian M.	Principal Scientist Designate, ICRISAT	UK	Orientation on GRD activities
23 Sep	Devaraj, K.V.	UAS Bangalore	India	General orientation

1. APAU = Andhra Pradesh Agricultural University, UAS = University of Agricultural Sciences.

Genetic Enhancement Division

Sorghum Breeding

Short-duration Dual-purpose Sorghums

Genetic variation for growth rate

In continuation of work reported in last quarter, a growth study was conducted in the 1994 rainy season, providing results from a third environment. Combined analyses of growth rates over 3 years of testing indicated that there were two-fold differences among landrace varieties for growth rates both during the exponential seedling phase of growth (range from 3.0 to 6.5 $gm^{-2}d^{-1}$) as well as during the linear phase of growth (range from 12.8 to 21.6 $gm^{-2}d^{-1}$). These differences were highly consistent over environments, with broad sense heritabilities of 0.75 and 0.73 for growth during exponential and linear growth, respectively. The growth rates of the control cultivar ICSV 1, were intermediate relative to the landrace varieties. These results indicate that genetic variation for growth rate could have major implications for productivity of short-duration dual-purpose sorghums, and encourages further study into use of germplasm materials for enhancing productivity of current breeding materials.

Population improvement

We initiated evaluations of the progress from recurrent selection for both enhanced grain and stover yields in a short-duration dual-purpose population, and for seedling vigor in the US/R and RS/R populations. The results obtained from these evaluations will indicate the effectiveness of the selection methods used and help guide the future direction of these population improvement efforts.

Pearl Millet Breeding

Grain Yield and Heterosis of Open-pollinated Variety Pollinators

High-yielding topcross pollinators can be used directly as open-pollinated varieties and their topcross hybrids can be used as hybrid cultivars. The objective of this study was to examine the possibility of increasing the grain yield of pollinators and their hybrids using this topcross approach.

Six open-pollinated varieties bred by random mating were selected as pollinator lines. Their grain yields were compared with that of WC-C75, a widely cultivated open-pollinated variety in India. Replicated experiments conducted across three Indian environments (1993 rainy season at IAC, 1994 summer season at IAC, and 1993 rainy season at Gwalior) indicated that five of these six varieties had significantly higher grain yield than WC-C75. Mean grain yield heterosis of hybrids of these six varieties on five male-sterile lines (81A, 842A, 843A, 863A, and ICMA 88004) ranged from 7 to 17% (**Table 1**). Mean topcross performance of PRLBSC was the highest, both in terms of absolute grain yield and heterosis.

PRLBSC has attractive large grain with a 1000-grain mass of 15 g. It has thick, medium-long panicles. This topcross pollinator is highly uniform. PRLBSC appears to be a promising topcross pollinator.

Table 1. Grain yield and heterosis of topcross pollinators of pearl millet, ICRISAT Asia Center and Gwalior, rainy and summer seasons 1993-94.

Topcross pollinator	Grain yield (t ha^{-1})		
	Pollinator	Mean of 5 hybrids	Heterosis (%)
PRLDMR	3.22	3.50	9
PRLICR	3.16	3.40	7
PRLBSC	3.18	3.72	17
POLCOL	3.32	3.66	10
TGPMBJ	3.25	3.52	8
HICPO (E)	2.86	3.31	16
WC-C75	2.94		
Trial mean		3.44	
SE		±0.104	

Development of a Male-sterile Population

A male-sterile population of pearl millet can be used in breeding inter-population hybrids. This strategy for exploiting heterosis may be particularly useful in western Africa where phenotypic uniformity of pearl millet cultivars is not yet a rigid requirement. Further, hybrid seed multiplication on such a seed parent in western Africa would be less risky than that on inbred lines due to the poorer stand establishment of inbreds and avoidance of the genetic uniformity that predisposes inbreds to rapid breakdown of their resistance to pearl millet downy mildew caused by *Sclerospora graminicola*.

The greater stability of male sterility of A_m-system male-sterile lines and the higher frequency of maintainers that this cytoplasmic-nuclear male-sterility system identifies in a wide range of germplasm, provided the basis for initiating development of a male-sterile version of the dwarf Nigerian Composite (NCD2). This composite is among the highest-yielding dwarf populations, and has high degrees of both downy mildew resistance and seedling heat tolerance. One cycle of recurrent selection, using 81A_m as a tester for male-sterility, increased the frequency of male-sterile plants from 50% in the 81A_m x NCD2 (C0) topcross hybrid to 91% in the 81A_m x NCD2 (C1) topcross hybrid. Concurrent to improvement of its sterility maintenance ability, NCD2 is being converted into a male-sterile population in the A_m cytoplasm using a sidecar backcross approach. Initial results show that 94% of plants of the BC_1 population are male-sterile, indicating good prospects for converting NCD2 into a male-sterile population.

A new source of cytoplasmic-nuclear male sterility

Several sources of cytoplasmic-nuclear male sterility have been reported in pearl millet. One of these, designated A_m, produces the highest previously reported frequencies of male-sterile hybrids. In a bulk sowing of about 10 000 plants of a Large-Seeded Gene Pool (LSGP) at IAC during the 1989 cool-dry season, we observed that 67 plants did not shed pollen but had good seed set on their open-pollinated panicles. During the 1990 rainy and cool-dry seasons, all plants grown from the open-pollinated seeds of one of these male-sterile plants, designated LSGP-66, were male sterile. The cytoplasm of this male-sterile plant was combined with the nuclear genome of inbred line 81B to develop male-sterile line 81A_{LG6}. Thirteen inbred pollen parents, previously found to be restorers of 81A_m,

produced completely male-sterile hybrids when crossed onto $81A_{L66}$. Four diverse composites (Inter-Varietal Composite, ExBornu D2, Bold-Seeded Early Composite, and Medium Composite) also produced only male-sterile hybrid plants when crossed onto $81A_{L66}$. However, 10-35% of hybrid plants from crosses of these composites onto $81A_m$ had >50% selfed seed set. Thus this new LSGP cytoplasm is different from A_m and all other pearl millet cytoplasms reported so far. Unless restorers can be found, this new cytoplasm is of no use in breeding grain hybrids. However, it provides an excellent opportunity for both genetic and cytoplasmic diversification of male-sterile lines for pearl millet forage hybrids.

Microsporogenesis and Anther Development in Isonuclear Lines

Six isonuclear A-lines and 81B, used as a male-fertile control, were examined for the influence of cytoplasmic-nuclear male-sterility systems on anther development and microsporogenesis. The isonuclear A-lines were: $81A_1$ with Tift $23A_1$ cytoplasm, ICMA 88001 (= $81A_v$) with *violaceum* cytoplasm, $81A_m$ (= $81A_4$) with *monodii* = *violaceum* cytoplasm, Pb $310A_2$ and Pb $311A_2$ with A_2 cytoplasm, and Pb $406A_3$ with A_3 cytoplasm.

The material was grown in the polyhouse in the cool-dry season (CDS) and hot-dry season (HDS) of 1993/94 at IAC. Observations on meiosis, anther development, and microsporogenesis were recorded in both seasons. For meiotic studies, 4-5 spikes each from 5 plants of each line were used each season. Florets for histological studies were collected at premeiotic, meiotic, and postmeiotic stages of anther development.

Meiosis was regular in all isonuclear A-lines and 81B, except Pb $406A_3$ where a low frequency of pollen mother cells (PMCs) showed anomalous meiosis.

Microsporogenesis and anther development were normal in 81B. PMC/microspore/pollen degeneration in the six A-lines occurred at different stages of anther development. Developing microspores degenerated at premeiotic stages in about 55% of locules in Pb $406A_3$ due to the formation of an intra-tapetal syncytium (ITS). In the other A-lines microspore degeneration occurred during meiotic stages in most anther locules. The cause of pollen abortion differed from line to line, floret to floret within a spikelet, anther to anther within a floret, and in some cases even from locule to locule within an anther. Each line followed its own anther developmental pattern. Postmeiotic degeneration was recorded in very few locules in each line except in Pb $406A_3$ where it occurred in 40-45% of locules.

The tapetum attained its maximum thickness at the tetrad stage in most of the isonuclear lines. There were slight differences in its developmental pattern in the CDS and HDS. In 81B, tapetum thickness was maximum at the tetrad stage. Thereafter, it reduced drastically and nearly disappeared at anther dehiscence. In $81A_1$, tapetum thickness started decreasing after the tetrad stage in the CDS or young microspore stage in the HDS, but the tapetum was still conspicuous at anther maturity. The tapetal cells were vacuolated and remained intact. A similar developmental pattern was observed in $81A_m$ during early stages, but tapetum thickness of $81A_m$ declined as anthers matured. Further, tapetal cells of $81A_m$ were not vacuolated and lost their identity, so only their remains were seen at anther maturity. Tapetum thickness continued to increase after the tetrad stage in male-sterile lines having the A_2 and A_3 cytoplasms. Maximum thickness was attained at either the young microspore stage or at pollen formation (i.e., the tapetum persisted until anther maturity), but tapetal cells lost their identity because of ITS formation.

The endothecium was well developed in all seven isonuclear lines at early stages of anther development. In 81B the endothecium attained its maximum thickness at the dyad stage then decreased in thickness as microspores matured, facilitating anther dehiscence. In $81A_1$ and $81A_m$ endothecium thickness increased rapidly as anthers matured. The increase in endothecium thickness might have contributed to the nondehiscence of anthers in these A-lines. In Pb $406A_3$ and Pb $311A_2$ endothecium thickness declined after the dyad/tetrad stage. Pollen fertility of these two lines was also higher than other A-lines (IAC Quarterly Technical Report, Apr-Jun 1994) in which the endothecium was thicker.

Anther epidermis thickness and its growth pattern remained more or less the same in all seven isonuclear lines. Its thickness continued to increase gradually up to the young microspore or pollen maturation stage in all lines in both seasons.

The anther middle layer did not follow any consistent developmental pattern in any of the seven isonuclear lines.

Anther lobes of 81B were wider than those of its isonuclear A-lines at all growth stages in both seasons. The developing fertile microspores must exert considerable pressure on anther walls resulting in expansion of the anther lobe and thereby increasing its diameter. In A-lines the anther lobe was compressed/shrivelled at maturity.

These studies clearly indicated that anther/pollen development is more irregular in Pb 406A_3. In 81A_m and 81A_1 more than 95% of anther locules followed a definite developmental path to pollen abortion. In the other A-lines many developmental paths were observed within the line and pollen degeneration occurred at various stages. This could be one of the reasons for greater instability of male sterility in the A_2 and A_3 systems and greater stability of male sterility in the A_1 and A_m systems.

Chickpea Breeding

Breeding for Adaptation to Different Agroclimatic Regions

Desi Chickpea *(LC-002 to LC-004)*

The F_1s of crosses made in the main season were advanced to F_2 generation in the off-season nursery under rainout shelters at IAC. Seventy new crosses were attempted and reasonable numbers of seeds were harvested in each cross.

A number of plants grown under the rainout shelters showed symptoms of scorching on the leaf margins. There appeared to be genetic differences for such symptoms of scorching which have been noticed in the previous years also. The causes of leaf scorching are still under investigation.

The data collected from experiments in the main season were analyzed and tabulated. Selections were made on the basis of seed yield, seed size and color. Sowing plans and seed packets were prepared for sowing in the main season after experiments were finalized in consultation with colleague scientists in other disciplines.

Research activities were also continued in the greenhouse and under controlled environment at IAC. A number of breeding populations and advanced lines were screened in the 'Chickpea Growth Room' for resistance to botrytis gray mold and plants with low rating were identified and transplanted in the greenhouse and in the field. One F_2 population of BC_2 involving wilt susceptible but high-yielding variety JG 62 was screened for wilt in pots and resistant plants were identified. Similarly, seeds from seven wilt susceptible JG 62 plants that survived in the wilt-sick plot last season were screened against fusarium wilt in pots in the greenhouse to check for any gene mutation for resistance; 3 plants are surviving in the wilt-sick pots after 70 days of sowing.

In the All India Coordinated Pulses Improvement Project (AICPIP) trials, ICCV 90201 averaged 36% higher seed yield than the control over 3 years. The variety also had the lowest incidence of wilt and root rots, and was recommended as a donor parent in the Indian national crossing program. Out of 8 entries, which were contributed to the Initial Evaluation Trials (IET) by our collaborators in the polygon breeding programs in 1993/94, 7 performed well and were promoted to the more advanced trials in 1994/95. Also, 9 new entries, products of NARS-ICRISAT joint programs were contributed to the AICPIP trials for 1994/95. We also supplied F_2 seeds of 9 crosses to AICPIP's national crossing program.

Sowing of replicated yield tests and progenies with no irrigation was started on 27 September and nearly 4 ha area was sown. Germination in these fields is good.

Seed stores were regularly fumigated to keep them free from bruchids. We received a number of seed requests from NARS scientists, farmers, and private and public seed agencies, and depending upon the availability of seeds, more than 1 t seeds were supplied.

Report of work for 1992/93 was completed for desi chickpea projects and the document was despatched to NARS cooperators.

Kabuli Chickpea (LC-006 to LC-008)

The activities in the kabuli projects were similar to those described under the desi projects. We made 15 crosses and advanced 26 F_1s to the F_2 generation in the off season under rainout shelters, and sown yield tests and progenies in nonirrigated fields during 27–29 September.

Breeding Desi and Kabuli Chickpeas for Specific Situations *(LC-010 to LC-013)*

We advanced 22 F_1s to the F_2 generation in the off season under rainout shelters at IAC for the rice-based cropping systems project. Those entries that were contributed by our collaborating center at Gwalior (JNKVV) to the High Fertility Trial of AICPIP in 1993/94, gave good performance and were promoted to the next stage of testing. The same collaborator contributed two new entries for these trials for the 1994/95 season.

Other activities in this project were similar to those described under the desi projects.

Germplasm Enhancement for Biotic Stresses

Resistance to ascochyta blight *(LC-015)*

The project to enhance genetic resistance of chickpea to ascochyta blight was initiated in 1989. Twenty-five lines derived from populations made for this purpose and screened in the Chickpea Growth Room at IAC, were field tested in cooperation with the Punjab Agricultural University, Ludhiana in 1993/94. Seven lines showed ratings of 3.0 to 3.2 when the susceptible control was rated 9.0. These selections will be evaluated for their yield potential and agronomic traits.

Resistance to *Helicoverpa* pod borer *(LC-016)*

The project was initiated in 1990 to enhance the existing levels of pod borer resistance in the germplasm. Eight best parents were chosen and crossed in 2-way, 4-way, and 8-way combinations. The resulting F_2 populations were screened under nonsprayed conditions and most promising (resistant) plants were selected. The progenies, of these plants are now in various generations (F_3 to F_5). In 1993/94, 15 F_2-derived F_4 progenies showing enhanced level of resistance to *Helicoverpa* pod borer were used to make six new crosses to initiate second cycle of germplasm enhancement. These F_1s were advanced to F_2 in the off-season nursery at IAC. The resulting F_2 as well as other materials in F_2 to F_5 generations were sown in the nonsprayed areas on 29 September and emergence is good.

Upstream and Backstop Research *(LC-017)*

The F_1 and parents were grown in the off season to complete the sets of F_1s, F_2s, and backcrosses to study the inheritance of the following trials: pod/seed volume ratio, nodulation, nematode resistance, and ideotype traits like fewer leaflets, root size, and wilt resistance. Seeds and sowing plans for the main season were prepared.

Cold tolerance

The F_2 population of two crosses was screened for cold tolerance in the plant growth chambers (convirons) at IAC, by simulating cold conditions of northern India. Data were recorded on flowering, pod-set, and seed-fill to characterize the plants as cold tolerant or susceptible. Freeze-dried leaf samples of all the F_2 plants and parents were sent to the John Innes Institute (JII) for gene marker studies. Results are awaited from them to relate these with the morphological data collected at IAC.

Currently we are screening crosses of two more F_2 populations in the convirons with the aim of combining freezing tolerance (relating to ICARDA region) and chilling tolerance (relating to northern India conditions) so as to achieve higher degree of cold tolerance. Both the populations are progressing well with normal vegetative growth despite low temperatures. However, some plants are already showing cold susceptibility symptoms.

Fusarium wilt

Molecular markers for resistance to fusarium wilt of chickpea. We collaborated with the Washington State University (WSU), Pullman, USA, in the search for molecular markers for resistance to fusarium wilt of chickpea. Parents and F_2 generation of a cross between wilt resistant (WR 315) and wilt susceptible (late wilter, C 104) were supplied from IAC. Random amplified polymorphic DNA (RAPD) analysis was performed on the F_2 derived F_6 lines at the WSU. One of the 370, 10-mer RAPD primers amplified a DNA fragment linked to resistance to fusarium wilt (UBC 170_{550}; another primer amplified a DNA fragment linked to susceptibility (CS 27_{700}). The data suggest that these two markers are located on the same side of the fusarium wilt resistance gene. These results will be useful in quicker screening and making genetic maps of chickpea genome.

A similar collaborative study is in progress with JII, Norwich, England. We have provided parents and F_2 generation of a cross of fusarium wilt resistant (ICCV 2) and susceptible (JG 62) genotypes. The DNA analysis being done at the JII might produce an RFLP map based on AFLPs but with a few RFLPs generated from about 100 F_2 individuals. Characterization of F_2 and F_3 populations is being done at IAC. These studies will complement the work being done at the WSU.

For studying the inheritance of dry root rot, F_2 parents of two crosses were grown in pots in a greenhouse and screened for resistance to *Rhizoctonia bataticola* using the "Blotting Paper Technique".

Seed materials in F_4, F_6, and F_7 generations and their sowing plans were exchanged among the collaborators under the joint chickpea improvement project (polygon breeding) being done by the Punjabrao Krishi Vidyapeeth (PKV) Akola, Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Sehore, and IAC. Four promising lines selected under this program were contributed to the AICPIP trials by the two collaborating centers.

International Trials and Nurseries *(LC-018)*

Results of international trials/nurseries received from 80 cooperators were analyzed and tabulated, and selections were made for constituting the nurseries for 1994/95. The seeds of such entries were cleared through plant quarantine and prepared for despatch. The seed requests for other materials, such as germplasm, advanced breeding lines, segregating populations etc., were also met. Details of the trials/nurseries and other materials supplied to cooperators are presented in Seed Exchange in page 125 of this report.

A brief report of the Nineteenth International Chickpea Trials and Nurseries organized by ICRISAT was prepared and distributed at the Annual AICPIP Rabi Pulses Workshop held at Bikaner, 15-18 September.

Transfer of Information and Technology *(LC-019)*

The ICRISAT chickpea cultivars have become popular with farmers in several countries and it is getting difficult to meet all the seed requests. ICCC 37, ICCV 2, ICCV 10, and ICCV 88202 are in great demand in Andhra Pradesh, Maharashtra, and Gujarat in India and also in Myanmar. We could meet these requests only partially and were able to supply 320 kg of ICCV 2, 710 kg of ICCV 10, 138 kg of ICCC 37, 200 kg of ICCV 88202, and 150 kg of ICCC 42. We also supplied 90 kg seed of ICCV 93122, a line resistant to pod borer and soilborne diseases, for on-station and on-farm trials in Andhra Pradesh.

A report from Myanmar says that ICCV 2 and ICCC 42 have been released to the farmers, although a formal notification has yet to be issued.

Collaborative Activities with Asian NARS

Consultancy with the Crop Diversification Programme (CPD) of CIDA in Bangladesh

Dr Jagdish Kumar was invited to review Pulses research for 1993/94 and plan experiments for 1994/95 by the Crop Diversification Programme of CIDA in Bangladesh during 3 Jul to 4 Sep 1994. This consultancy was in continuation

of his earlier assignments since 1991. He participated in BARI pulses and oilseed reviews and helped in developing research plans for 1994/95.

Of particular interest to ICRISAT is the increased emphasis for chickpea, pigeonpea, and groundnut research; and expansion of chickpea area in the Barind Region. Good results were obtained in the development of disease-resistant materials, particularly with botrytis gray mold (BGM) field screening. A mist-irrigation system for creating humidity in the field was installed with CDP support. This facility is now being used for BARI-ICRISAT collaborative BGM studies.

Bangladesh Institute of Nuclear Agriculture (BINA), released a chickpea variety BINA SOLA 2. This entry ICC 4998 was supplied as part of ICRISAT coordinated trial (ICCT-DL) to BINA.

Three new promising lines of chickpea, ICCL 85222, ICCL 83149, and RBH 228, were found superior in seed yield to local varieties. These have fusarium wilt resistance and have relatively larger seed size. The draft proposals for release of these as varieties were prepared with BARI scientists for submission to Bangladesh National Seed Board.

Two groundnut promising lines ICG(E) 11 and ICG(E) 55 developed with ICRISAT collaboration are in the pipe line for release by BARI in 1995.

CIDA has approved a budget of CDN $30 000 (1 US$ = 1.35 CDN) for a National Workshop on Pulses in Bangladesh in 1995. ICRISAT may be invited to participate.

Chickpea in Barind Region

Bangladesh and ICRISAT collaborate in the extension of chickpea cultivation in rice fallows in Barind region of Bangladesh. The data presented during the recent Pulses Research Reviews (Jul '94) indicated that the area sown to this crop increased nearly three fold in 1993/94 over that of 1992/93. This increase was attributed to availability of good seed particularly, Nabin, a chickpea variety released with ICRISAT collaboration and efforts of the CDP.

ICRISAT/ICARDA Joint Kabuli Chickpea Project

Genetic enhancement

One of the major activities of the project has been the evaluation of chickpea germplasm accessions to identify sources of resistance to biotic and abiotic stresses. Results of screening with regard to leaf miner, drought, and fusarium wilt are reported in this quarter.

Leaf miner. Over 6000 accessions were evaluated for resistance to this insect since 1981. A total of 293 lines were identified as promising. These were evaluated in a replicated trial at Tel Hadya during 1993/94. The results of screening from the 1993/94 season and cumulative results from 1991 to 1994 are presented in **Table 2**. Only three lines were found resistant (rating scale 3) and five lines were found moderately resistant (rating scale 4). The results indicate that very few sources of resistance are available to this important pest that causes up to 40% yield loss in favorable conditions. The three resistant lines, namely ILC 3800, ILC 5901, and ILC 7738, will be useful in breeding for resistance to leaf miner in chickpea.

Fusarium wilt. After ascochyta blight, fusarium wilt is considered economically important in parts of northern Africa. It is also a serious constraint in eastern Africa and Latin America. Hence, a systematic evaluation of germplasm accessions were initiated in 1987 in collaboration with the University of Cordoba, Spain. Until 1994, we have evaluated 3019 accessions (**Table 3**). Seven accessions remained completely free and 40 accessions showed resistance to this disease. Our effort to identify additional sources of resistance will continue.

Since 1991, an effort was made to create a wilt-sick plot at ICARDA on a 2 ha plot. We have been growing chickpea for the past six seasons in this field and finally we were successful in developing the sick plot for the 1994 off season sowing in September. This field will be utilized for evaluation of germplasm and breeding materials from the 1995 season.

Table 2. Screening of chickpea lines against leaf miner, Tel Hadya, Syria, spring seasons 1981–94.

	Number of tested entries falling into scale	
Stress rating[1]	1993/94 spring	1981-94 cumulative
1	0	0
2	0	0
3	3	3
4	3	5
5	150	485
6	133	710
7	4	1269
8	0	13
9	0	3540
Total	*293*	*6025*

1. Scored on a scale of 1-9, where 1 = free from any damage; 9 = >40% yield loss.

Table 3. Screening of chickpea lines against fusarium wilt until 1994 at Cordoba, Spain.

Rating[1]	Till 1991	1992	1994	Total
1	0	7	0	7
2	2	1	0	3
3	0	5	1	6
4	26	5	0	31
5	57	10	1	68
6	155	15	4	174
7	251	18	8	277
8	584	39	13	636
9	1547	178	92	1817
Total	*2622*	*278*	*119*	*3019*

1. On a scale of 1-9, where 1 = free from disease, 5 = tolerant, and 9 = all plants killed.

Drought. After developing a suitable screening technique and rating scale for drought tolerance, we started screening of germplasm during 1992. The results of evaluation for three seasons are presented in **Table 4.** During the last 3 years screening, no accession was found tolerant to this stress. Only three accessions, namely ILC 6119, FLIP 87-59C, and FLIP 88-42C, were identified to be moderately tolerant. Efforts will continue to identify better sources of tolerance to drought.

Off-season nursery. The F_1 and F_6 generations sown at Terbol in Fields 9 and 11 were badly affected by fusarium wilt and part of the material was destroyed. However, F_3 bulks sown in Field 1 was by far the best this year. The materials have reached maturity and we will soon start harvesting. We have made alternative arrangements to grow them under light.

Cold. The materials for cold tolerance was prepared and sown. Our emphasis is now focussed towards transfer of genes for cold tolerance from wild species to cultivated types.

Varietal release

FLIP 86-5C was identified for release for commercial cultivation in low rainfall areas of Syria. This line has a 100-seed mass of over 45 g and thus will meet a long demand from the farmers for large-seeded chickpea.

FLIP 86-5C was also identified for on-farm testing and release in Iraq. Under their conditions, this line was proved to be high yielding besides having large seed.

Human resource development

M. Labdi completed analysis of data for his Ph.D. degree and developed the first draft. He left for Montpellier, France to finalize his thesis work with his major Professor and submit it for the award of Ph.D. degree.

Table 4. Reaction of chickpea germplasm to drought at Tel Hadya between 1992 and 1994.

Rating[1]	1992	1993	Reconfirmed	1994	Total
1	0	0	0	0	0
2	0	0	0	0	0
3	0	1	0	0	0
4	3	14	3	16	19
5	114	90	90	112	202
6	526	1103	1738	269	2007
7	290	545	854	318	1172
8	66	193	260	347	607
9	1	54	55	122	177
Total	*1000*	*2000*	*3000*	*1184*	*4184*

1. On a scale of 1-9, where 1 = free from stress, 5 = tolerant to stress, and 9 = all plants killed.

Seed exchange

The major activity of our program during this quarter was preparation of international nurseries and trials and despatch them to cooperators in 41 countries. The nurseries distributed during September are as follows:

Type of nursery	No. of sets distributed
Yield	123
Screening	93
Segregating materials	23
Stress	119
Total	358

Pigeonpea Breeding

Development of Extra-short- and Short-duration Types

All the extra-short-duration multilocational trials (EXPPMLT 94DT, Large and Cream Seeded EXPPMLT 94 DT-1 and 2, and EXPPMLT 94-NDT) grown during the 1994 rainy season have good plant growth. Six lines, viz., ICPLs 94045, 94044, 93099, 93072, 93097, and 94036 flowered 10-15 days earlier than their respective controls, ICPL 4 and UPAS 120.

In the short-duration group, two genotypes, i.e., ICPL 94022 and ICPL 94051 in EXPPMLT DT-1 large white/cream-seeded trial, and ICPL 91013 in EPPMLT DT-2 trial, flowered about 10 days earlier than the control cultivar ICPL 87, which flowered in 81 days.

In collaboration with the Agronomy Division, 18 waterlogging-tolerant genotypes (earlier identified under greenhouse conditions) were transplanted in field BP 11B to produce pure seed.

The following five crosses are being attempted during the rainy season. They include: ICPL 93083 x ICPL 87091, ICPL 84023 x ICPL 93086, ICPL 84023 x ICPL 94039, ICPL 84023 x ICPL 94043, ICPL 84023 x ICPL 93087.

Vegetable Types

The first pod picking from green vegetable-type genotypes was done in two trials. About 54 kg of pods were harvested. Sixty samples of green pods (0.5 kg each) were given to the ICRISAT Association for Community Development (IACD) and 11 samples were distributed to pigeonpea breeding staff for acceptance evaluation.

Development of Medium- and Long-duration Types

The yield trials, breeding materials, and seed production plots have good plant stand and growth. Seed multiplication plot of four postrainy season pigeonpea varieties sown in September has good germination and plant stand.

During the 1993/94 cropping season, a Medium-duration Pigeonpea International Trial (MPIT) was sent to 11 locations in India. Data were received from seven locations. On the basis of mean performance of the trial, ICPL 92060 recorded the highest yield in the trial (**Table 5**).

At IAC, ICPL 92062 recorded the highest grain yield of 2.22 t ha^{-1} compared to 2.06 t ha^{-1} for the best control cultivar BDN 1. The best performers at different locations are: ICPL 92060 at Adilabad (3.36 t ha^{-1}), ICPL 92059 at Akola (1.47 t ha^{-1}), ICPL 92069 at Gulbarga (1.99 t ha^{-1}), and ICPL 92060 at Jabalpur (2.43 t ha^{-1}).

Development of Hybrids and Their Seed Production Technology

Data on days to 50% flowering and maturity were recorded in all the 1994 rainy season trials. Based on visual observations, few short-duration determinate hybrids scored better over the control cultivars. Identification of male steriles in the seed production plot of ICPH 8 and in ms Prabhat (DT), IMS 1 (I) and ms ICPL 288 maintenance blocks was completed. Crosses to develop short-duration hybrids are in progress. Identification in backcross F_2s in conversion program was completed and selections were done in the progenies for next generation of backcrosses.

About 10-15 sterility mosaic susceptible plants were removed in ms ICP 3783 in the disease nursery.

Table 5. Performance of entries in the Medium-duration Pigeonpea International Trial (MPIT) at different locations in India, cropping season 1993/94.

Genotype	Location and yield (t ha^{-1})							Mean with CV below 20%
	IAC (1)	Adilabad (2)	Akola (3)	Gulbarga (4)	Jabalpur (5)	Ranchi (6)	Jorhat (7)	
ICPL 92060	2.09	3.36	1.04	1.77	2.43	0.50	0.06	2.14
ICPL 92057	2.11	3.16	1.20	1.73	2.22	0.27	0.10	2.08
ICPL 92066	2.20	2.90	1.12	1.92	2.00	0.66	0.11	2.04
ICPL 92062	2.22	2.90	1.10	1.69	2.07	0.58	0.13	1.99
ICPL 92059	1.62	2.79	1.47	1.94	2.06	0.77	0.06	1.97
ICPL 92069	1.91	2.87	0.79	1.99	2.12	0.69	0.05	1.93
ICPL 92065	1.87	2.50	1.08	1.69	1.95	0.96	0.11	1.82
ICPL 92070	1.88	2.67	0.85	1.71	1.94	0.37	0.12	1.81
ICPL 93005	1.95	2.36	1.21	1.71	1.62	0.33	0.10	1.77
ICPL 93003	1.29	2.63	0.96	1.92	1.94	0.56	0.10	1.75
ICPL 93004	1.78	2.51	0.85	1.84	1.56	0.66	0.06	1.71
ICPL 93001	1.37	2.58	1.13	1.28	1.69	0.69	0.08	1.61
ICPL 93002	1.16	2.05	0.71	1.07	1.74	0.58	0.10	1.35
Control								
ICPL 87119	1.76	3.07	0.89	2.12	2.01	0.93	0.12	1.97
C 11	1.85	2.69	1.08	1.81	2.00	0.46	0.06	1.89
BDN 1	2.06	2.43	0.80	1.77	1.73	0.25	0.10	1.76
SE	±0.162	±0.296	±0.092	±0.202	±0.147	±0.074	±0.030	
Mean	1.82	2.72	1.02	1.75	1.94	0.58	0.09	
CV (%)	15	19	16	20	13	22	57	

Gene-cytoplasmic Male Sterility

A Consultative Group Meeting on Cytoplasmic Male Sterility (CMS) in pigeonpea was organized at IAC on 26-27 July 1994. The purpose of this Meeting was to review the current research in CMS in pigeonpea, to develop a research strategy for achieving a viable CMS system, and to establish a collaborative work plan for the future.

A work plan was developed and a set of recommendations was made for the implementation by Indian NARS and ICRISAT. IAC was unanimously chosen for coordinating these activities. Responsibilities were delegated to various NARS to avoid duplication of work within this group.

Work in progress at IAC in this area of research is as follows:

Wide Hybridization

Some 270 seeds were sown in GTS 6 generation in a greenhouse on 18 Jul 1994. Flowering has commenced and observations on pollen sterility/fertility are in progress. We continued making crosses on GTS 5 plants to get more number of seeds per plant. Studies on pods and seed-set on CMS plants by open pollination is also in progress in five isolation plots. Good pot-set was observed in CMS plots in BL 4A and RCE 24D isolation.

Mutagenesis

Identification of CMS lines was completed. Fourteen progenies in M_7 and 16 progenies in M_6 were identified as promising for CMS. All the 19 plants of progeny no. 506 in M_6 generation was male steriles. Another progeny (No. 664) had 38 sterile out of 42 plants (**Table 6**).

Sib-mating and crossing with other parents is in progress.

Table 6. Promising CMS progenies of pigeonpea identified from QMS 1 mutagenic material in M_7/M_6 generations, ICRISAT Asia Center, rainy season 1994.

Generation	progeny	No. of plants			% sterility in the progeny
		Total	Sterile	Fertile	
M_7	1	4	4	0	100
	10[1]	16	14	2	88
	12[1]	44	34	10	77
	68	13	11	2	85
	93	4	4	0	100
	127	7	7	0	100
	131	6	5	1	83
	136[1]	13	13	0	100
	143[1]	10	10	0	100
	144[1]	10	10	0	100
	197	36	29	7	81
	201	15	13	2	87
	222	10	8	2	80
	217	13	10	2	85
M_6	281[1]	11	11	0	100
	326	10	9	1	90
	349	10	8	2	80
	387	25	20	5	80
	490	9	8	1	89
	506[1]	18	18	0	100
	509[1]	18	17	1	94
	518	6	6	0	100
	519	9	8	1	89
	521[1]	36	29	7	81
	528	7	7	0	100
	531	9	8	1	89
	528	7	7	0	100
	664[1]	42	38	4	90
	694	12	11	1	92
	696[1]	12	12	0	100

1. Selected for crossing.

On-farm Trials

Drs Laxman Singh, M.V. Reddy, and T.G. Shanower visited on-farm trials in Warangal District in the north Telangana region of Andhra Pradesh. Three short-duration pigeonpea lines (ICPLs 85010, 84031, and 88034) are being tested in the prevalent cropping systems and are being compared with other rainy season crops. Good plant stand was noticed in most trials. Some plots at Pallagutta and Macherla were partly waterlogged.

The seed plots of 0.2-0.3 ha each of ICPL 85010 were in good condition at Mr Y. Ramachandra Rao's farm at Alia (sown on 8 Jul '94) and Dr Prasad's farm at Ghanpur (sown on 16 Aug '94).

On-station trials on cropping systems and varietal evaluation at the Agricultural Research Station (ARS), Warangal were also monitored. The cropping systems trial sown on 18 Jun had four rainy-season crops (pigeonpea cv ICPL 85010, groundnut cv TMV 2, sesame cv Rajeshwari, and mung bean cv Warangal 2) to be followed by four postrainy season crops (pigeonpea cv ICPL 87119, groundnut cv TMV 2, sunflower hybrid MFSH 8, and maize hybrid DHM 5). It was disappointing to note that pigeonpea in this trial had been sprayed thrice (Jul 18, Jul 28, and Aug 9) including the one at flowering on 9 Aug. It was pointed out that prior to flowering, pigeonpea does not require insecticides. The insecticides had been applied for leaf webbers and thrips. Blister beetle was also a problem at this time.

The salient observations and aspects of discussions with the farmers and scientists were:

- Two farmers sprayed insecticide on the crop, in spite of clear instructions not to spray till 50% flowering/early podding is achieved. Farmers are accustomed to spraying cotton weekly, beginning 10 days after sowing. Need for judicious use of insecticides was explained.

  A considerable amount of on-farm education for proper use of insecticides is essential. NARS scientists decided to hold a Field Day at two sites in cooperation with the Department of Agriculture to acquaint with on-farm research and insect pest management.
- The field books (English and Telugu) were arranged to each farmer and the scientist by Dr M.V. Reddy during first week of September. Data recording and direct monitoring of above trials will be done by Dr C. Cheralu and his associates.

  Other 15 trials planned will be farmer supervised and advised for minimum data set.
- The need for judicious use of insecticides at the research station was also emphasized.

Groundnut Breeding

The 1994 rainy season crop suffered uneven disease pressure at IAC. The crop in RP 3B and RP 3C fields had heavy plant mortality (≈ 30%) due to root rot pathogen. The pressure of late leaf spot in RP 11B was much severe than other groundnut fields and caused premature defoliation in many spanish breeding lines.

Breeding for Foliar Diseases Resistance

In the Fifth International Foliar Diseases Resistance Groundnut Varietal Trial (V IFDRGVT) conducted at Cader Station, Ouani, Comores during 1993/94, six varieties ICGVs 87281, 87288, 88247, 87282, 87867, and 87291 gave significantly superior pod yields compared to the local control Malgache. ICGV 87281 produced the highest pod yield of 3.98 t ha^{-1}, where as Malgache gave 2.06 t ha^{-1}. In addition to superior pod yields, three varieties, ICGVs 87288 (60 g), 88247 (73 g), and 87291 (60 g), also had higher 100-seed mass than Malgache (41 g). All varieties showed less incidence of rust and late leaf spot diseases.

In the Advanced Foliar Diseases Resistance Groundnut Varietal Trial (AFDRGVT) conducted at CuChi, southern Vietnam during the 1993/94 winter-spring season, ICGV 87206 (3.43 t ha^{-1}) gave significantly higher pod yield than the local control variety LY (2.63 t ha^{-1}). In addition, it also showed higher levels of resistance to rust (4.3) and late

leaf spot (6.7) compared to LY (rust: 6.7; late leaf spot: 8.3) on a 1-9 scale, where 1 = no disease and 9 = 81-100% damage.

In an another Foliar Diseases Resistance Groundnut Varietal Trial (FDRGVT) conducted at Trang Bang, southern Vietnam during the 1993/94 winter-spring season, all the 14 test entries showed higher levels of resistance for rust with scores ranging from 1.0 to 4.7 compared to the local variety LY with 6.3. Among these, three varieties (ICGVs 91237, 91236, and 91223) scored 4.7, 5.7, and 5.7 for late leaf spot compared to 9.0 for LY.

Oil content in 81 varieties tested in different trials during the 1993/94 postrainy season ranged between 41.4 and 54.3%. Eight varieties showed an oil content of >52%. ICGV 93189 showed the highest oil content of 54.3% compared to 49.6% of JL 24.

Breeding for Resistance to Aflatoxin Contamination

We obtained results from CMBD (Crop Quality Unit) on oil content of 159 varieties tested in an elite, an advanced, and two preliminary yield trials during the 1993/94 postrainy season at IAC. The oil content in these varieties ranged from 41.1 to 49.5%. Eight varieties, ICGVs 91308, 92302, 93278, 93279, 93280, 93281, 93358, and 93363, had an oil content of >48%. ICGV 93279 recorded the highest oil content of 49.5% compared to 42.2% of the resistant control cultivar J 11.

Breeding for Resistance to Groundnut Viruses

Resistance to peanut bud necrosis disease (PBND)

We evaluated 69 advanced varieties/interspecific derivatives in three replicated trials at Narkoda research farm, Directorate of Oilseeds Research, Andhra Pradesh during the 1994 rainy season. The cumulative disease incidence at 70 DAS ranged from 16.7 to 67.6% in EBDRGVT, from 5.3 to 50.2% in ABDRGVT(SB), and from 7.6 to 78.8% in ABDRGVT(VB). The disease incidence in these trials ranged from 4.0 to 20.0% in the resistant control ICGV 86031 and from 60.0 to 79.0% in the susceptible control JL 24 in these trials.

The disease incidence in five varieties in EBDRGVT (ICGVs 91071, 88248, 86598, 91249, and 90266), four in ABDRGVT(SB) (ICGVs 94260, 94265, 94268, and 94255), and two in ABDRGVT(VB) (ICGV 91236 and ICGV 91077) was the same as that of the resistant control ICGV 86031.

Breeding for Resistance to Insect Pests

Varietal performance

In a trial conducted at Matsamudu, Comores, eight insect pests resistant varieties (ICGVs 86252, 86522, 86436, 86398, 89280, 87415, 86462, and 86031) significantly outyielded the local cultivar Malgache. Pod yield of these varieties ranged from 2.97 to 3.28 ± 1.88 t ha^{-1}, ICGV 86252 being the highest yielder. The control cultivar, produced only 1.88 t pod ha^{-1}. These varieties also recorded greater 100-seed mass (56-72 g) than Malgache (49 g).

Oil content in selected varieties

Of the 130 insect pests and/or PBND-resistant varieties evaluated for oil content during the 1993/94 postrainy season, ICGV 93006 and ICGV 91038 recorded 53% oil content compared to 48-49% oil in the control cultivar ICGS 76 (ICGV 87141). It also significantly outyielded ICGS 76 and the resistant control NC Ac 343. It produced 5.73 t pod ha^{-1} compared with 4.30 ± 0.26 t of ICGS 76 and NC Ac 343.

Breeding for Drought Tolerance

Heavy incidence of root rot was noticed in segregating populations sown in RP 3B field during the current crop season. Some crosses ICGXs 891354, 891313, 891301, 900501, 900506, and 900514 showed very less mortality compared to others.

We received data from CMBD (Crop Quality Unit) on oil content of 81 varieties tested during the 1993/94 postrainy season with two treatments (normal irrigation and created mid-season drought stress). The effect of the treatments on oil content was not significant. The oil content among the varieties ranged between 44.6 and 52.7%. ICGV 92122 and ICGV 93258 showed the highest oil content of 52.7% compared to 45.5% of control variety TMV 2.

Breeding for Short-duration Varieties

Rainy season 1994

Harvesting of two preliminary trials and an elite trial at cumulative 1240 °Cd (equivalent to 75 DAS in rainy season at IAC) was completed. In the preliminary trials, five test varieties, ICGVs 94286, 94309, 94313, 94326, and 94343, and in the elite trial two test varieties, ICGV 92196 and ICGV 92206, showed similar maturity as that of the short-duration control cultivar Chico.

We also completed harvesting of an elite trial and an advanced trial at cumulative 1470 °Cd (equivalent to 90 DAS in rainy season at IAC), which were severely damaged by late leaf spot disease. In the elite trial, four test varieties, ICGVs 92247, 92243, 92206, and 92196, and in the advanced trial, three test varieties, ICGVs 93417, 93421, and 93416, showed similar maturity as that of Chico. The pod filling and yield in both harvests appear to be poor.

Varietal performance in India

Raichur. In the postrainy/summer 1993/94 season, four ICRISAT short-duration varieties were evaluated along with the local control KRG 1 and national control JL 24. ICGV 89027 produced the highest pod yield (1.27 t ha^{-1}), and was closely followed by ICGV 92256 (1.24 t ha^{-1}). Controls in the trial, KRG 1 produced 1.09 t ha^{-1} and JL 24 produced 0.083 t pods ha^{-1}.

Varietal performance in other countries

Malawi. At Chitedze, 103 short-duration varieties were evaluated in two preliminary trials in the 1993/94 season. ICGV 91119 ranked first in the PSGVT 1 and produced 2.71 t seeds ha^{-1} and ICGV 91134 ranked first in the PSGVT 2 and produced 2.5 t seeds ha^{-1} compared to 2.1 t seeds ha^{-1} of Malimba, a local control in both trials.

In the SADC Regional Groundnut Varietal Trial during the 1992/93 season, ICGV 87480 ranked first at Chitedze and produced 4.61 t pods ha^{-1} and 3.41 t seeds ha^{-1} compared to 2.93 t pods ha^{-1} and 2.21 t seeds ha^{-1} by the highest-yielding control Spancross. In the SADC Regional Groundnut Varietal Trial during the 1993/94 season, ICGV 87069 and ICGV 87003 produced 1.80 and 1.77 t pods ha^{-1}, respectively, compared to 1.54 t ha^{-1} by the highest-yielding control cultivar JL 24 and 1.02 t ha^{-1} by the local control cultivar.

Fifty-five short-duration varieties were evaluated in a preliminary trial during the 1993/94 season at Chitedze. ICGV 92194 ranked first and produced 2.20 t pods ha^{-1} and 1.56 t seeds ha^{-1} compared to 1.97 t pods ha^{-1} and 1.33 t seeds ha^{-1} by the highest-yielding control ICGV-SM 91002 and 0.99 t pods ha^{-1} and 0.48 t seeds ha^{-1} by the local control cultivar Malimba. Other promising varieties were ICGV 92245 and ICGV 92224.

Breeding Medium-duration Varieties with Resistance to Multiple Stress Factors

During July-September, most of the time was spent on recording morphological/agronomic observations on entries in replicated yield trials and on segregating populations. Seed increase plots were thoroughly rogued. Leftover produce from the previous season was discarded and seed stores were fumigated.

Varietal performance in Comores

One set each of IMGVT(SB) and IMGVT(VB) were sent to Comores in 1992. Results of these trials were received recently.

All the entries in IMGVT(SB) significantly outyielded the local control Malgache. The pod yield superiority in breeding lines ranged from 72 to 139%. The highest pod yield of 3.80 t ha^{-1} in the trial was produced by ICGV 88348. Malgache produced only 1.59 t pods ha^{-1}. Most of the breeding lines had greater 100-seed mass (range 48.1 - 74.6 g) than Malgache (48.8 g).

Ten of the fourteen breeding lines in IMGVT(VB) produced significantly greater pod yield than Malgache (1.95 t ha^{-1}). The pod yield in these breeding lines ranged between 2.73 and 3.78 t ha^{-1}, ICGV 88314 being the highest yielder. The 100-seed mass in these breeding lines ranged from 49.0 to 94.4 g as against 48.8 g in Malgache.

Breeding for Confectionery Requirements

Varietal performance

In a 4-year trial conducted over six locations at Athelia/Zyghi in Cyprus, ICGVs 88451, 88454, 88456, and 89214 produced mean seed yields of 3.98 to 4.36 t ha^{-1}, ICGV 88451 being the highest yielder. The local cultivar produced only 3.33 t seeds ha^{-1}. These varieties recorded greater 100-seed mass (87.7 to 102.4 g) than the local control (80.5 g). ICGV 88451 and ICGV 89214 showed 100-seed mass of 97.5 and 102.4 g, respectively.

Of the 19 varieties evaluated at Santiago in Chile, ICGV 88448 produced the highest pod yield of 1.87 t ha^{-1}. It also recorded a 100-seed mass of 80 g.

ICGV 90210 at CuChi and Trang Bang locations in southern Vietnam produced similar yields as that of LY (1.46 t pods ha^{-1}) during the 1994 summer-autumn season. In another trial, OPI 9404 produced the highest pod yield of 1.56 t ha^{-1} and significantly outyielded LY by 46%. It is a cross derivative of LY with confectionery breeding line, CF4-20. The cross was made at IAC, and the F_5 breeding population was evaluated for local adaptation/selection during the 1993/94 winter-spring season.

Oil content in selected varieties

The oil content of 15 confectionery varieties (ICGVs 91080, 92172, 92173, 92174, 92176, 92151, 93029, 93030, 93033, 93050, 93057, 93058, 93069, 93086, and 93089) was in the range of 53 to 56% from the 1993/94 postrainy season evaluation. The control cultivars, ICGS 11 (ICGV 87123) and Chandra, recorded only 48-49% oil content. ICGV 92173, a sequentially branched variety, significantly outyielded ICGS 11. It produced a pod yield of 4.41 t ha^{-1} compared to 3.33 $\pm$ 0.205 t of ICGS 11. It also recorded the highest oil content of 56%.

Staffing

Doreen Margaret Mashler Distinguished Scientific Achievement Award

Seventeen pearl millet scientists—Drs K. Anand Kumar, D.J. Andrews, S.B. Chavan, S.C. Gupta, C.T. Hash, R.P. Jain, Pheru Singh, K.N. Rai, S.D. Singh, B.S. Talukdar, and J.R. Witcombe from ICRISAT, and collaborating pearl millet breeders Drs K.R. Chopra, O.P. Govila, R.L. Kapoor, W.R. Leuchner, W.D. Stegmeier, and K.L. Vyas—were awarded the first Doreen Margaret Mashler Distinguished Scientific Achievement Award in 1994 for their contribution to "Pearl millet improvement with special attention to downy mildew resistance" since ICRISAT was founded 22 years ago. Members of this team contributed directly to the development of one or more released downy mildew resistant pearl millet cultivars. This team formally acknowledged the substantial contributions of Drs F.R. Bidinger, G. Harinarayana, S.B. King, V. Mahalakshmi, E.S. Monyo, T.T. Patil, R.P. Thakur, and R.J. Williams in developing screening procedures, evaluating experimental cultivars, and popularizing these cultivars following their release.

Jagdish Kumar, Sr. Scientist (Chickpea Breeding), proceeded on leave without pay from 2 July to 4 September as a consultant to the Crop Diversification Programme (CDP) of the Canadian International Development Agency (CIDA) in Bangladesh and participated in pulses reviews.

M.M. Rahman, Principal Scientific Officer, BARI, Bangladesh completed his term as a Visiting Scientist at IAC and returned to BARI on 9 August after spending 6 months. He was involved in chickpea pedigree management, botrytis gray mold resistance, and molecular biology.

K.B. Saxena, Senior Scientist (Pigeonpea Breeding), was appointed as a Resident Scientist to work with the Sri Lanka-ADB-ICRISAT Pigeonpea Project (Phase II) from 1 Aug to 31 Oct 1994.

V. Sashikala, Secretary, and **A. Satyanarayana**, Sr. Driver-cum-General Assistant, separated from the Institute under the Voluntary Retirement Scheme on 28 and 30 Sep, respectively.

Mohd. Ejazuddin Khan, Senior DGA, was awarded the "Safe Driving Award 1993".

Staff Travel

Travel within India

Period	Staff name(s)	Organization[1]/ Location	State(s)/ Region	Purpose
11 Jul	Jain, K.C.	Adilabad	Andhra Pradesh	Sowing of on-farm trials in Adilabad District
15-22 Jul	Laxman Singh	Ludhiana Palampur	Punjab	To observe on-going pigeonpea research and collaborative program, and follow-up work of AICPIP meetings
8-13 Aug	Weltzien R., E.	Durgapura Fatehpur Jodhpur Mandore Aagolaie	Rajasthan	To acquaint Drs K. Anand Kumar and C. Renard with our on-station and on-farm collaborative activities in Rajasthan
8-31 Aug	Reddy, B.P.	CAZRI Jodhpur	Rajasthan	To observe collaborative pearl millet trials/nurseries
24-25 Aug	Laxman Singh	Warangal	Andhra Pradesh	To observe on-farm trials on short-duration pigeonpea in Warangal District
31 Aug- 08 Sep	Laxman Singh	Coimbatore	Tamil Nadu	To visit cooperative pigeonpea research at TNAU and other locations (Vamban, Kovilpatti, etc.), and to study cropping systems of pigeonpea
13-19 Sep	Laxman Singh	Bikaner	Rajasthan	To attend AICPIP workshop
16-31 Sep	Weltzien, R., E.	Jodhpur Barmer Aagolaie Kidiyar Fatehpur Tilonia	Rajasthan	To evaluate on-farm and on-station trials in Rajasthan and acquaint Dr S.C. Gupta with methods used in our on-farm studies
23-25 Sep	Talukdar, B.S.	Pune	Maharashtra	To visit demonstration plots of the pearl millet topcross hybrid Puja
23 Sep - 5 Oct	Rao, A.S.	Jaipur Durgapura Gwalior Hisar	Rajasthan Madhya Pradesh Haryana	To evaluate collaborative pearl millet trials and nurseries

1. CAZRI = Central Arid Zone Research Institute.

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Travel outside India

Period	Staff name(s)	Organization[1]/ Location	Country(s)	Purpose
30 Jun 03 Jul	Laxman Singh	Nairobi	Kenya	To consult with Project Planning Team (PP 2) members for final submission and to discuss work program on pigeonpea
31 Jul - 06 Aug	Hash, C.T.	IGER Aberystwyth	UK	To consult with collaborators on ODA-funded molecular marker projects
19-22 Sep	Stenhouse, J.W.	NARS	Thailand	To consult NARS scientists in Thailand on Project Formulation
18-24 Sep	K.C. Jain	NARC, Kathmandu BARI, Dhaka	Nepal Bangladesh	Consultation with NARS scientists on project formulation
20-26 Sep	Laxman Singh	EARCAL	Kenya Nairobi	To attend review and planning meeting of AfDB Project
ICRISAT/ICARDA Chickpea Project				
18-20 Jul	Singh, K.B.	USDA	USA	To monitor chickpea trials/nurseries
21-23 Jul	Singh, K.B.	Univ. of Saskatchewan	Canada	To monitor chickpea trials/nurseries
26-29 Sep	Singh, K.B.	ICARDA	Lebanon	Selection in off-season nursery

1. BARI = Bangladesh Agricultural Research Institute, CIDA = Canadian International Development Agency, EARCAL = Eastern Africa Regional Cereals and Legumes Program, IGER = Institute of Grassland and Environmental Research, ISC = ICRISAT Sahelian Center, NARC = National Agricultural Research Centre, USDA = United States Department of Agriculture.

Workshops, Meetings, and Conferences Attended

Period	Workshop/ Meeting	Organizer[1]/ Location	Country	Staff name(s)
14-20 Jul	AICPIP Rabi Pulses workshop and consultation with Indian scientists on project formulation	Bikaner	India	Sethi, S.C.
14-25 Jul	RPRC Meeting to present pigeonpea project proposals	ISC, Niamey	Niger	Saxena, K.B.
18-22 Jul	RPRC Meeting to present chickpea project proposals	ISC, Niamey	Niger	van Rheenen, H.A.
26-27 Jul	Consultative Group Meeting on Cytoplasmic Male Sterility	IAC	India	Several pigeonpea scientists from IAC, Indian NARS, and private and public seed companies
Jul-Aug	Project planning meetings	IAC	India	van Rheenen, H.A. Onkar Singh Sethi, S.C.
05-06 Sep	Consultation on Sorghum Projects	AICSIP Rajendranagar	India	Reddy, Belum V.S. Stenhouse, J.W.
10-18 Sep	Project planning meeting	EARCAL Nairobi	Kenya	Reddy, Belum V.S. Stenhouse, J.W.
25-29 Sep	Consultation with Myanma scientists on ICRISAT Medium Term Plan and project formulation	Yangaon	Myanmar	Onkar Singh
27-29 Sep	Asia & Pacific Seed Association Conference	FAO Chiang Mai	Thailand	Rai, K.N.
ICRISAT/ICARDA Chickpea Project				
21-22 Sep	Coordination meeting	INRA	Moracco	Singh, K.B.

1. AICSIP = All India Coordinated Sorghum Improvement Project, EARCAL = Eastern Africa Regional Cereals and Legumes Program, FAO = Food and Agriculture Organization of the United Nations, INRA = Institut National de la recherche agronomique, ISC = ICRISAT Sahelian Center.

Visitors

Period	Name of visitor(s)	Organization[1]/ Location	Country(s)	Purpose
16 Aug	Anand Rao, P.K.	Pioneer Overseas Corporation, Hyderabad	India	To select sorghum breeding materials
05 Sep	25 postgraduate students	APAU, Rajendra-nagar, Hyderabad	India	To learn about recent advances in pigeonpea breeding
6 Sep	Executive Committee Members of ICRISAT Governing Board	various	various	To learn about latest develop-ments in pigeonpea breeding
15 Sep	Rao, P.S.N.	Plantgene Seeds, Hyderabad	India	To obtain information on hybrid parent breeding materials
20 Sep	Lenné, Jillian M.	Principal Scientist designate (Plant Pathology)	UK	To discuss on chickpea projects
22 Sep	Hussain Sahib, K.	APAU, Palem	India	To visit and select breeding materials
23 Sep	Devaraj, K.V.	UAS, Bangalore	India	To explore possibilities future collaboration
23 Sep	David Josey	Horticulture Research International, Wellesbourne	UK	To discuss activities on chickpea collaboration
30 Sep	Mahala, R.S.	Pioneer Hi-bred International Hyderabad	India	To obtain information on downy mildew resistance breeding

1. APAU = Andhra Pradesh Agricultural University, UAS = University of Agricultural Sciences.

Cellular and Molecular Biology Division

Sorghum

Molecular Characterization

RAPD analysis *(CSM-270)*

We analyzed F_6 progenies from a cross between a cultivated sorghum (IS 2146) and its wild relative (*Sorghum dimidiatum*; IS 18945) with randomly amplified polymorphic DNA (RAPD) markers, and examined the extent of introgression of the wild genome in the progenies. The RAPD analysis confirmed that the wild type genome was introgressed to varying degrees in different progenies. Most of the amplification products corresponding to the progenies, when visualized as bands on a gel showed resemblance to either of the parents. As reported earlier on the nature of seed proteins in these progenies, some bands of amplified DNA with the RAPD primers were unique and were found in neither of the parents, suggesting significant genomic rearrangements after interspecific hybridization.

Tissue Culture *(CSM-273)*

Protoplast cultures

We have made significant progress in our protoplast culture technique. Mesophyll protoplasts from several genotypes including those from 296B, M 35-1, and IS 32266 were embedded in agarose and successfully regenerated in large numbers. Further, we established an agarose bead system for protoplast culture. Above experiences have paved the way for initiating experiments on genetic transformation using protoplasts.

Variability in anthracnose pathogens *(CS-128)*

DNA fingerprinting facilitates the use of minisatellites and microsatellites which are hypervariable and dispersed in the form of long arrays of short tandem repeat units throughout the genome. These mini- and micro-satellites are flanked by unique restriction endonuclease sites. DNA fingerprinting using the oligonucleotides probe $(GATA)_4$ and a few restriction enzymes was tried to study the extent of genetic variation in the sorghum anthracnose pathogen, *Colletotrichum graminicola*. The method needs to be standardized for dry blots incontrast to dry agarose gels.

Crop Quality

Identification of factors associated with grain mold *(BS-008)*

Proteins were extracted from endosperm and embryo portions of the grains of cultivars. Grain mold resistant (B 48826, B 48890) and mold-susceptible (IS 2433, IS 2516) cultivars that had white grain was used in this study. Protein electrophoresis was standardized using 100 to 120 µg protein in each with a view to identify antifungal proteins. Further studies are needed to confirm the differences in protein bands between mold-resistant and mold-susceptible cultivars.

Bioecology of host-plant resistance and management of shoot pests *(CS-152)*

Sugar content. Sorghum leaves (surface) of shoot fly susceptible and resistant cultivars were washed with a minimum quantity of distilled water. Total soluble sugars content in these solutions was determined. The sugar content in susceptible cultivars CSH 1 was 62.72 µg mL^{-1} and ICSV 112 was 171.29 µg mL^{-1}; whereas the sugar content in resistant cultivars was 25.53 µg mL^{-1} for IS 18551 and 4.17-4.2 µg mL^{-1} for ICSV 705. There is a distinct difference for sugar concentration in the leaf surface between susceptible and resistant cultivars.

Seedling volatiles. Volatile components were determined in seedlings using gas chromatograph (GC) in shoot fly susceptible (CSH 1) and resistant lines (IS 18551). The samples were analyzed for their volatiles between 1000 and 1200 h and also between 1400 and 1500 h. It was observed that a major peak of volatile compound was observed at 0.403 min after the injection of the sample. The concentration was very high in susceptible (nearly double) than the resistant cultivar.

Pearl Millet

Molecular Characterization *(CSM-270)*

Studies on isozymes and RAPD markers

We completed a study on use of isozymes and RAPD markers for genotype identification. For this, we examined 11 isozyme and 10 RAPD profiles. Data are being analyzed.

Classification of male-sterile cytoplasm and characterization of genetic variation *(CM-271)*

Rearrangements in mtDNA associated with cytoplasmic male sterility result in the formation of novel polypeptides in the mitochondria. To investigate the production of such polypeptides in the different cytoplasmic male-sterile lines, attempts were made to standardize the method for 'in organelle' protein synthesis. Mitochondria from a male-sterile (81 A) and a maintainer (81 B) were isolated and purified by sucrose gradient centrifugation. The synthesis of proteins by the mitochondria was done in the presence of [^{35}S]-L methionine. Though the mitochondrial proteins were fractionated by PAGE and detected by autoradiography the incorporation of the radioactive label was too low.

The method of two-dimensional electrophoresis was standardized for the separation of radioactively labelled proteins. Isoelectric focussing was done on the first dimension in tube gels using ampholytes (PH 3-10). Further separation of the proteins on the second dimension was done on slab gels by SDS-PAGE. Initially nonlabelled proteins were separated by this technique and stained with Coomassie blue.

Tissue Culture

Microspore cultures *(CSM-273)*

We have succeed in inducing formation of pollen embryo-like structures in pearl millet by culturing spikelets at 14°C on activated charcoal containing medium. Although the frequency of anthers showing formation of pollen embryoids was small, numerous embryoids were seen to arise from within each responding anther. These embryoids reached 8–16-celled stage by about 5 weeks. These structures are much different from the multicellular structures isolated from culturing anthers; the latter had only small cells, and it proved to be very difficult to grow them on any of the media tried. Anther-derived embryoids measuring $\geq$1.0 mm in length were transferred to a regeneration medium for further studies.

Variability in downy mildew pathogens *(CS-128)*

DNA was isolated from 23 zoospore and oospore isolates of downy mildew pathogen. DNA fingerprinting on dry agarose gels with $(GATA)_4$ showed polymorphism among the different groups of isolates. The data need to be analyzed further for grouping the different isolates. However, when $(GATA)_4$ was used in a ^{32}P labelled PCR not much polymorphism among the host-specific isolates could be detected.

Chickpea

Gene Transfer

DNA transfer by asexual means *(LC-051)*

Experiments were carried out to test the age of donor seedlings for obtaining leaflet explants on somatic embryogenesis response. Leaflets obtained from 7-day-old seedlings produced nodular calluses on the explant surface after about 2 weeks of culture on the selected medium containing an auxin. After transfer to hormone-free medium, the nodules increased in size and had a glassy appearance. These were considered as proembryos. Further work on the maturation of these proembryos into more normal looking embryos is in progress.

Transfer of desirable traits from wild species of chickpea by sexual means *(LC-052)*

More pollinations were carried out using cultivated chickpea as the female plant and annual wild *Cicer* species as the pollen donor. Immature seeds were obtained only in the cross between cv ICCV 4 and *Cicer pinnatifidum* (ICCW 37 and ICCW 38). These have been cultured on the ovule culture medium.

Tissue Culture

Tissue culture and regeneration of chickpea and its wild relatives *(LC-053)*

Shoots of the hybrid GL 769 x *C. pinnatifidum* (ICCW 38) was subcultured on the micropropagation medium. Efforts are underway to identify a medium which induces roots on the hybrid shoots.

Crop Quality

Functional properties of desi and kabuli chickpea *(BC-004)*

The nitrogen solubility index (NSI) of desi (ICCV 88202 and Annigeri) and kabuli (ICCV 16 and L 550) genotypes at different pH levels (2.0, 4.0, 6.0 and 8.0) was examined. At all pH levels, the NSI values were higher in desi than in kabuli chickpea. However, these differences in NSI were more pronounced at lower pH level, i.e., 2.0 and 4.0.

The major storage protein fraction, globulin was extracted and freeze-dried using two desi (ICCC 37 and Annigeri) and two kabuli (ICCV 6 and L 550) genotypes. Freeze-dried fractions were studied for their emulsification capacity (EC) and gelation capacity. The mean EC value of desi was higher than that of kabuli genotypes. The gelation capacity did not show much variation.

Pigeonpea

Gene Transfer

Transfer of desirable traits from wild species of pigeonpea by sexual means *(LP-351)*

Tissue culture techniques have been standardized to maintain the 21 F_1 hybrid plants in vitro. At regular intervals shoots from F_1 hybrid embryos are rooted and transferred to soil. By this method, the F_1 population has been immortalized in vitro. As a result of colchicine treatment to F_1 seedlings, 2 plants with varying levels of pollen fertility have been obtained. The flowers from these plants were self pollinated. As a result, pods with well developed seeds were obtained. However, none of the seeds reached maturity, hence to obtain F_2 population generation these embryos were cultured in vitro. As a result there are 22 F_2 hybrid plants that showed vigorous vegetative growth. Some of these plants have just begun to flower.

Transformation by asexual means *(LP-351)*

The shoots produced in transformation experiments were subcultured on selection medium containing 20 mg L^{-1} hygromycin. In experiments concerning optimization of tissue culture methods from leaves and stem explants, the callus was transferred to fresh medium. While the callus continued to proliferate, only 5% of the calluses produced shoot buds.

Tissue Culture

Tissue culture and regeneration *(LP-351)*

The R_2 plants selected for minimal *Helicoverpa* damage or high *Helicoverpa* damage were sown in a randomized split plot design for evaluation of *Helicoverpa* resistance. The R_2 plants selected for low biomass with high harvest index, high biomass with high harvest index, small plants, small pod-bearing length per branch, high 100-seed mass, white seed-coat color, presence of strophiole or flowering habit were sown in a randomized complete block design for agronomic evaluation for the characters like high harvest index, high 100-seed mass, high shelling percent, short duration, and short plants. Besides these, R_2 seed harvested from R_1 plants regenerated from gamma-irradiated cotyledon explants were also sown for segregation analysis. All the seeds were sown in a row system, with row-to-row spacing of 75 cms and plant-to-plant spacing of 35 or 20 cms. The pre- and post-harvest observations on quantitative and qualitative characters will be recorded on these plants.

An experiment was also initiated on micropropagation of the somaclones selected for white or purple seed-coat color and seed strophiolation.

Crop Quality

Alternative food uses of pigeonpea *(BP-005)*

Effect of preprocessing treatments on cooking quality was examined by using four genotypes C 11, ICPL 87052, ICPL 87075, and BDN 2. The cooking time, water absorption and solid dispersion as influenced by different treatments, i.e., sodium bi-carbonate (1% w/v), edible oil (1% w/v), and preheating at 80°C for 10 min were examined. The sodium bi-carbonate pretreatment considerably reduced (nearly 23%) the cooking time. Maximum

reduction in cooking time was observed in ICPL 87052 (28.6%) and minimum in C 11 (17.4%) as compared to the control. No large differences in water absorption and solids dispersion were observed.

Having standardized the procedure for preparation of quick cooking *dhal*, 15 genotypes were studied for their quick cooking *dhal* quality. For preparation of quick cooking *dhal*, pectinase enzyme was more effective as compared to sodium bi-carbonate treatment. Also, there were considerable differences in quick cooking *dhal* quality of different genotypes.

Groundnut

Gene Transfer

Transfer of desirable traits from wild species of groundnut by sexual means *(LG-651)*

Fifty hybrid plants (members of section *Arachis* x *Erectoides*) which were observed to be pollen sterile were colchicine-treated to double the chromosome number based on pollen stainability analyses. Four plants have been identified as pollen fertile.

Since it was not possible to recover fertile hybrid plants in large numbers, the experiment to cross members of the section *Arachis* with members of the section *Erectoides* was repeated. Immature ovules obtained from the crossing experiment were cultured in vitro.

DNA transfer by asexual means *(LG-652)*

Leaf explants obtained from 3-day-old seedlings were used for transformation studies. Experiments were initiated by co-culturing these explants with *Agrobacterium* strains carrying npt GUS-Intron genes, or npt II and PCV coat protein genes. The shoots thus obtained are being selected on a selection media containing 20 mg L^{-1} hygromycin or 150 mg L^{-1} kanamycin.

The shoots obtained earlier after transformation with PCV coat protein gene were analyzed by ELISA. Two shoots out of 22 gave a positive reaction showing the possible presence of the PCV coat protein gene in these putative transformants. These shoots along with others will be characterized in detail once sufficient leaf material is available.

Southern blot hybridization was carried out with putative transformants carrying npt II and GUS genes. The DIG-labelled 3.0 kb GUS gene fragment positively hybridized with the Hind III restricted genomic DNA, thus confirming presence of the introduced gene.

Strains of *Agrobacterium* and *Escherichia coli* were periodically maintained by subculture.

Tissue culture and regeneration *(LG-653)*

Immature embryos cultured in vitro as a result of crossing members of the section *Arachis* with members of the section *Erectoides*, developed multiple shoots. The somaclones obtained will be treated with colchicine in the present quarter.

Crop Quality

Chemical analysis of selected wild species of groundnut *(BG-007)*

Proteins were extracted from defatted samples of nine bulk advanced/released groundnut genotypes (ICGSs 1, 5, 11, 21, 44, 76, ICGV 86564, Kadiri 3, and JL 24) using sodium phosphate buffer (pH 7.0) containing 1.0 M sodium chloride. The protein extracts were further purified into *arachin* and *conarachin* fractions by repeated cryoprecipitation and centrifugation steps. The final *arachin* and *conarachin* fractions are being studied by SDS-PAGE.

Breeding medium-duration varieties for resistance to multiple stress factors *(LG-607)*

Crude fiber, mineral, and trace element composition were determined in three newly developed groundnut genotypes (ICGS 21, ICGS 11, and ICGS 76) and results were compared with the controls (J 11, JL 24, TMV 2, and Kadiri 3). These genotypes were grown in the 1992/93 postrainy and 1993 rainy seasons. The crude fiber content was similar in all the cultivars and no significant difference was noticed between the postrainy and rainy seasons. The major mineral elements potassium and calcium were in significantly higher amounts in the 1993 rainy season than in 1992/93 postrainy season. The trace elements zinc, copper, and magnesium were in slightly higher amounts in the 1992/93 postrainy season than in the 1993 rainy season.

Breeding for confectionery requirements *(LG-609)*

Oil content was determined in 291 groundnut samples grown during the 1993/94 postrainy season yield trials. The oil content varied between 42.6 and 54.2%. Fatty acid composition was determined in 287 groundnut samples grown in the 1992/93 postrainy season. O/L ratio in these samples varied between 1.04 and 2.81.

Breeding for short-duration varieties *(LG-606)*

Protein and oil contents were determined in 179 groundnut grown in the 1993 rainy season. The oil content varied between 43.2 and 55.6% and the protein content between 14.4 and 25.0% in these samples. Fatty acid composition was also determined in these samples. The O/L ratio in these samples varied between 0.97 and 1.83.

Workshops, Meetings, and Conferences Attended

Period	Workshop/Meeting	Organizer/ Location	Country	Staff name(s)
19-22 Sep	XVI International Conference of Biochemistry and Molecular Biology	New Delhi	India	Sastry, J.G.
20-22 Jul	SINCA summer conference on sorghum Biotechnology and visit to sorghum biotechnologists at the Iowa and Kansas State Universities for collaborative work	College Station, Texas	USA	Seetharama, N.

Visitors

Period	Name of visitor(s)	Organization[1]/ Location	Country(s)	Purpose
12 Jul	Raman, K.V.	Cornell University	USA	To familiarize with CMBD activities
13 Jul	Prof Bhalla, J.K.	Osmania University	India	To familiarize with CMBD activities
2 Aug	Fredric Renard	Belgium Embassy	India	Visited CMBD
18 Aug	Officers	NPPTI	India	To familiarize with crop quality activities
25 Aug	Mathew Nelson	Glasgow Univ. Scotland	UK	Visited CMBD
26 Aug	45 students	Osmania University	India	Visited CMBD
5 Sep	Participants of a training course	NIN Hyderabad	India	To familiarize with crop quality activities
8 Sep	M.Sc. students	Holy Cross College	India	To familiarize with crop quality activities
12 Sep	Sweaney, A.L. Meeks, C.	The Univ. of Georgia	USA	To familiarize with crop quality activities
19 Sep	Anjali Bhagwat	BARC, Bombay	India	To familiarize with CMBD activities
19 Sep	Singh, M.P.	IIPR, Kanpur	India	To familiarize with CMBD activities
23 Sep	David Josey	Horticulture Research International	UK	To familiarize with CMBD activities

1. BARC = Bhabha Atomic Research Centre, IIPR = Indian Institute of Pulses Research, NIN = National Institute of Nutrition, NPPTI=National Plant Protection Training Institute.

Crop Protection Division

Sorghum

Entomology

Effects of infestation time of spotted stem borer on genotypic resistance and grain yield

We studied the insect and host-plant interactions for spotted stem borer (*Chilo partellus*) across five infestation times (0, 15, 20, 25, and 30 days after seedling emergence, DAE) in a set of 20 stem borer resistant and 5 stem borer susceptible genotypes. The 25 genotypes were sown in a split-plot design with infestation periods as the main plots, and genotypes as subplots. The crops were raised without insecticide application. The seedlings were infested with 5–7 first-instar larvae plant^{-1} with a Bazooka applicator at different intervals. Data were recorded on percentage deadheart formation at 35 DAE and on grain yield at harvest.

Deadheart formation ranged from 7.6% to 30.3% across infestations. At 15, 20, 25, and 30-day infestations, the deadheart incidence across genotypes was 35.5, 26.2, 17.9, and 18.1%, respectively. The deadheart incidence was greater in the crop infested at 15 DAE than in the crops infested at 25 and 30 DAE. IS 12308 was stable in its resistance to stem borer across times of infestation. Grain yield across genotypes in plots infested at 15, 20, 25, and 30 DAE were 1.081, 1.056, 0.967, and 1.080 t ha^{-1}, respectively (compare with 1.39 t ha^{-1} from noninfested plots). Maximum reduction in grain yield was recorded in plots infested at 25 DAE.

Grain yields of ICSV 714 (1.422 t ha^{-1}), IS 5604 (1.345 t), and IS 5469 (1.422 t) were greater than those of the commercial controls, ICSV 1 (1.095 t ha^{-1}), ICSV 112 (1.296 t ha^{-1}), and Maldandi (0.823 t ha^{-1}) across infestation times.

Reduction in grain yield in crops infested at 15 DAE was greater in IS 1044 (0.517 vs 1.045 t ha^{-1} in infested vs noninfested crops), IS 18333 (0.616 vs 0.751 t ha^{-1}), and IS 2263 (0.676 vs 0.912 t ha^{-1}). In the commercial controls, the grain yields in crops infested at 15 DAE in relation to noninfested crops were 0.946 vs 1.460 t ha^{-1} for ICSV 1, 1.390 vs 1.320 t ha^{-1} for ICSV 112, and 0.872 vs 1.298 t ha^{-1} for Maldandi. In crops infested at 25 DAE, when maximum reduction in grain yield was recorded, IS 1044, ICSV 714, IS 5604, IS 18573, IS 21444, Nagawhite, Seredo, ICSV 1, ICSV 112, and Maldandi suffered significant losses in grain yield compared to the noninfested crops. ISs 5469, 2123, 5566, 2265, 2146, 13100, and 2269 did not suffer a reduction in grain yield as a result of borer infestation at 25 DAE.

These studies indicated that IS 12308 was stable in its resistance to stem borer across times of infestation. ICSV 714, IS 5604, and IS 5469 yielded better than the commercial controls, ICSV 1, ICSV 112, and Maldandi across times of infestation, and these genotypes might be useful as sources of resistance for breeding stem borer resistant lines. Maximum borer damage was observed in crops infested at 15 DAE, while yield reduction was greater in crops infested at 25 DAE.

Utilization of natural plant products for pest management

We tested four formulations derived from neem (*Azadirachta indica*; NF 20, Azatin, Bioneem, and Fortune Bio), one each from custard apple (*Anona squamosa*; ASF 16), a bacterium (*Bacillus thuringiensis*; Biocasp), and a commonly used insecticide (endosulfan) for pest control in sorghum. The trials were laid out in a randomized complete block design. There were eight treatments including a nontreated control, and three replications. The crop was infested artificially with spotted stem borer, *Chilo partellus*, and oriental armyworm, *Mythimna separata*, at 15 and 25 days after seedling emergence (DAE).

The infested crops were sprayed with different test formulations 6 h after infestation. Data were recorded on leaf damage on a 1 to 9 damage rating (DR) scale (1 = <10% leaf area damaged, and 9 = >80% leaf area damaged)

by stem borer and armyworm at 1 week after infestation. Deadheart formation due to stem borer and phytotoxic effects of different formulations were recorded at 30 DAE. Leaf feeding DR was <2.3 for stem borer and armyworm in crops treated with ASF 16, NF 20, Azatin, Bioneem, and endosulfan compared with a DR of 8.3 and 4.3 in the nontreated crops for stem borer and armyworm, respectively. Deadheart incidence was <10% in crops treated with NF 20, Biocasp, Azatin, and endosulfan compared with 87% deadhearts in nontreated controls. Azatin formulation was phytotoxic to the plants. ASF 16 and NF 20 formulations also showed some phytotoxicity effects.

The results indicated that neem, custard apple, and Bt formulations were as effective for pest control on sorghum as endosulfan.

Pathology

Sorghum grain mold

Evaluation for resistance. Eighty-three sorghum grain mold (SGM)-resistant zera-zera conversions selected during the 1993 rainy season, were evaluated for resistance at physiological maturity, and 14 days later. To facilitate mold development, high relative humidity (>90%) was created by running overhead sprinklers twice a day on rain-free days. In the first observation all selections received a score of 2 on a 1-9 scale (1 = no mold and 9 = >60% mold). In the second observation >60% of the selections scored 2 and 40% scored 3. Most promising selections were from IS 18758C and IS 30469C. Observations on colonization of grains by individual fungi (*Fusarium moniliforme*, *F. pallidorosum*, *Curvularia lunata*, and *Phoma* sp) and mold scores on threshed grains are in progress.

Anthracnose (*Colletotrichum graminicola*)

Epidemiology. An experiment was laid out during the 1994 rainy season to study the spread of the anthracnose pathogen under field conditions. Five genotypes, one resistant (A 2267-2), two moderately resistant (ICSV 89102 and ICSR 92021), and two susceptible (H 112 and HR 91048) to anthracnose were used. Each genotype was grown in 16 rows of 9 m length in two replications in a randomized-block design. A locus of infection was created in the center of each plot by adding anthracnose-infected sorghum seeds to the soil 2 weeks after seedling emergence. Each plot was divided into 48 sectors of 2.25 m^2 each. The total and the number of diseased plants were recorded in each sector at 15-day intervals up to seed maturity. The data computation and analyses are in progress.

Pathogen variability. We have already identified the various isolates of *C. graminicola* using RAPDS (IAC Quarterly Technical Report, Jan-Mar 1994, p. 37). In DNA fingerprinting micro- and mini-satellites are used as DNA probes. We tried to standardize the DNA fingerprinting method to study the variation among the isolates using the probe $(GATA)_4$. We also used the oligonucleotide probe $(GATA)_4$ as a primer in a PCR reaction to study the genetic variation among the 14 isolates of *C. graminicola*. The results showed polymorphism among a few isolates which needs further confirmation.

Disease survey. About 30 samples of sorghum anthracnose were collected, mostly from farmers' fields, in the Indian states of Maharashtra and Karnataka for studying pathogenic variability. Of 30 samples, 22 were from dual purpose fodder sorghum, 2 from yellow sorghum, and 1 each from CSH 9, Khundi Jowar, SPV 1018, D 340, DMS 652, and H 112. The incidence of anthracnose ranged from 10 to 80%, with 5-60% severity on fodder sorghum. Twenty-five samples of leaf blight (*Exserohilum torcicum*), mostly from local sorghum and CSH 9, were collected. The most striking disease was leaf blight on CSH 9 (100% incidence, 80% severity) and on fodder sorghum (10-100% incidence, 5-80% severity) in several fields in Maharashtra.

Pearl Millet

Pathology

Downy mildew (*Sclerospora graminicola*)

Pathogenic variability 1. The 1994 International Pearl Millet Downy Mildew Virulence Nursery (IPMDMVN) consisting of 15 entries was sent to eight locations in West Africa and four in India. The nursery was also sown at IAC. Each entry was sown in two rows, 4-m long with two replications. First observation on total and infected plants was made at 30 days after seedling emergence. The second observation will be made at the soft dough stage. Based on the first observation, two entries, IP 18292 and IP 18293, remained free from downy mildew; P 310-17, 7042R, MBH 110, and ICMP 85410 showed ≤5% incidence, and 852B had 9% incidence. P 7-4 and 700651 had 21 and 14% incidence, respectively. The remaining entries and the susceptible controls (7042S and 7042S-11) showed between 74 and 100% incidence.

Pathogenic variability 2. To study the variation in RFLP among the single zoospore isolates of the host genotype, specific pathotypes DNA was extracted from 40 such isolates. The results from this study will be used to check the observations made earlier on the host-specific genotypes obtained with RAPD markers and DNA fingerprinting.

Effect of cultivar mixtures on disease development. A field experiment was conducted during the 1994 rainy season to investigate the effect of mixtures of resistant and susceptible cultivars on disease development. The seeds of resistant (IP 18293) and susceptible (NHB 3) cultivars were mixed by weight in the ratios of 1:1, 2:1, 1:0 and 0:1. Each treatment was sown in twenty-four 13-m long rows in two replications. Pearl millet variety WC-C 75 was included as a resistant control. Five downy mildew infected plants raised in pots were centrally placed in each plot for 10 days after seedling emergence as source of inoculum. The plants of the resistant cultivar in the mixture were identified by their characteristic purple pigmentation. Total plants and number of infected plants were recorded in each plot at weekly intervals until the soft dough stage. Data computation and analysis are in progress.

Resistance screening. A total of 1635 entries from five trials [Initial trials of the All India Coordinated Pearl Millet Improvement Project (AICPMIP), ICRISAT breeding trials, and germplasm accessions] were evaluated for downy mildew resistance at IAC. Of 321 AICPMIP entries (involving hybrids, varieties and lines), 67 remained free from downy mildew at 30 days after seedling emergence, and of 266 germplasm accessions (185 photoperiod sensitive and 81 short-duration genetic stocks selected from earlier greenhouse screening) screened, most lines were free from downy mildew at this stage. The lines were also evaluated at Mysore and Aurangabad. Data recording at the soft drought stage is in progress.

Disease surveys. Two surveys were conducted in the Indian states of Maharashtra, Karnataka, and Andhra Pradesh during August and September 1994 to record the disease prevalence and severity on sorghum and pearl millet. The pearl millet crop in most of the areas in Maharashtra was very good but only few disease-free fields were seen in Karnataka and Andhra Pradesh. About 15 samples of downy mildew (oospores) were collected from MLBH 104, MLBH 267, BK 560, ICTP 8203, and a hybrid from the private sector. The disease incidence ranged between 10 and 50% on ICTP 8203, 20 and 40% on MLBH 104, and 20 and 70% on BK 560. These collections will be used in studies on variability in populations of the downy mildew pathogen.

Chickpea

Entomology

Integrated pest management (*LC-153*)

Analysis of the efficacy of *Helicoverpa* NPV for the control of *H. armigera*. Analysis of data from the 1993 postrainy season experiments has shown that the effects of host-plant resistance and NPV on *H. armigera* densities on chickpea are not independent. NPV had a greater effect on *H. armigera* populations on susceptible genotypes than on a resistant genotype. Further studies are now required to examine the potential for increasing the efficacy of NPV when it is used in conjunction with *Helicoverpa*-resistant chickpea genotypes.

Collation and analysis of data from international *Helicoverpa* resistance nurseries, 1985-93. Work has begun on the production of a summary of the International Chickpea *Helicoverpa* Resistance Nursery (ICHRN) data for publication.

Assessment of the feasibility of establishing and maintaining a lab culture of the Hymenopteran parasitoid, *Campoletis chloridae*. Currently there is interest in the use of "bio-rational" products, including neem and Bt, for the management of insect pests on chickpea. Both these products have been shown to have adverse effects on some natural enemies. We have investigated the feasibility of establishing a culture of *C. chloridae* to conduct laboratory experiments which would supplement field toxicological studies. Maximal levels of parasitism were recorded when Ist instar *H. armigera* were confined with parasitoid females in small pots. Techniques which reduce larval cannibalism (e.g., use of *H. peltigera* larvae) should make maintenance of the culture less time consuming.

Identification and utilization of host-plant resistance

***Helicoverpa* resistance in chickpea.** We reported in the last quarter that oxalic acid, a major component of chickpea leaf exudate, retarded larval growth of *Helicoverpa armigera* when included in a semi-artificial diet. Considering that the amount of oxalic acid on the leaves was greater in chickpea genotypes resistant to *H. armigera* than in susceptible genotypes, we concluded that oxalic acid is one of the factors conferring resistance to *Helicoverpa* in chickpea. Malic acid, another major component of the leaf exudate, had no effect on larval growth, though it has been reported to have some relation to *Helicoverpa* resistance in chickpea. In this quarter we investigated the effect of malic acid on oviposition of *H. armigera* moths.

A sheet of tissue paper (One-Way Nappy Liners, The Boots Co., Nottingham, England) was dipped in L-malic acid solution, squeezed and dried in an oven at 60°C for 1 h. It was cut into 3 strips and hung on the wall of a cylindrical plastic cage (23 cm in diameter). Control paper was treated with distilled water in the same way, and hung in alternate strips with the malic acid treated strips. A gravid female moth and a male moth which had been mated 2 days before were released in the cage. Absorbent cotton soaked in 10% honey solution was placed in the cage for feeding of the moths. They were kept for 40 h in a laboratory at 25°C. Eight replicates were taken for each malic acid concentration. The percentage of eggs on the malic acid treated strips of the total eggs laid on the tissue paper strips was calculated. Oviposition preference for the two strips was evaluated by G-test on angular transformed percentage data.

Two malic acid solutions (0.025 and 0.05 M) were tested, and retained 0.2 and 0.6 µm malic acid cm^{-2}, respectively. More eggs were laid on the malic acid treated paper than on the control paper. When the malic acid concentration was 0.1 M, the paper retained 0.8 µm malic acid cm^{-2}, and 50% eggs were laid on the acid-treated paper. When the paper was treated with 0.25 and 0.5 M malic acid solutions, it retained 2 and 4 µm malic acid cm^{-2}, respectively, and less eggs were laid on the acid-treated paper than on the control paper. This result suggests that lower concentrations of malic acid on the leaves stimulates oviposition of *H. armigera*, but higher concentration of the acid inhibits the oviposition.

The amount of malic acid accumulated on the leaf surface of chickpea grown in a greenhouse in May 1994 ranged between 0.15 and 0.75 μm cm^{-2}, within the range where oviposition stimulation would be observed. We will measure the malic acid concentration on the leaf surface of chickpea grown in the field in the next quarter. We will also investigate the effect of oxalic acid on the oviposition behavior of *H. armigera*.

Pathology

Biology and management of wilt and root rots (*LC-228*)

International Root Rots/Wilt Nursery (ICRRWN) 1994-95 was formulated with 50 entries. The nursery was dispatched through the Plant Quarantine Unit (PQU) to 33 locations in 16 countries.

ICAR-ICRISAT Root Rots/Wilt Nursery (IIUCRRWN) 1994-95 was formulated with 70 entries. The seeds were prepared for dispatch to various locations in India.

Two F_2 bulks were screened for resistance to dry root rot under laboratory conditions. Data are being compiled.

Biology and management of foliar fungal diseases (*LC-229*)

International Ascochyta Blight Nursery (IABN) 1994-95 was formulated with 21 entries. The nursery was dispatched through PQU to 4 locations in 3 countries.

Ascochyta Blight Nursery (ABN) 1994-95 was formulated with 33 entries. Seed packets were prepared for dispatch to various locations in India.

Botrytis Gray Mold Observation Nursery (BGMON) 1994-95 was formulated with 24 entries. The nursery was dispatched through PQU to 3 locations in 2 countries.

Integrated Management Trial on Botrytis Gray Mold was formulated with 2 experiments of 5 entries each. The trials were dispatched to 3 locations in 2 countries.

Several F_4 progenies and advanced breeding lines were screened for resistance to botrytis gray mold in the Plant Growth Room at IAC. Resistant plants selected were transplanted in pots in the greenhouse or in the field for seed production.

Virology

Identification and characterization of economically important viruses and their management (*LC-230*)

International Chickpea Stunt Disease Nursery (ICSDN) 1994-95 was formulated with 21 entries. The nursery was dispatched through PQU to 8 locations in 5 countries. Seeds were prepared for dispatch to various locations in India.

We have earlier reported the transmission of chickpea luteovirus (A24), collected from ICRISAT fields, by *Myzus persicae* (Legumes Program Quarterly Technical Report, Jan-Mar 1993, p. 70). We were unable to maintain the virus by aphid transmission due to very low transmission frequency (<10%) by *Myzus persicae*. The low rate of virus transmission could be due to the presence of biotypes in the aphid colony, or to the virus being very inefficiently transmitted by the colony of *M. persicae* used in the experiments.

Chickpea plants infected with the luteovirus (A24) collected from IAC fields were pooled and used for purification of the luteovirus. The preparation was used for membrane feeding (acquisition access feeding) by *M. persicae*. Exposed aphids were then transferred to pea, *Physalis floridana*, and radish plants for 2 days of inoculation access feeding. After 3 weeks the test plants were tested by ELISA. Only peas (ca. 5% of the plants) were infected by A24 isolate. Infected pea plants are currently being used as a source for multiplying the virus. Additionally, 11 groups of aphids, each containing 10 adults, were transferred to individual pea plants and are being tested for their

efficacy in transmitting the A24 isolate. If variation in ability to transmit the A24 isolate exists within the aphid colony, we should be able to identify the efficient transmitters by testing them firstly in groups, and subsequently as individuals within the groups.

Pigeonpea

Entomology

Integrated pest management (*LP-461*)

The effect of manipulations of the cropping system on the interactions between host-plant, pest, and natural enemies. Weekly counts of aphids, jassids, and damage to cotton "squares" and bolls were begun in the pigeonpea: cotton intercropping trial in BM 7. This trial will compare the effect of three spray regimes on pest and natural enemy population dynamics in a pigeonpea:cotton intercropping system, and two pigeonpea cultivars, one tolerant and one susceptible to *Helicoverpa armigera*. Analyses of the most recent pest counts (27 September) are presented in **Table 1**. Nine insecticide applications have been made to 'farmer' and five to IRM treatments.

Table 1. Incidence of various pests on cotton and damage to cotton reproductive structures in a pigeonpea:cotton intercrop trial, ICRISAT Asia Center, rainy season 1994.

Treatment/ intercropped with pigeonpea genotype	Insects leaf^{-1}			*Helicoverpa* plant^{-1}		Boll/square damage (%)
	Aphid	Jassid	Thrip	Eggs	Larvae	
No insecticide						
ICPL 87119[1]	0.38	1.38	0.84	1.80	1.93	4.13 (11.09)[2]
ICPL 332	0.16	0.98	0.49	1.80	1.27	2.23 (8.55)
Mean	0.27	1.18	0.67	1.80	1.60	3.18 (9.82)
IRM practice						
ICPL 87119	0.51	0.73	0.24	4.13	3.47	5.15 (12.61)
ICPL 332	0.71	0.71	0.31	1.80	2.07	4.27 (11.81)
Mean	0.61	0.72	0.28	2.97	2.77	4.71 (12.21)
Farmers' practice						
ICPL 87119	0.27	0.42	0.07	1.73	1.93	1.93 (7.76)
ICPL 332	0.89	0.38	0.29	1.07	0.87	3.94 (11.24)
Mean	0.58	0.40	0.18	1.40	1.40	2.94 (9.50)
Trial mean	0.49	0.77	0.37	2.06	1.92	3.61 (10.51)
SE (m) ±	0.404	0.109	0.353	0.493	0.446	1.167(1.697)

1. Treatments differentiated by pigeonpea cultivar; pest counts were taken on cotton cv 'Anjali' in all treatments.
2. Figures in parentheses are angular transformed values.

Development and implementation of IPM in farmers' fields by incorporating resistant varieties, enhanced biological control, and manipulation of farming systems. Field measurements of on-farm trials at Marepally, Andhra Pradesh, India, were made using an optical compass to measure field perimeters, and area calculated in square meters. Also, a follow up of the survey of pesticide dealers in Tandur, Andhra Pradesh was completed. This information is being combined with household survey data collected in Marepally in 1994, and will be covered in a Progress Report later this year. Budding has begun in both ICPL 84060 and ICPL 87119 and weekly pest counts were initiated from mid-September onwards. *Helicoverpa* eggs were observed on local and ICRISAT lines. Black gram (*Vigna mungo*) and green gram (*V. radiata*) were harvested and yields were recorded. Both crops were intercropped with ICRISAT pigeonpea lines and yield data are presented in **Table 2**. The yields of black gram intercropped with ICRISAT pigeonpea genotypes in minikits are provided in **Table 3**.

We have reported earlier that we sowed sorghum CSH 9 and short-duration pigeonpeas ICPL 85012 and ICPL 84052, which flower and mature at the same time, in a trial on strip and sole cropping to study the pest/parasitoid activities in these two systems. In general, during flowering and grain development stages (between 55 and 90 days), *H. armigera* incidence on short-duration pigeonpeas was negligible, <0.1 larvae plant^{-1} compared to 0.4 larvae panicle^{-1} of sorghum. However, after 90 days, as sorghum grains started becoming harder, *H. armigera* activity started decreasing on sorghum and increasing on pigeonpea. However, this did not cause much concern as 70% of pigeonpea pods were nearing maturity. In general, pigeonpea ICPL 85012 flowered and podded earlier than ICPL 84052 and both pigeonpea lines flowered 7-10 days earlier in sole cropping than in strip cropping.

Table 2. Yield of green gram and black gram intercropped with pigeonpea in on-farm trials at Marepally, rainy season 1994.

	Black gram		Green gram	
Pigeonpea genotype	Plot yield (g)	Yield (kg ha^{-1})	Plot yield (g)	Yield (kg ha^{-1})
ICPL 84060	120.3	499	106.4	709
ICPL 87119	143.9	634	134.7	898
Local	136.9	583	115.3	768
Trial mean	133.7	572	118.8	792
SE (m) ±	9.63	42.1	10.54	70.3

Table 3. Yield (kg ha^{-1}) of black gram intercropped with ICRISAT pigeonpea genotypes in four minikit trials at Marepally, rainy season 1994.

	Minikit farmers[1] (black soil)				
Intercropped with black gram	A	B	C	D	Mean
ICPL 84060	392	354	578	270	398
ICPL 87119	520	501	699	344	516
ICPL 88046	570	438	390	425	456
ICPL 88047	604	412	547	555	529
ICPL 85063	547	335	541	428	463
Local	344	743	372	545	501
Mean	496	464	521	428	
Trial mean	477				
SE (m)±	73.1				

1. A = Shabuddin, B = Ananth Reddy, C = Ramanna, D = Bheemanna.

The predator coccinellid was found more active during flowering and grain formation in both sorghum and pigeonpea and its activity was more in strip-intercrops than in sole crops. On average 0.6 beetles plant^{-1} was recorded in strip pigeonpea compared to 0.4 beetles plant^{-1} in sole pigeonpea between 55 and 90 days of crop development. The egg parasitoid *Trichogramma* was found relatively more active on intercropped sorghum than on sole sorghum. It naturally parasitized 36% of *H. armigera* eggs on intercropped sorghum compared with 26% on sole sorghum. No releases of laboratory-bred *Trichogramma* were made because of some unavoidable problems. Further, no egg collections were made on pigeonpeas as *H. armigera* activity was very low on pigeonpea.

Among pigeonpeas varieties, ICPL 84052 (indeterminate) attracted more of blister beetle activity than ICPL 85012 (determinate), while pod bugs were relatively more active on ICPL 85012 than on ICPL 84052. It was observed that on indeterminate pigeonpea, blister beetles can obtain a good grip on a twig or branch while feeding on flowers or flower-buds.

Identification and utilization of host-plant resistance

Helicoverpa resistance in pigeonpea. We are trying to identify chemicals which retard growth of *H. armigera* larvae on pods of wild pigeonpeas. Pods of *Cajanus scarabaeoides*, on which the growth of *H. armigera* larvae was poor, were freeze-dried, milled by a blender and extracted with solvents sequentially from non-polar to polar; n-hexane, ethylacetate, acetone, 70% aqueous methanol, and water. The extracts were concentrated in vacuo by a rotary evaporator and mixed into a chickpea-based semi-artificial diet, except in the case of water extract, which was directly incorporated into a diet in place of water. The extracts from 100 g dry weight of pods were incorporated into a diet of 100 g dry weight. Forty-eight *H. armigera* larvae were reared on each diet from the 1st instar to observe the effect of the extracts on growth and survival. A very strong growth inhibition was observed on the acetone extract, and a weak growth inhibition on the 70% aqueous methanol and water extracts. Similar growth inhibition was noted in the same fractions from pigeonpea pods (ICP 909), on which *H. armigera* grows very well. Therefore, we could not conclude that the chemicals in the extracts from *C. scarabaeoides* were the causes of its resistance to *H. armigera*.

It is likely that some chemical(s) in the acetone extracts of pigeonpea and *C. scarabaeoides* react with component(s) of the semi-artificial diet producing very strong repellent and/or growth inhibition to *H. armigera*. This may be also the reason why the growth of *H. armigera* was strongly inhibited when freeze-dried pod mash of pigeonpea and *C. scarabaeoides* were included in the semi-artificial diet. For this reason it seems that the semi-artificial diet feeding test is not a suitable method for screening chemicals which cause the *Helicoverpa* resistance in the wild pigeonpea. Therefore an alternative bioassay, a filter paper feeding test, will be used in future experiments.

Groundnut

Entomology

Biological studies of foliar pests carried out to provide background information for IPM program (*LG-751*)

Surveys. During the early part of the 1994 rainy season, pest surveys in Mahabubnagar District of Andhra Pradesh and Raichur District of Karnataka clearly indicated the severity of red hairy caterpillars. This pest occurred in epidemic proportions in Nagarkurnool, Kolhapur, and Palem areas of Mahabubnagar District, attacking crops of cotton, groundnut, sesame, and castor. During the first week of August, the pest was in a migratory phase, most probably in search of food and resting sites. Though farmers used chemical sprays and manual control measures, some farmers have resown their crops assuming the pest disappears in a short period (pupation).

Groundnut fields near Kolhapur had high incidence of leaf miner and white grubs, particularly in the early-sown crop. Field visits in the second fortnight of August around Raichur showed a drastic decline in the red hairy caterpillar population. However, the samples (25 larvae) collected from the Raichur area revealed 100% parasitization

of red hairy caterpillar by braconid wasps. Observations in farmers' crops around Anantapur and Kurnool during August showed high incidence of jassids. There was 5-10% plant mortality caused by soil insects, but due to severe drought, the causal organism could not be confirmed (it was probably due to white grubs).

Determination of the relationships between insect density and crop loss and subsequent economic analysis. The release of five *Spodoptera* fourth instar larvae plant^{-1}, around 30 days after emergence (DAE) on 40 selected groundnut varieties in a replicated trial under nonsprayed conditions resulted in 12-47% defoliation. Performance of these lines in terms of yield will be analyzed after harvest.

Modeling of the effects of foliar pests and diseases on growth and production (work reported by K.E. Neering, Visiting Scientist). A field trial using a foliar pest-susceptible (ICGS 44) and a pest-resistant (ICG 2271) groundnut varieties was conducted at ICRISAT Asia Centre from December 1993 till May 1994. The aim of the trial was to gather data for the development of mathematical models to describe the effects of foliar pests and diseases on groundnut development and yield. Treatments were reduction of pest and disease populations by application of chemicals and natural infestation as a control. Leaf miner (*Aproaerema modicella*), was the main pest. In December, record numbers of male adults were caught in pheromone traps. This vast adult population gave rise to a large infestation of first generation leaf miners, which attacked the crop at an early stage. Insecticide was applied too late to prevent damage completely. Second and third generation densities were comparatively low (**Fig. 1**). Thrips populations increased later in the season (**Fig. 2**). Leafhoppers were present in low densities. Late leaf spot (*Phaeoisariopsis personata*), was virtually absent. Preventive fungicide applications had no significant effect on plant

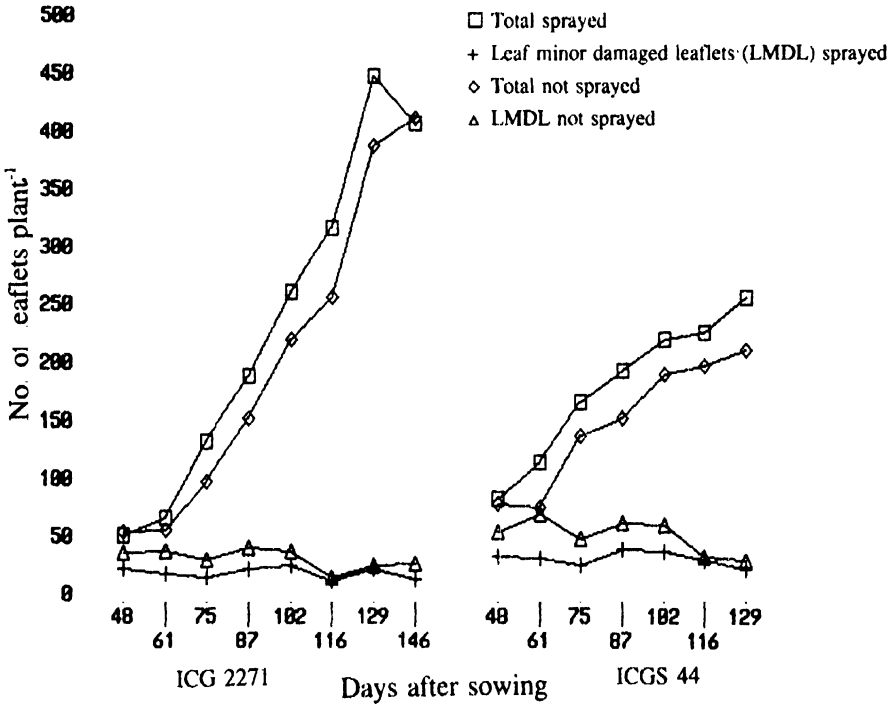


Figure 1. Total number of leaflets and number of leaf miner damaged leaflets in groundnut, ICRISAT Asia Center, postrainy season 1993/94.

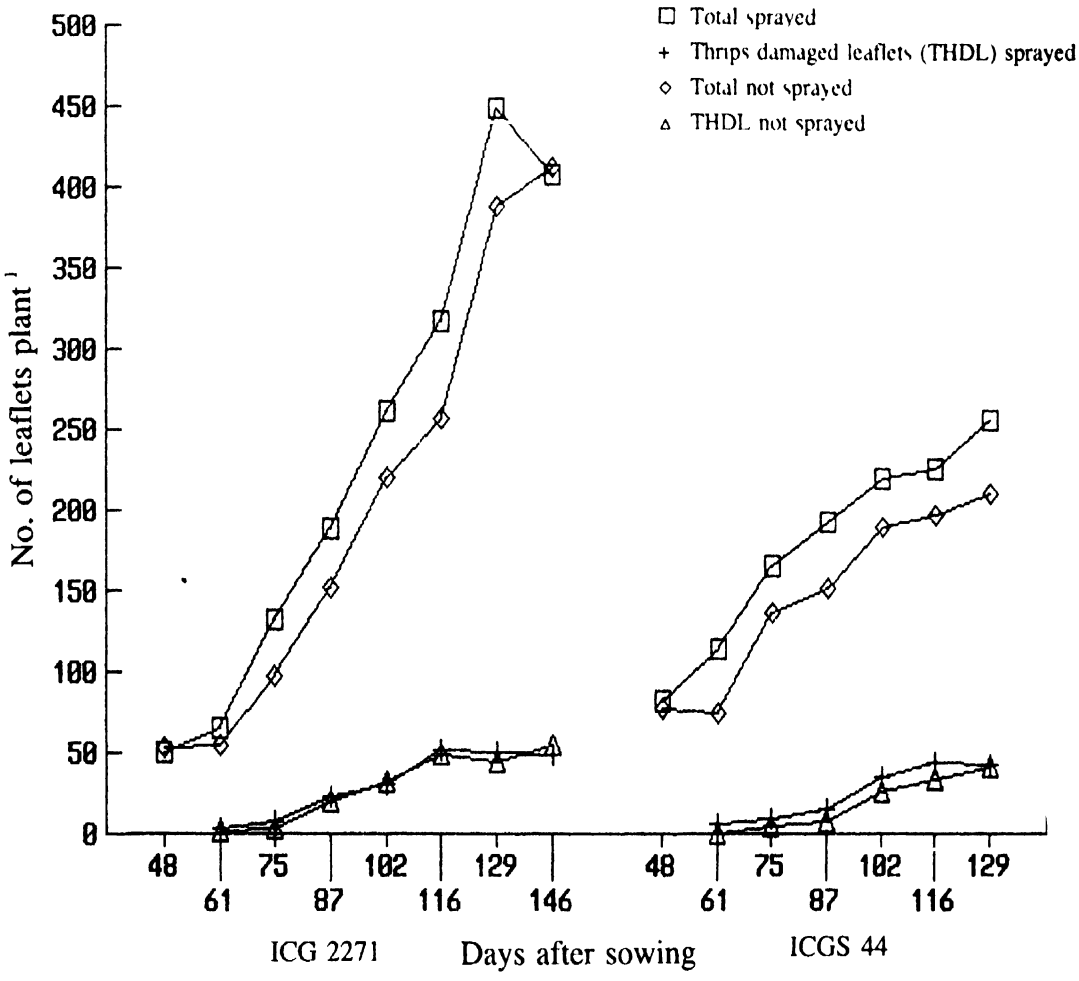


Figure 2. Total number of leaflets and number of thrips damaged leaflets in groundnut, ICRISAT Asia Center, postrainy season 1993/94.

growth or development. Plant growth was strongly influenced by the early leaf miner attack Canopy weights (**Fig. 3**) and leaf areas (**Fig. 4**) were reduced, flowering and fruit-set (**Fig. 5**) were retarded and reduced. The susceptible variety ICGS 44 was affected more (up to almost 100% infested leaflets at early growth stages) than the multiple insect resistant variety ICG 2271. At later growth stages plants recovered slightly from the damage inflicted earlier, but generative yields remained well below the yields of plants that had received chemical protection (**Table 4**). Unfortunately the insect-resistant variety ICG 2271 had to be harvested prematurely, 70 75% mature pods was not reached at the time the field had to be abandoned so the potential of this variety could not be demonstrated. This delay in reaching maturity was due to damage by first generation leaf miner and by cold nights in December/January, which delayed plant development. The data will be used for development of models, but can only be used for verification, not for calibration as the field conditions were too extreme.

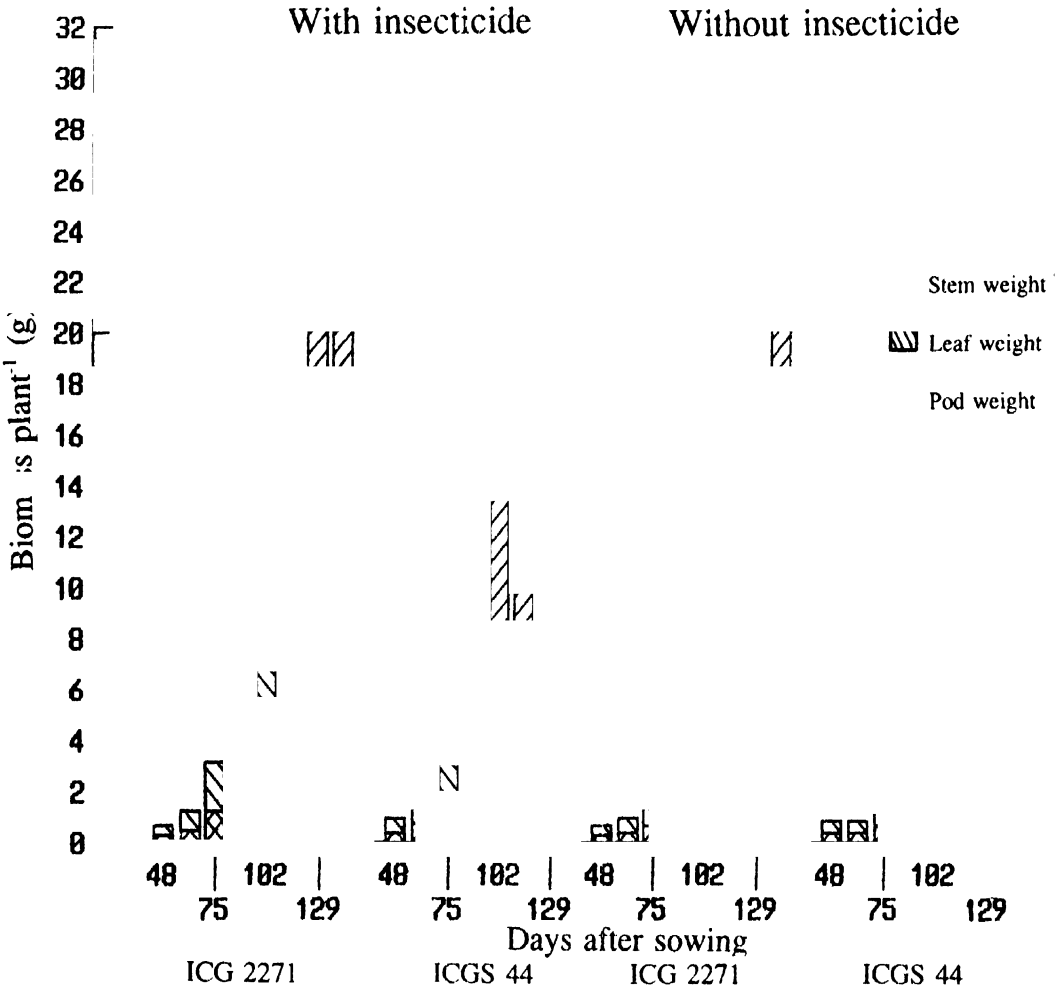


Figure 3. Biomass of groundnut as influenced by leaf miner damage, ICRISAT Asia Center, postrainy season 1993/94.

In July a new trial was sown. Treatments were varieties: standard varieties ICGS 44 and TMV 2, the insect-resistant variety ICG 2271 and foliar disease resistant variety ICG(FDRS) 10. Factorially combined treatments are with and without chemical control of foliar pests and/or diseases. Data collected so far in this trial showed predominance of foliar diseases, not pests, which is in accordance with previous experience. The data collected so far are suitable for the development and calibration of models.

Testing and installation of a network of pheromone traps for key groundnut pests to facilitate forecasting pest damage across the SAT. The pheromone septa of leaf miner and *Spodoptera* have been supplied to the network locations for continuation of monitoring. *Spodoptera* pheromone trap data at ICRISAT Asia Center showed a good peak in the 2nd week of August with 400 moths per trap and later declined to 75 moths per trap by the end of September.

Groundnut leaf miner population showed a peak with 487 moths per trap in the first generation. The second generation moth catch showed considerable increase in the population with 1865 moths per trap in the last week of August. And later the moth catch declined drastically by the last week of September to 2 moths per trap.

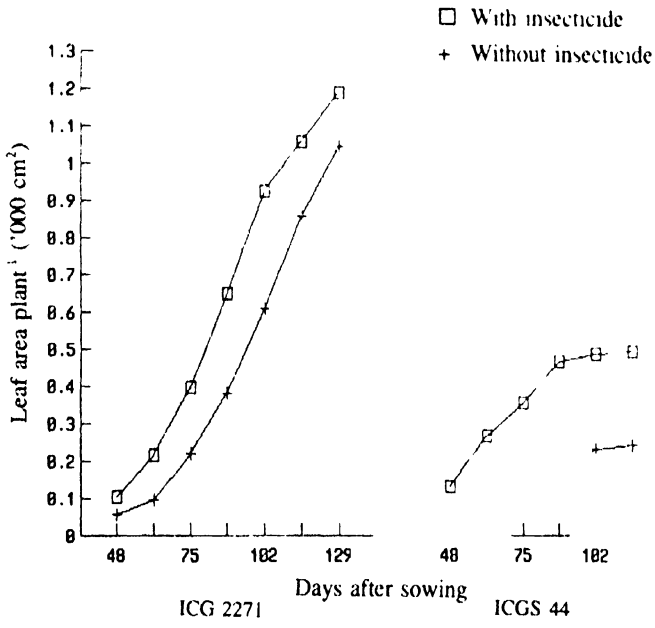


Figure 4. Leaf area of groundnut as influenced by leaf miner damage, ICRISAT Asia Center, postrainy season 1993/94.

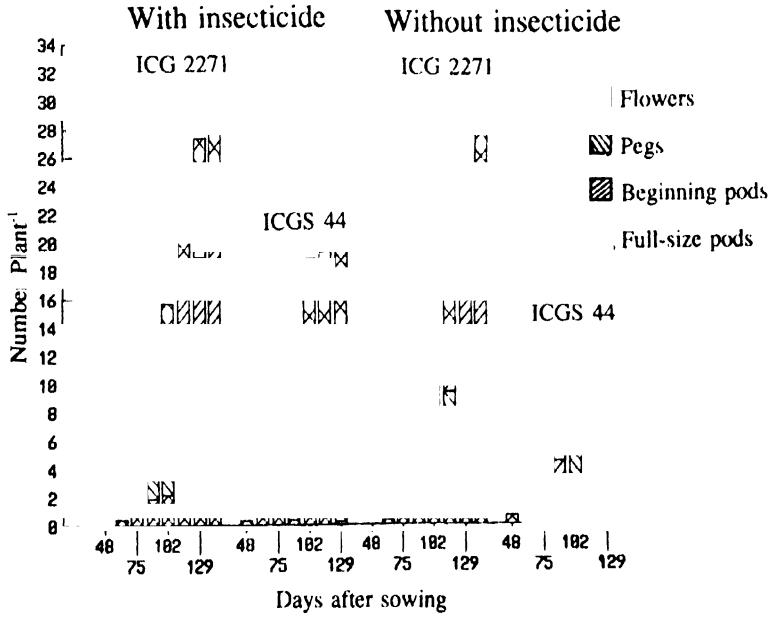


Figure 5. Number of reproductive organs in groundnut as influenced by leaf miner damage, ICRISAT Asia Center, postrainy season 1993/94.

Table 4. Yield of two groundnut varieties at different days after sowing[1] (DAS), ICRISAT Asia Center, postrainy season 1993/94.

Variety/ treatment	Plants ha^{-1} ('000)	Haulm mass (t ha^{-1})	Pod yield (t ha^{-1})	Seed mass (t ha^{-1})	SMK[2] (t ha^{-1})	100-seed mass (g)	100 SMK (g)	Maturity (%)
ICGV 87128 (ICGS 44)								
Harvest date 14/04/94 (124 DAS)								
Insecticide+ fungicide	231	1.20	1.60	1.21	0.91	38.1	50.5	56.7
Insecticide	201	1.35	1.74	1.30	0.96	36.6	50.5	53.7
Fungicide	201	0.61	0.58	0.42	0.27	29.0	46.9	36.3
Control	226	0.81	0.88	0.66	0.50	34.2	50.8	48.3
Harvest date 21/04/94 (131 DAS)								
Insecticide+ fungicide	217	1.22	1.41	1.09	0.88	39.8	50.5	64.0
Insecticide	198	1.27	1.84	1.44	1.16	44.1	53.7	66.3
Fungicide	217	0.71	1.08	0.82	0.63	33.5	48.0	51.0
Control	216	0.74	0.83	0.63	0.47	33.7	48.6	50.7
Harvest 28/04/94 (138 DAS)								
Insecticide+ fungicide	210	1.19	1.76	1.40	1.18	44.7	56.8	67.3
Insecticide	195	1.20	1.81	1.45	1.23	46.7	56.2	70.0
Fungicide	199	0.66	0.74	0.57	0.43	37.0	50.1	54.0
Control	187	0.62	0.73	0.57	0.42	37.0	50.6	49.7
ICG 2271 (NC Ac 343)								
Harvest date 02/05/94 (142 DAS)								
Insecticide+ fungicide	236	3.91	2.94	2.09	1.24	52.9	75.8	38.3
Insecticide	226	3.60	2.71	1.49	0.96	50.8	77.1	31.4
Fungicide	211	2.84	2.07	1.37	0.54	46.5	75.7	21.3
Control	229	2.96	2.01	1.32	0.57	45.5	77.2	23.0
Harvest date 09/05/94 (149 DAS)								
Insecticide+ fungicide	212	4.13	3.28	2.39	1.49	56.5	78.5	43.8
Insecticide	223	3.88	2.96	2.14	1.17	53.6	77.4	37.5
Fungicide	216	3.20	2.19	1.51	0.79	46.0	70.3	31.0
Control	243	3.27	2.59	1.82	1.00	50.4	74.9	34.4
Harvest date 16/05/94 (156 DAS)								
Insecticide+ fungicide	217	3.83	3.69	2.80	2.12	65.8	82.9	59.9
Insecticide	196	3.14	3.18	2.39	1.61	63.5	81.2	53.2
Fungicide	212	2.70	2.16	1.51	0.88	46.3	71.6	37.5
Control	214	2.47	2.62	1.96	1.36	60.0	78.3	52.3

1. Sowing date: 11.12.1993.
2. SMK = Sound mature kernel.

Research on host-plant resistance to insects in the genus *Arachis* (*LG-752*)

Ten first instar white grubs have been released into white grub screening plots in Field RCE 20 containing wild *Arachis* spp accessions. The experiment is in progress and the plots should be harvested in the second week of October for final insect and plant counts.

Spodoptera larval populations reared artificially have been released in nonsprayed fields for evaluating the performance of some selected groundnut varieties for resistance to leaf-eating caterpillars. The release of five 4th instar larvae on 40 selected lines showed different levels of defoliation ranging from 12-47%. The effect of defoliation on yield will be known after harvest.

Cultural control of groundnut pests including the influence of crop management on the efficiency of natural control processes (*LG-753*)

Observations on natural enemies of groundnut leaf miner in the 1st generation showed 6% larval parasitization which increased to 52% in the 2nd generation.

Observations on *Spodoptera* larval parasites activity indicated 48% parasitization by tachinids.

The IPM of soil insects in groundnut fields (*LG-754*)

To define the relationship between white grub density and yield, an experiment has been carried out in Field RCE 20 using artificially reared insect populations. Four treatments with 0, 10, 20, 30 larvae per treatment with two dates of sowing have been taken up with 10 replications. Observations on larval development, plant mortality, and parasite activity were recorded along with haulm and pod yield.

In collaboration with the Microclimatology and Economics Units, and the Andhra Pradesh Agricultural University, an on-farm trial has been conducted at Gudipadu Village near Anantapur in Andhra Pradesh State of India to evaluate the economic status of various insect pests on groundnut, particularly white grubs. Effects of soil application with Thimmet®, and seed treatment with chloropyriphos will be examined after harvest of the crop during November. The effect of leaf miner will be assessed by the application of need-based foliar sprays and comparison of treated plants with nonsprayed control. In order to measure population dynamics of the pests, pheromone traps have been arranged in these areas.

Epidemiology and control of virus vectors (*LG-756*)

Studies on yellow spot disease and its vector relationship with *Scirtothrips dorsalis* and *Thrips palmi* are in progress.

The rationalization of insecticide application for the control of groundnut pests within the context of IPM (*LG-757*)

NRI/ICRISAT/ICAR collaborative project on *H. armigera* insecticide resistance management

Resistance monitoring. The first significant populations of *H. armigera* on the IAC farm during the 1994/95 season were found on wild hosts in mid June.

Pyrethroid resistance levels at the start of the season were high, with 71% and 76% survival at the cypermethrin, and fenvalerate discriminating doses respectively (**Fig. 6**). From late July there has been a marked increase in the levels of suppression of pyrethroid resistance by the synergist piperonyl butoxide (Pbo) from 30% suppression in June to 70% by August. This suggests a reversion in resistance to more amenable metabolic detoxification during the start of the cropping season when no insecticide selection pressure is operating. Both endosulfan and organo-

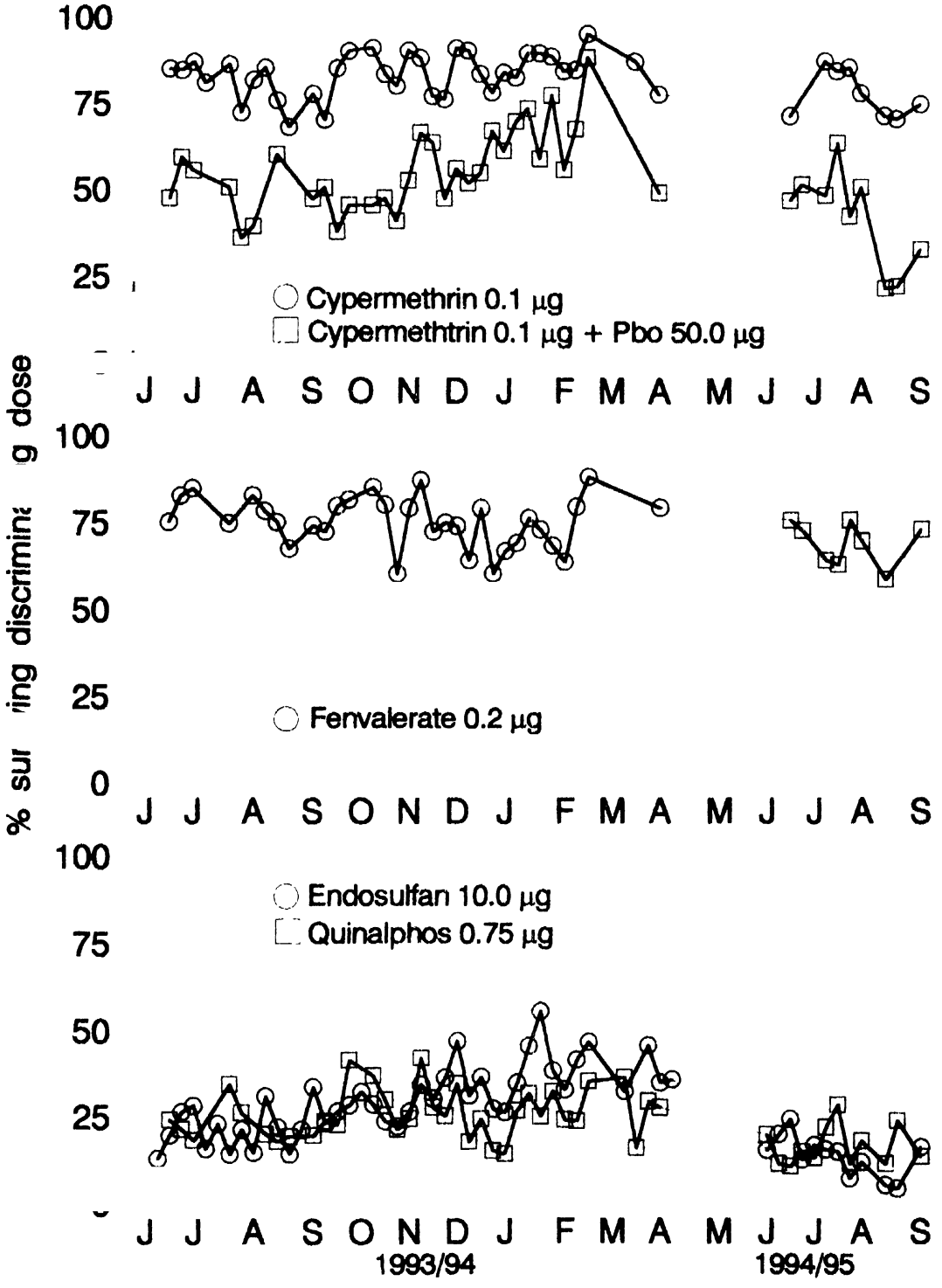


Figure 6. Average weekly resistance frequencies to cypermethrin, fenvalerate, endosulfan, and quinalphos in *Helicoverpa armigera*, ICRISAT Asia Center, 1993/94 season and the start of the 1994/95 season.

phosphate (quinalphos as indicator chemical) resistance have decreased significantly compared to the end of 1993/94 season results. Endosulfan resistance is currently averaging around 15% and quinalphos at 14%. This compares with 1993/94 end-of-season levels of 35% and 27%, respectively.

Monitoring has also commenced this season at the four NARS resistance monitoring centres funded under the NRI/ICRISAT/ICAR project.

Resistance management. A 4-ha cotton/pigeonpea field trial was sown at IAC in June where farmer management practice of weekly pesticide application to cotton (amounting to 20-25 sprays in the season) is being compared with a 'best-bet' resistance management strategy where insecticide application is minimized through careful crop scouting and spray scheduling based on pest counts (9-12 sprays envisaged this season). A third treatment — 'no insecticide treatment' has been included to determine the benefits (if any) of using chemical control measure against insecticide resistant *H. armigera*. Because of the high levels of resistance in *H. armigera* to all commonly available conventional insecticides, mixtures of conventionals plus biological insecticides (neem [botanical], *Bacillus thuringiensis* [bacteria], and nuclear polyhedrosis virus) are being evaluated. So far this season *H. armigera* populations have been quite low and sucking insect pests (aphids, jassids, and thrips) have been the major problem on cotton so far.

Project review meeting. A 2-day meeting was held at IAC on 25-26 August to review results obtained during the first operational season of the NRI/ICRISAT/ICAR insecticide resistance management (IRM) project. Thirteen scientists from IAC and NARS attended. Key areas for *H. armigera* IRM research over the next 3 years were considered to be:

- Continue resistance monitoring for 3-4 years to build-up a comprehensive picture of seasonal resistance changes in major cotton and pulse growing regions (continuation of monitoring after this period was only considered useful if it was tied-in with area-wide practical IRM implementation in farmers' fields).
- Add new insecticides with novel modes of action to the monitoring program, e.g., synergists, biorationals.
- Establish an IRM lab in each of Punjab and Gujurat States — all major cotton-growing regions in India would then be covered by the monitoring program.
- Strengthen capability to undertake metabolic and neurophysiological resistance mechanisms studies at the Central Institute of Cotton Research (CICR), Nagpur, Indian Agricultural Research Institute (IARI), New Delhi, and Tamil Nadu Agricultural University (TNAU), Coimbatore.
- Investigate the role of migration and diapause in the dynamics of resistance — considered to be particularly important in low pesticide use regions which appear to inherit their resistance problems from the heavily sprayed cotton/pulse areas. BHU, Varanasi, was considered an ideal location in which to base this study.
- Identify practical and sustainable IRM protocols for major cotton-growing regions. APAU, Guntur, CICR, Sirsa, and TNAU, Coimbatore were identified as the priority centres to undertake such studies.
- Cotton IRM trials should initially be conducted on research farms (already in progress at APAU, Guntur, IAC, and TNAU, Coimbatore). Once 'best-bet' strategies have been refined (may take 2-3 seasons), active collaboration with regional extension departments should be sought to undertake demonstrations in farmers' fields.
- Develop skills in modeling/forecasting insecticide resistance at one institution in India. This institution should also be responsible for holding and updating a database on pest resistance for India and to advise government departments and national and international scientists on the status of resistance in insect pests.

Insect cultures. *Helicoverpa armigera* cultures have been despatched to the following during the reporting period:

- Andhra Pradesh Agricultural University, Guntur
- Central Institute for Cotton Research, Nagpur
- Indian Agricultural Research Institute, New Delhi
- Natural Resources Institute, UK

About 1000 larvae of *Maruca testulalis* were collected from which 572 pupae were sent to NRI, UK. NRI is working on synthesis of the *M. testulalis* pheromone.

Pathology

Identification of stable resistance to rust and late leaf spot (*LG-801*)

Thirty-five groundnut breeding lines in an advanced resistance screening trial in the 1994 rainy season were scored for reaction to rust and late leaf spot diseases. High disease pressure has been created in the trial, and this proved useful in effective resistance screening. At 90 DAS marked genotypic differences in resistance to late leaf spot and/or rust were observed.

Twenty late leaf spot resistant genotypes were evaluated for components of resistance using the detached-leaf and whole-plant techniques under laboratory and greenhouse conditions. Considerable differences were observed among genotypes for components of resistance studied (infection frequency, percent leaf area damage, incubation period, lesion diameter, and sporulation index). These data are now being analyzed.

All rust and late leaf spot resistant genotypes are being multiplied. They showed resistant reactions at 90 DAS.

Isolates of the late leaf spot pathogen, *Phaeoisariopsis personata*, obtained from several locations in India were established on a culture medium. These will be used to study possible variability in the pathogen.

Integrated management systems for control of aflatoxin contamination (*LG-806*)

A trial on "Effects of farm yard manure and vermiculture compost on *Aspergillus flavus* seed infection and aflatoxin contamination in groundnut" sown in the 1994 rainy season is progressing well. Only limited drought stress has been experienced by the crop in September. If the rains continue to be well distributed during October, environmental conditions will not be conducive to infection by the aflatoxigenic fungus *Aspergillus flavus*.

Integrated management of diseases (*LG-809*)

Integration of partial resistance with chemical control

Foliar diseases. Foliar diseases pressure was very high and uniform throughout the field. Early leaf spot was the first to appear, followed by late leaf spot and rust. In general, late leaf spot and rust were the dominant foliar diseases. The fungicide cyproconizole (Sandoz India Ltd.) controlled both rust and leaf spots more effectively than did chlorothalonil (Kavach®) in all the spray regimes tested. Cyproconizole when sprayed at 45 and 75 DAP on moderately resistant cultivars (ICG(FDRS-10), ICGV 86564, ICGV 86590, NC Ac 17090, and ICGS 76) controlled rust and leaf spots more effectively than chlorothalonil. Collection of further data is in progress.

Bud necrosis. Bud necrosis disease caused by peanut bud necrosis virus (PBNV) was comparatively less in plots sprayed with cyproconizole than chlorothalonil (Kavach®) sprayed plots. This is attributed to interaction between the crop canopy and the thrips vector of PBNV.

Seed treatment and fungal diseases control

Foliar disease. In preliminary experiments, seed treatment with cyproconizole @ 0.2% delayed the rust and leaf spot severities by about 10 days in the greenhouse/dew chamber experiments.

Stem rot. In preliminary experiments, seed treatment with cyproconizole @ 0.2 and 0.3% controlled *Sclerotium rolfsii* stem rot disease in the greenhouse. Similarly, a combination of seed treatment plus one foliar spray of cyproconizole @ 0.15% completely controlled the stem rot disease. These observations will be checked in the detailed ongoing investigations.

Production of monoclonal antibodies for Aflatoxin B1

To produce aflatoxin B1-specific monoclonal antibodies, aflatoxin B1 oxime-bovine serum albumin (BSA) conjugate was injected into four 6-week-old female Balb-C mice. Some 320 µg of AFB1 oxime-BSA conjugate suspended in 100 µL of sterile PBS was mixed with equal volume of Freunds' complete adjuvant and injected intraperitonially into each mouse. Freunds' incomplete adjuvant was used in subsequent immunizations.

Virology

Characterization of isolates, epidemiology, and management of bud necrosis disease (*LG-851*)

Experiments to produce monoclonal antibodies to G1 and G2 proteins of peanut bud necrosis virus (PBNV) were initiated (IAC Quarterly Technical Report, Apr-Jun 1994, pp. 47–48). Unfortunately these experiments failed largely because hybridomas could not be transferred at the intervals required due to lack of adequate trained staff in the monoclonal antibodies laboratory, and the failure of the carbon dioxide incubator which killed the majority of the hybridomas. Another Research Associate is currently being trained in this technology and a new carbon dioxide incubator has been ordered to overcome such problems.

PBNV western immunoblots and monoclonal antibodies to PBNV nucleocapsid polypeptide were sent to the Oklahoma State University, USA for testing the serological relationship of PBNV with tomato spotted wilt virus.

Since cDNA clones prepared against the PBNV RNA in June 1994 reacted with nucleic acids extracts from healthy plants, different protocols to purify PBNV were tried to avoid contamination of healthy plant components in the purified virus. Among the different protocols tried, the following protocol gave preparations devoid of RNA from healthy plants.

Frozen PBNV infected groundnut (stored at -70°C) was triturated in 0.1 M potassium phosphate buffer pH 7.6, containing 10 mM Na_2So_3, EDTA (pH 8.0) (PSE) and clarified. To the supernatant NP40 was added and centrifuged through linear sucrose gradients (made by layering 10 to 40% sucrose, and held at 4°C overnight) at 30 000 rpm for 2 h. Three light scattering zones, which were absent in similarly processed healthy groundnut leaf extracts, were collected from sucrose gradients. After diluting in 0.01 M PSE the zones were subjected to centrifugation at 35 000 rpm for 2 h. The pellets contained nucleocapsids, as determined by the polypeptide analysis. They were suspended in 0.01 PSE and employed for RNA extraction.

The RNA's extracted from the three different zones were fractionated through 1.0% agarose gel containing methyl mercuric hydroxide. The three RNA's of PBNV were clearly resolved, and no other RNA's were detected, indicating that the samples were free of RNA from healthy plants. The smallest of the three RNA's (RNA3) was electroeluted from the agarose gel and employed for preparing cDNA. The cDNA was cloned into pUC 119. Thirty-seven recombinant clones were detected in x-gal + IPTG - treated plates. Among these, two clones reacted with PBNV virus RNA3 in Northern hybridization utilizing ^{32}P-labelled cDNA. The two clones were 0.6 kb and 1.1 kb in length, representing nearly 50% of PBNV-RNA3. Evidence has been obtained to show that the two clones represent different regions of RNA3. The probe did not react with nucleic acids from healthy plants.

Screening of the remaining clones utilizing the three RNAs of PBNV is in progress.

A field trial to test the effect of plant density on peanut bud necrosis disease (PBND) incidence was repeated. The incidence of PBND was assessed at 2-week intervals following germination. Thrips populations were also recorded at the same times in plots with the lowest and the highest plant density.

In another field trial thrips populations and incidence of PBND were recorded on 16 groundnut genotypes, including a susceptible and a resistant control. These genotypes were known to possess field resistance, but their thrips resistance was not known.

Studies on inheritance of resistance to PBND included field testing of single plant lines in the F_5 generation from 21 crosses, as well as testing of F_5 bulk lines (from single plant F_4 progenies) from six crosses between JL 24 and six resistant parents. The F_5 bulk lines were sown in three replications, two replications at IAC and one replication at the Directorate of Oilseeds Research (DOR), Rajendranagar. Also F_5 single plant lines were sown at IAC. A very

high natural PBND incidence at IAC (of more than 60% in the susceptible control JL 24) was observed by the middle of August, i.e., 35 days after sowing.

Results from sap inoculation experiments under laboratory conditions confirmed earlier findings that i) 'Adult plant resistance' occurs which leads to decline in virus infection when older leaves are inoculated with the virus, and ii) systemically infected leaves of resistant and susceptible genotypes have similar levels of virus concentration. Virus concentration is related to the percentage of incidence and not influenced by the genotype.

Southern Runner, which was shown to be field-resistant to tomato spotted wilt virus in the USA, was also found to possess field resistance to PBND in India. Southern Runner is susceptible to PBNV and was expected to have thrips resistance. It is interesting to note that the thrips resistance found in the USA in Southern Runner, where *Frankliniella fusca* and *F. occidentalis* are the vectors, also operates against *Thrips palmi*.

Three PBNV field-resistant lines and two controls (one susceptible and one resistant) were screened under greenhouse conditions by using 10^{-2} inoculum dilution. The average incidence from six replications in susceptible line was 94% and in field-resistant lines it was from 53 to 73%. The same field-resistant lines in a previous test gave disease incidence not higher than 28%. Reasons for this increase in incidence are currently being investigated.

Development of detection methods and management of peanut clump virus disease (*LG-852*); *and associated collaborative project with Unite de Phytopathologie, UCL, Lourain la Neure, Belgium*

Production of polyclonal antibodies for HIPCV by utilizing coat protein expressed in *Escherichia coli*

Production of polyclonal antibodies to in vitro expressed HIPCV coat protein was initiated (IAC Quarterly Technical Report, Apr-Jun 1994, p. 48). Three weeks after the fifth injection, blood samples were drawn at weekly intervals and titres for HIPCV antibodies were tested by DAS-ELISA. Although the antibodies did not react with healthy groundnut leaf extracts, the titres obtained were less than 1:2000. As a result, two booster injections with HIPCV coat proteins (IAC Quarterly Technical Report, Apr-Jun 1994, p. 48) were given. Blood samples will soon be analyzed for titres of HIPCV specific antibodies.

Seed transmission of HIPCV

Seeds from HIPCV-infected TMV 2 plants (collected from field-infected plants), were utilized in tests to correlate the virus presence (in cotyledons and embryos) with growing out tests. One hundred percent correlation was observed between the virus presence in cotyledons and disease incidence in growing out tests (IAC Quarterly Technical Report, Apr-Jun 1994, p. 49). Another test on a lot of 94 seeds was performed with the aim of comparing the ELISA tests with cDNA tests (procedure described in the IAC Quarterly Technical Report Apr-Jun 1994, p. 49). Again the ELISA test (DAS procedure) gave 100% correlation between the virus in dry seed and disease incidence in growing out tests. Despite the improvements introduced, cDNA tests continued to give nonspecific reaction when dry seeds were used for testing. In further experiments seed treatment with hexane or chloroform were tried. In addition, cDNA probes prepared by incorporating Dig dUTP in a PCR reaction were also tried. None of these modifications prevented of nonspecific reaction.

Virus detection in seed by PCR was tried to compare its sensitivity with ELISA. Approximately 5 mg seed was ground in 500 µL of ELISA carbonate coating buffer. To 50 µL of the sap 150 µL of 1M Tris, pH 8.0 and 200 µL of a buffer containing 1M Tris. pH 8.0, 200 mM LiCl, 2% SDS, 20 mM EDTA was added. The sample was mixed thoroughly, extracted with 400 µL (i.e., equal volume) of water saturated phenol/chloroform at 65°C for 5 min once and repeated at room temperature. The aqueous phase removed, the nucleic acids were precipitated in ethanol and stored at -20°C. Prior to PCR analysis the samples were resuspended in 20 µL of DEPC-treated water. Aliquots of 1.5 and 3.0 µL of total nucleic acid were used for reverse transcription-PCR using Perkin Elmer kit at thermal profile: 95°C for 1 min, 55°C for 1.3 min and 72°C for 2.3 min and the cycle was repeated 35 times in a programmable thermal cycler (MJ Research). The PCR products from each sample were extracted with chloroform, ethanol precipitated and analyzed on a 1.5% agarose gel. In all the seed which contained the virus, clear bands (ca.

700 bp) were visible and absolutely no background was obtained in the healthy material. The product yield increased when larger amounts of nucleic acid were employed for analysis. Using this procedure, extracts in PBS were compared with those prepared in carbonate buffer and were found to be better than carbonate buffer in terms of the yield of 700 bp product.

Detection of *Polymyxa graminis*

Recently several reports have appeared on the utilization of cDNA probes for the detection of fungi. In order to utilize cDNA probes for the detection of *Polymyxa graminis*, a method for the extraction of fungal DNA was tried. It comprised grinding the cystosori in the presence of liquid nitrogen and extraction with a buffer containing 50 mM Tris-HCl (pH 7.2), 50 mM EDTA, 3% SDS, 1% 2-mercaptoethanol. The DNA was digested with *Eco*RI and cloned into *Eco* RI digested pUC 19, pUC119 and pBluescript KS+ vectors. On transforming *E.coli* JM101 cells only three recombinants were obtained and only one of them contained an insert about 1.5 kb length. This insert was labelled with ^{32}P and utilized to probe DNA from roots of healthy and *P. graminis* infected sorghum roots. The probe did not react either with healthy or with *Polymyxa*-infected roots. Therefore, it appears that the sample used for analysis contained other fungi in addition to *P. graminis* and that the method employed did not yield any DNA from *P. graminis* cystosori. To overcome this, cystosori were ground in liquid nitrogen in the presence of sterile sand and the procedure was repeated three times to ensure release of DNA from cystosori. The DNA obtained is yet to be tested.

Studies on life cycle and host range of *Polymyxa graminis* and Indian peanut clump virus (HIPCV)

To elucidate the life cycle of Indian peanut clump virus (IPCV) under field conditions, groundnut, sorghum, pearl millet, and finger millet were sown in infested and noninfested areas of Field RCW 17A at IAC. The cereals were included in the study because groundnut is not a good host for *P. graminis*. The cereal plants were uprooted and tested at weekly intervals by ELISA for IPCV detection. Half of the plants were transplanted into test tubes with sterile sand and grown in a greenhouse to allow the fungal development in roots. The roots of the remaining plants were stained with lacto-glycerol-blue cotton and observed under a light microscope for the presence of *P. graminis*. Groundnut plants were scored visually in the field at 2-week intervals for clump disease symptoms.

Sorghum and pearl millet seedlings were raised in polyvinylchloride tubes, containing sterile sand, in a greenhouse. One-week old seedlings were transplanted in the field. After 1 week of exposure they were removed, the roots were carefully washed to remove soil, and they were transferred to glass tubes containing sterile sand. If *P. graminis* infection had occurred during the 1 week of exposure in the field, the fungus should be established in the roots. After maintaining them for 4 weeks, the plants were harvested, roots were washed free of sand, stained and observed for the presence of *P. graminis*. This method facilitated monitoring of fungal infection during the growing season, and permitted correlation of infection with weather conditions such as rainfall, soil temperatures, and moisture.

Results obtained so far have indicated the presence of *P. graminis* plasmodia in sorghum, pearl millet, and finger millet roots 2 weeks after sowing (WAS), and cystosori were present in sorghum roots 3 WAS. The fungus was detected in infested patches of soil as well as in non-infested areas. In pearl millet plants exposed to infested patches, IPCV was detected by ELISA within 3 WAS. Sorghum and finger millet showed IPCV presence after 4 WAS. Following 7 WAS, the number of positive plants decreased, and by the end of September none of 461 pearl millet plants tested showed IPCV presence. Twelve finger millet plants of 350 tested and only one sorghum of 410 tested were infected by IPCV. Not all the plants infected with IPCV under field conditions showed the presence of *P. graminis*.

Identification of crop plants resistant to IPCV and *P. graminis*

Four IPCV-infested patches in Field RCW 17A were chosen during the 1993/94 postrainy season to study the effect of crop rotation on the incidence of clump. Half of each patch was sown with *Sorghum bicolor* (cv ICSV 88036) while the other half was sown with *Arachis hypogaea* (cv NC Ac 17090) (IAC Quarterly Technical Report, Jan-Mar 1994, pp 48–49). During the 1994 rainy season groundnut was sown in all the four patches. They were scored at 2-week intervals for IPCV symptoms. It was very interesting to note that clump incidence was more in the plots where sorghum was grown in the previous season as compared to groundnut (**Table 5**).

Development of detection methods and identification of genotypes with resistance to peanut mottle and peanut stripe viruses (*LG-853*)

We have screened all the groundnut genotypes currently being grown in Field RP 7B by the Genetics Resources Division (GRD) for the presence of peanut mottle and peanut stripe viruses (PStV). Scoring was performed from 30-31 Aug 1994. Three PMV-infected plants were found. In the second scoring (27-28 Sep 1994) none of the plants showed symptoms of PMV or PStV. The three PMV-infected plants were destroyed.

Three seed samples from Niger and 350 samples from Brazil imported into India for adding to ICRISAT's collection were tested by ELISA for the presence of PMV and PStV. None of the seed contained PMV or PStV. They are currently being grown in a quarantine greenhouse at Rajendrangar by NBPGR scientists.

Two hundred and twenty samples of seed intended for export to Zimbabwe (from Groundnut Breeding) were tested nondestructively by ELISA for the presence of PMV and PStV. All the seed samples were free of PMV and PStV.

Microclimatology

Weather and disease (*R-360*)

A field experiment was sown on 5 July to test a weather-based scheme for the timing of fungicide sprays to control leaf spot diseases of groundnut. The scheme follows last year's method, where spraying is done only when diseased leaflets exceed 10% and the cumulative wetness index is greater than or equal to 2.3. The 10% threshold is used as an indicator of inoculum supply, while the 2.3 index serves as an indicator of optimal weather conditions for infection.

Table 5. Percentage of groundnut plants showing typical clump disease symptoms in the 1994 rainy season in plots where groundnut or sorghum were grown in the previous year (postrainy season 1993/94).

Weeks after sowing	Patch 1		Patch 2		Patch 3		Patch 4		Average	
	GN[1]	S[2]	GN	S	GN	S	GN	S	GN	S
2	0.6	2.2	0.0	0.5	2.5	2.1	2.0	6.0	0.9	1.9
4	1.2	6.7	1.1	4.6	4.9	5.7	2.0	16.0	2.1	6.5
6	6.5	17.9	1.1	10.8	12.3	25.7	12.2	52.0	6.48	20.6

1. plots where *Arachis hypogaea* (cv NC Ac 17090) was grown in the 1993/94 postrainy season.
2. plots where *Sorghum bicolor* (cv ICSV 88036) was grown in the 1993/94 postrainy season.

Natural disease development was assessed weekly In the 1994 rainy season we had severe rust and rather less severe late leaf spot (LLS) and early leaf spot (ELS) attacks Following the prototype weather based advisory scheme fungicide was applied three times, and provided good control for the first 80 days of crop growth

The crop microclimate is being monitored throughout the growing season in Field RP 4 so that natural disease development can be related to weather conditions Besides the standard variables from the automatic weather station, the measurements include a soil temperature profile, net and short wave radiation interception by the crop and soil water potential In addition, stomatal conductance as well as soil resistance to water vapor flux have been measured for selected periods over a 5 day drying cycle when soil water was being depleted, using a standard leaf porometer for stomatal conductance and a "soil porometer" we assembled for soil resistance During the same 5 day drying cycle to complement the soil resistance measurement, soil moisture content and soil water potentials were determined at the same selected periods by gravimetric and paper filter methods, respectively, at depths of 0-5 cm and 5-10 cm from the soil surface Data from these measurements will be used to test and improve the Choudhury-Monteith microclimate simulation model

Initial experiments using single plant chambers to control relative humidity (rh) have been performed with ELS of groundnut, examining spore production The initial results show that conidia are not released from sporulating lesions until the rh exceeds 94%, and a rapid increase in conidia number between 94 and 100% On going experiments are aimed at establishing a response curve for ELS relating spore release to rh

The use of weather-disease relationships to advise on chemical control of foliar diseases

On-station trials

Experiments to test our weather-based scheme to advise on fungicide control of leaf spots are being carried out at three sites. Dryland Farming Agricultural Research Station (DFARS), Anantapur, Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, and IAC, Patancheru Automatic weather stations with leaf wetness sensors are being operated at all sites and, in the nonsprayed plots, detailed disease assessments are being carried out weekly to provide information on natural disease development

On-farm trials

Together with the entomologists, we are carrying out collaborative on-farm trials to evaluate the feasibility of our weather-based forecasting scheme to advise on fungicide control of leaf spots in the Gudipadu National Watershed, Kurnool District, Andhra Pradesh with the staff of the Agricultural Research Station at Anantapur In this site it is not feasible to use leaf wetness sensors, so we have provided our collaborators with a "user-friendly" program to estimate leaf wetness periods from daily temperature and humidity readings The leaf wetness values are needed to compute the cumulative leaf wetness index crucial to the weather based forecasting scheme

Legumes

Nematology

Management of important nematode pests of chickpea, groundnut and pigeonpea (*LL-925*)

Cropping systems

Data on nematode densities associated with chickpea, pigeonpea, mung bean, safflower, and cowpea in on-farm cropping systems trials were statistically analyzed Populations of an unidentified species of cyst nematode in an Alfisol were extracted from soil samples. Nematode eggs, juveniles, and females are being studied in detail to identify the species

Chickpea. Populations of the root-knot nematodes were collected from farmers' fields and added to Field RP 14C to enhance the field population of the nematode. This field will eventually be used for field screening of chickpea and pigeonpea lines for resistance to the root-knot nematode.

Pasteuria penetrans, a parasite of the cyst nematode, was isolated from females of the nematode. It is being multiplied on the nematode population to understand its disease cycle.

Groundnut. Ninety-three promising breeding lines were screened for resistance to the root-knot nematode in a greenhouse. All the lines had many egg masses and galls on roots and were rated as susceptible. ICGV 92103 had a relatively low disease rating and its reaction will be confirmed. Screening of another set of 100 selected germplasm lines from Australia, China, Israel, Nigeria, Peru, and Vietnam is in progress.

Pigeonpea. A set of 292 pigeonpea germplasm lines which were found to have low infection of the cyst nematode in preliminary testing, was screened again to verify their reaction. All the lines had more than 30 cysts on roots within 4 weeks and were rated as susceptible. *Cajanus platycarpus* accessions ICPWs 62, 69, and 70 have resistance to the cyst nematode. Seed of these accessions was purified by transplanting plants that had the apparent cysts on their roots in 30-cm diameter pots and seeds were collected at maturity. The collected seed was tested again and plants without any cysts on their roots were selected and again transplanted for seed production.

Two hundred and fifty germplasm accessions are being checked for resistance to the reniform nematode. Promising *C. platycarpus* accessions (ICPW 62 and ICPW 66) are being purified for resistance to the reniform nematode.

In Field RL 9D, selected medium-duration pigeonpea lines are being purified for tolerance to the reniform nematode. Interestingly, the nematode susceptible control ICPL 270 (wilt resistant) is wilting in this reniform nematode infested field. Infection of *Fusarium udum* has been confirmed in the wilted plants. It is, however, not clear as to why the wilt resistant reaction of ICPL 270 is not stable in this field. We have no knowledge of any influence of the reniform nematode, on the reaction of ICPL 270 to wilt.

Electron Microscope Unit

Following are highlights of work carried out in the Unit.

- TEM studies were carried out for determining the organization of the structure of the chloroplast in interspecific hybrids of *Cicer*. Small segments of leaf tissue were fixed in buffered glutaraldehyde and post-fixed in OsO_4. After serial dehydration, the leaf segments were embedded in epoxy resin. Ultrathin sections were examined using CM20 under low-dose mode. This work was a part of the project on "Wide hybridization and in vitro studies in *Cicer*".

- Mr Om Prakash, Research Scholar from the Haryana Agricultural University, India, was trained in techniques for processing samples for light microscopy. His work involving SEM studies of ascochyta blight of chickpea was completed. This forms a part of his thesis work leading to the award of Ph.D.
- Scanning electron microscopy studies to determine the association of *Trichoderma*, an antagonist to the botrytis gray mold pathogen in chickpea are in progress. Peldri-II, a commercial preparation alternative to dehydration protocols, was tried. The results are under evaluation for consistency.
- ISEM studies of chickpea stunt virus were conducted using various antisera.

Staff Travel

Travel within India

Period	Staff name(s)	Organization[1] Location	State(s) Region	Purpose
6 Jul	Ranga Rao, G V	APAU Anantapur	Andhra Pradesh	To organize on farm trials of groundnut
11 16 Jul	Duale, A H Reddy, Y V R	various	Maharashtra	To survey farmers fields for sorghum pests
20 22 Jul	Duale A H Reddy, Y V R	various	Andhra Pradesh	To survey farmers fields for sorghum pests
26 31 Jul	Rao, P J M	NARP Aurangabad	Maharashtra	To sow pearl millet test material
27 Jul to 01 Aug	Jayarajan, A V	University of Mysore	Karnataka	To sow downy mildew nursery of pearl millet
3 Aug	Ranga Rao, G V Wightman, J A Neering, K E	APAU, Palem	Andhra Pradesh	Groundnut crop survey
08-10 Aug	Kanaka Reddy, R	Anantapur Rekulakunta	Andhra Pradesh	To fix the automatic weather station in a collaborative experiment
08-17 Aug	Sathaiah, P	Various	Maharashtra	To survey for sorghum and pearl millet diseases
9 Aug	Cowgill, S Romeis, J	CIPMC, Hyderabad	Andhra Pradesh	To meet and discuss IPM activities with Dr Meera Gupta, Deputy Director
16-22 Aug	Jayarajan, A V	University of Mysore	Karnataka	For thinning of downy mildew nurseries
17-23 Aug	Gandaiah, K	NARP Aurangabad	Maharashtra	For thinning and recording of downy mildew observations in pearl millet test material
17 18 Aug	Ranga Rao, G V Neering, K E	UAS, Raichur	Karnataka	Groundnut pest surveys
12 18 Sep	Rao V P Narayana, Y D	various	Maharashtra Karnataka	Collection of sorghum and pearl millet disease samples
15-17 Sep	Ranga Rao, G V Rameswara Rao, V	APAU, Anantapur	Andhra Pradesh	To visit on farm trials
15-17 Sep	Kanaka Reddy, R	Anantapur	Andhra Pradesh	To record observations in groundnut on farm trials
17-22 Sep	Jayarajan, A V	University of Mysore	Karnataka	Evaluation of pearl millet downy mildew nursery

Contd

Travel within India. Contd.

Period	Staff name(s)	Organization[1]/ Location	State(s)/ Region	Purpose
19-22 Sep	Pawar, C.S.	Gulburga and Bidar Districts	Karnataka	To lead the Impact Assessment Survey Group to study the spread of pigeonpea cv ICP 8863 (Maruti)
21-29 Sep	Delfosse, P. Reddy, A.S.	RAU, Farmers' fields	Rajasthan	To survey IPCV incidence and to collect PCV-infected plants and soil samples
22 Sep	John Peter	Marepally	Andhra Pradesh	To get an overview of our on-farm research trials
24 Oct	Shanower, T.G. (with Jim Lang, Vanderbilt Univ. of Memphis, USA)	Marepally	Andhra Pradesh	To visit on-farm trials
24 Oct	Shanower, T.G. Laxman Singh Reddy, M.V.	Warangal	Andhra Pradesh	To visit on-farm trials
Periodical	Buiel, A.A.M. Lakhe, M.P. Reddy, S.P.	DOR Rajendranagar	Andhra Pradesh	Several visits to sow F_5 bulk lines of groundnut and to take observations on PBND incidence

1. APAU = Andhra Pradesh Agricultural University, CIPMC = Central Integrated Pest Management Centre, DOR = Directorate of Oilseeds Research, NARP = National Agricultural Research Project, OCRI = Oil Crops Research Institute, RAU = Rajasthan Agricultural University, UAS = University of Agricultural Sciences.

Travel outside India

Period	Staff name(s)	Organization[1]/ Location	Country(s)	Purpose
3-15 Jul	McDondald, D.		USA	Visited Myergen Corporation, San Diego, California to discuss biological control of *Aspergillus flavus* followed by a visit to the University of Georgia, Griffin for Peanut CRSP Board Meeting and to discuss collaborative research. Then to APRES Meeting in Tulsa, Oklahoma.
10-22 Jul	Armes, N.J.	Nanjing Agricultural University	China	To assist in establishment of an *H. armigera* insecticide resistance monitoring program and to follow-up on project planning for a proposed EEC DG1 funded cotton pest management project
July	Reddy, D.V.R.	Georgia Expt. Station, Griffin	USA	To discuss funding for the training course/working group meeting to be held in Khon Kaen in Feb-Mar 1995, and to attend APRES meeting in Oklahoma
9-26 Sep	Murthy, A.K.	Royal Microscopical Society, Oxford	UK	To attend a conference on the application of microscopy
		MPI, Koln. and 'versity of Konstanz	Germany	To gain first hand information about recent advances in EM&LM techniques
19-24 Sep	Haware, M.P.	Kathmandu	Nepal	To have discussion with NARS scientists on collaborative experiments
16-24 Jul	McDonald, D.	ISC, Niamey	Niger	To participate in RCC/RPRC and visit with CPD staff

Workshops, Meetings, and Conferences Attended

Period	Workshop/ Meeting	Organizer[1]/ Location	Country	Staff name(s)
25 Jun - 12 Jul	Third Working Group Meeting and Training Workshop on Bacterial Wilt of Groundnut	OCRI Wuhan	China	Mehan, V K
4-9 Jul	Eighth International Congress of Pesticide Chemistry	Washington, DC	USA	Yoshida, M
10-16 Jul	Fifteenth World Congress of Soil Science	Acapulco	Mexico	Yoshida, M
14-29 Jul	RPRC meeting to discuss sorghum projects	WASIP	Mali	Bandyopadhyay, R
18-20 Aug	Advisory Committee of a Ph.D student	PKV Akola	India	Thakur, R P
10-17 Sep	Project planning meetings	EARCAL Nairobi	Kenya	Nwanze, K F Bandyopadhyay, R
14-15 Sep	CRIDA Plant Protectionists Meeting	IAC	India	Wightman, J.A. Ranga Rao, G.V Shanower, T.G Cowgill, S
14-18 Sep	AICPIP Meeting	Bikaner	India	Haware, M P
18-20 Sep	Seminar on nonpesticidal methods of pest management	NRCS Rajendranagar	India	Nwanze, K F Sharma, H C
20-22 Sep	National Workshop on non-pesticidal approach to pest management — a new direction	NAARM Hyderabad	India	Wightman, J A Ranga Rao, G.V Rameswar Rao, V
21 Sep - 8 Oct	PTLs of the three pearl millet projects and subprojects coordinators	ISC Niamey	Niger	Thakur, R P.

1 CRIDA = Central Research Institute for Dryland Agriculture, EARCAL = Eastern Africa Regional Cereals and Legumes Program, ISC = ICRISAT Sahelian Center, NAARM = National Academy of Agricultural Research Management, NRCS = National Research Centre for Sorghum, PKV = Punjabrao Krishi Vidyapeeth, WASIP = West African Sorghum Improvement Program

Visitors

Period	Name of visitor(s)	Organization[1] Location	Country(s)	Purpose
12 Jul	Raman, K.V.	Cornell University	USA	To discuss with IPM specialists
15 Jul	Jim Lang	Vanderbilt University	USA	To discuss Research on cereals pathology
25-26 Jul	Demski, J.W.	Georgia Experimental Station, Griffin	USA	Visited the Virology Unit
1-26 Aug	Shree Baba Pradhan		Nepal	To learn about pigeonpea and chickpea entomology research activities including IPM
16 Aug	Anand Rao, P.K.	Pioneer Overseas Corporation	India	To discuss sorghum midge resistance research
16 Aug	Pioneer Corporation staff	Hyderabad	India	To acquaint with ICRISAT Overseas activities for developing commercial hybrids of sorghum and pearl millet
17 Aug	Peter Burt	NRI	UK	For discussing general biometeorological/environmental work
During Aug	Robinson, J. Isherwood, R.J.	Cyanamid, Ind.,	USA	Visited the Entomology Unit
During Aug	Gert Ernst	Ciba Geigy Ltd.	Switzerland	Visited the Entomology Unit
During Aug	Mike Tichon	Abbott Laboratories	Australia	Visited the Entomology Unit
12-20 Sep	Mayee, C.D.	MAU, Parbhani Maharashtra	India	To prepare an Information Bulletin on *Sclerotium rolfsii* caused stem and pod rot of groundnut
14-23 Sep	Parlevliet, J.E.	WAU Wageningen	Netherlands	Visited the Virology Unit in connection with the Duch-funded project on PBNV
20-21 Sep	Basu, M.S.	NRCG	India	To participate in an informal meeting to discuss possibilities for a 1-day meeting on PBNV in Mar 1995

1. MAU = Marathwada Agricultural University, NRCG = National Research Centre for Groundnut, NRI = Natural Resources Institute, WAU = Wageningen Agricultural University.

Agronomy Division

Cereal Physiology

Simulation of Water Availability Patterns to Explore Opportunities for Drought Escape *(CM-113)*

Previous reports analyzed the environmental component of the genotype-by-environment (GE) interaction to understand the effects of abiotic constraints on grain yield. An understanding of these effects combined with an analysis of long-term meteorological data to identify the prevalent stresses in a given region can enhance the efficiency of selecting plant material which is adapted to the environment of that region. Such a characterization is especially important in the variable stress environments of the dry areas in the semi-arid tropics.

Our analysis of a multi-environment trial showed that in variable moisture environments grain yield is a linear function of available soil water, whereas stress escape (heat, drought) was the major component of the GE interaction. This result has particular relevance for short-duration pearl millet hybrids which mature in 65 days from sowing, and that they better escape drought than the landraces which require about 80 days to mature. This report presents a case study in which long-term (>50 years) rainfall records of four sites in Rajasthan were used to estimate seasonal patterns in available soil water and the potential for early cultivars. Possible implications for a breeding program are briefly discussed.

Soil water was estimated using a very simple water budget, which used as input data: daily rainfall, potential evapotrans-piration (extrapolated from long-term monthly means), and estimates of soil depth and crop coefficients. Sowing was assumed to take place after the first significant rainfall of the rainy season. Patterns of available soil water were estimated for all site x year combinations, using a crop duration ranging from 65 days (early hybrids) to 80 days (local landraces).

The average seasonal rainfall at each site was 230, 240, 300, and 430 mm, respectively. The median sowing date was 29 June at the wettest site and 9 days later at the other sites. The probability of significant rainfall after 80 days from the median sowing date was 50% at the wettest site, but only 12% at the driest one. At the wettest site, little or no drought stress occurred in 80% of the years. At the driest sites, however, 70% of the crops experienced severe drought during grain filling. The probability of a crop failure at these sites increased sharply if sowing was more than a few days later than the median.

If environments with an early (1-10 June), normal (21-30 June), or late (16-25 July) sowing date were compared, crops with a normal sowing date experienced at each site, on average, the least drought stress, irrespective of their duration. An early sowing was especially disadvantageous for short-duration crops (65 days), because they were more affected by the erratic rainfall early in the season. A late-sown crop, by contrast, experienced drought stress mainly during grain filling, which affected especially the normal duration (80 days) crop.

The above analysis suggests that long-duration material is preferable if sowing is early, but that earlier genotypes have an advantage in case of delayed sowing. ICRISAT is currently trying to introduce new short-duration material into Rajasthan. These cultivars could have an important place in the dry areas, but should not completely replace the existing cultivars. However, they can provide farmers with more effective means than they presently have of adjusting to the variability in the onset of the rains and to the need to resow fields lost to early-season drought stress.

Most of the plant material grown at the driest sites are landraces, which typically have a low-yield potential. The analysis also suggests this is not a major constraint to production, because the favorable conditions to express yield potential rarely occur at those sites. At the wetter site, by contrast, yield potential can be better expressed. This contrast indicates the need for the selection of different plant types to meet these contrasting requirements.

Development of Research Materials *(CSM-111, CSM-114, CSM-115)*

Research on the evaluation of plant traits usually requires a considerable investment in the breeding of suitable genetic material for study. Evaluations of a plant trait or response to environment using test materials of very different phenotypic and genetic backgrounds are compromised by the other differences among the materials. For a true evaluation of the trait/response itself, it is usually necessary to develop test materials which differ only for the trait/response, by backcrossing, divergent selection, or near-isogenic line development. This report describes progress in developing such materials for three different traits.

Growth stage 2 length in pearl millet

Earlier research indicated that grain number in pearl millet appears to be linked to the length of growth stage (GS) 2 - the period between panicle initiation and flowering. These studies were done with dissimilar materials which differed in the length of GS1 (germination to panicle initiation) as well as GS2. We are developing two populations with a similar length of GS1, but a broad range in GS2 length. These are based on two crosses between pairs of parents with long and short GS2 periods [862B x 843B and Zongo x (834B x 7042)]. The progenies from these crosses have been selected for a common leaf number (a measure of the length of the GS1, as all leaves are initiated during this period only), but a broad range in flowering date (with a common GS1 length, time to flowering is directly related to the length of GS2). The material is now in the F_5 generation and has largely stabilized for leaf number (15 to 16), but progenies have a 2 week range in time to flowering. We will continue selection for one or two more generations, before making hybrids between inbred lines of similar time to flowering (i.e. GS2 length) between the two populations.

Tillering ability in sorghum

The ability to tiller is common in temperate sorghum and in some tropical sorghum landraces, but has largely been bred out of improved tropical sorghums as a result of selection pressure for large, main shoot panicles. Under well managed, higher input conditions, tillering may offer no advantages, but it is not clear that this is the case under low input, marginal environmental conditions characteristic of much of the SAT sorghum growing areas. In order to determine the conditions under which tillering is or is not advantageous we are developing near-isogenic lines for this trait. We are doing this by continued selfing of plants in progenies segregating for this trait, from crosses of tillering sources and population bulks/progenies, until lines are homozygous for all other characters but tillering. The material is now at the F_8 stage and ready to extract near-isogenic pairs with and without the ability to tiller.

Non-senescence on sorghum

The non-senescence trait is thought to provide tolerance to both terminal stress and charcoal rot, and appears to increase fodder quality (and possibly market price) of the stover. Current sources of non-senescence are mostly of temperate origin, and hence poorly adapted to SAT conditions. We have begun to produce lines for the study of the effects of stay green in backgrounds adapted to both rainy and postrainy season environments, through divergent selection for and against the non-senescence character in four crosses, utilizing two stay green sources. We also hope to be able to use molecular marker assisted backcrossing to transfer the trait to a range of adapted, high-yielding lines from ICRISAT's regional projects, to produce near-isogenic pairs for evaluation in regional locations. This approach should be much more efficient than divergent selection one, as three generations can be completed per year with the use of markers.

Legumes Physiology

Development of Traits to Improve Yield and Resistance to Important Abiotic Stress Factors in Chickpea *(LC-080)*

Evaluation of root growth dynamics of promising drought-resistant selections made for root/shoot traits, in relation to their parents

Root growth pattern of Annigeri and ICC 4958 (donor for large root mass) and three promising selections derived from the cross involving these parents were studied to confirm results of the 1993/94 season. The results indicated that the size of the root system and the pattern of its development varied among the entries and the size of the root system positively influenced soil moisture extraction. These chickpea selections were made on the criteria of a large root mass, higher grain yield under drought, and a higher drought tolerance index. The objectives of this experiment were to: a) confirm whether the large root mass trait persisted in the subsequent selections, b) relate differences in root system with soil moisture extraction, and c) study the effects of large root system on shoot mass and seed yield. The trial was sown on 10 Nov 1993. Root sampling was done by the monolith method and the soil water monitored by a neutron probe.

Genotype ICC 4958 and the selections 5-x-4-1-x-x-x and 5-x-6-3-x-x-x were relatively early, reaching 50% flowering at 42 days after sowing (DAS) and maturity at 83-85 DAS, compared to Annigeri and 13-x-6-4-x-x-x, which reached 50% flowering at 44 and 46 DAS and maturity at 86 and 89 DAS, respectively.

Root growth (total root length and root plus nodule mass) progressed rapidly up to 72 DAS (**Fig. 1**). Cessation of root growth coincided with the late pod-fill stage of the plants, at 10-15 days prior to maturity. There was a large difference in root growth pattern between the parents and among the selections. Genotype ICC 4958 and the two early selections 5-x-4-1-x-x-x and 5-x-6-3-x-x-x produced significantly higher root mass or total root length compared to Annigeri or 13-x-6-4-x-x-x up to 41 DAS. Later, roots of Annigeri and 13-x-6-4-x-x-x grew rapidly and compensated for the relatively poor early growth.

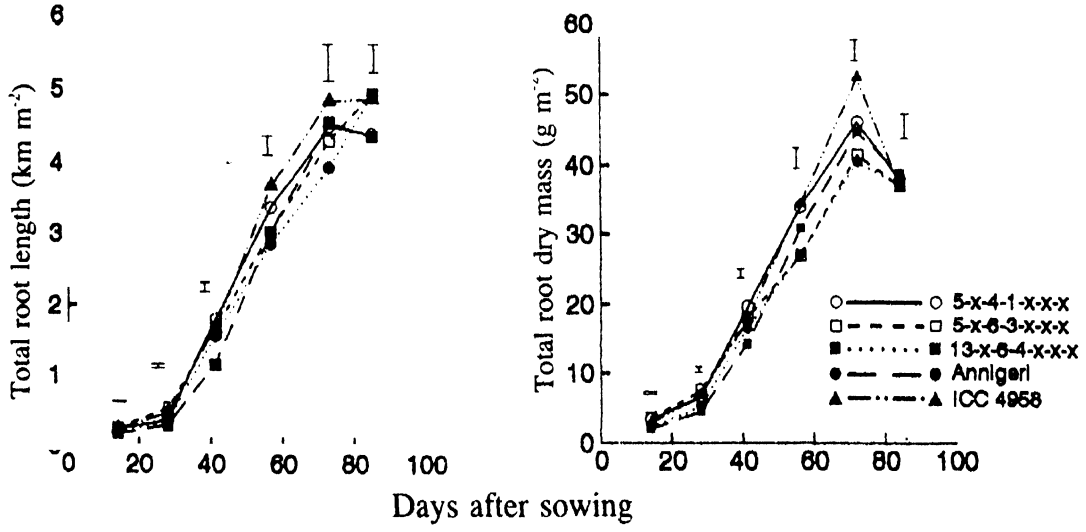


Figure 1. Seasonal changes in root growth of two genotypes and three selections of chickpea grown on a deep Vertisol under progressively receding soil moisture conditions, ICRISAT Asia Center, postrainy season 1993/94. (vertical bars denote SE)

The rooting depth did not differ between the entries at any stage of crop growth. The maximum rooting depth of 120 cm was observed at 72 DAS. Using this dataset the average rate of root penetration can be estimated at 17 mm day^{-1}. However, there were some considerable differences between the entries in the root length density across soil depths. At the early stages of crop growth, ICC 4958, 5-x-4-1-x-x-x, and 5-x-6-3-x-x-x produced significantly higher root length density at the surface soil layers (data not shown); whereas at later stages (after 72 days from sowing) Annigeri and 13-x-6-4-x-x-x produced higher root length densities at soil depths between 60 and 90 cm.

Soil moisture extraction by ICC 4958 was higher compared to Annigeri at 0-30 cm soil depth until 28 DAS (**Fig. 2**). The soil moisture extraction pattern of the two early selections (5-x-4-1-x-x-x and 5-x-6-3-x-x-x) was similar to that of ICC 4958. However, at maturity, no difference among entries was apparent (**Fig. 2**). The advantage of early prolific root system development seems to be the efficient use of surface soil moisture for transpiration which otherwise would be lost through evaporation.

The shoot growth pattern, in general, was similar to the root growth of various entries. The shoot mass production of all the root-trait selections was vigorous and similar to that of ICC 4958, but more than Annigeri (data not shown). This difference was significant up to 56 DAS. However, at later stages, shoot growth of Annigeri was rapid enabling an eventual comparable shoot dry matter production with ICC 4958.

The shoot mass, seed yield, and harvest index did not vary significantly among the entries but it appears that selection 13-x-6-4-x-x-x produced low seed yield due to it's poor harvest index (**Table 1**).

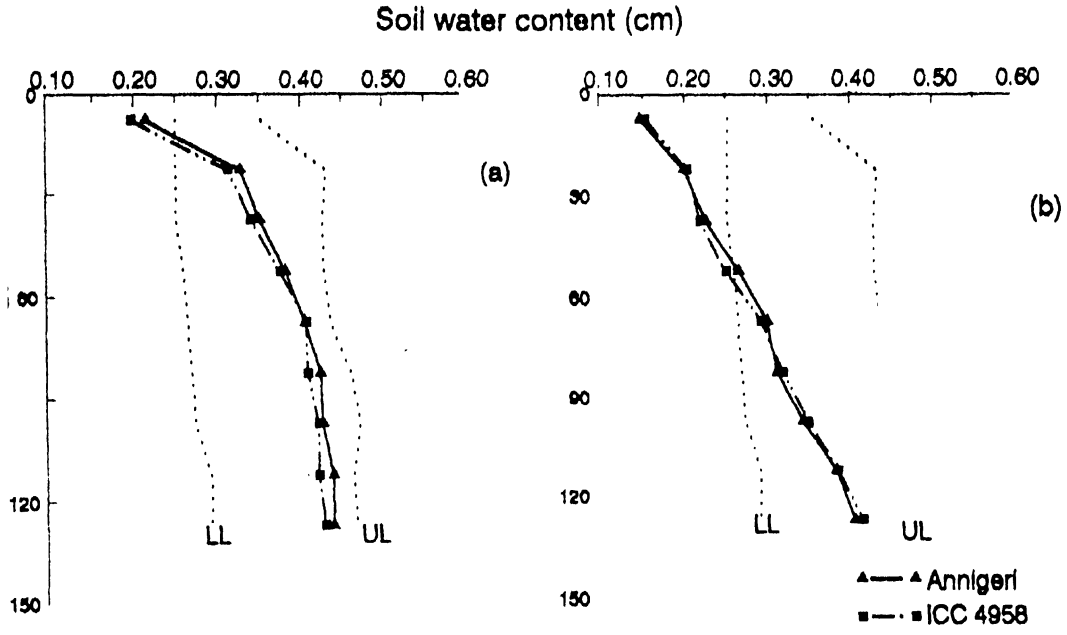


Figure 2. Distribution of soil water content with soil depth under genotypes Annigeri and ICC 4958 grown in receding soil water conditions: (a) at 43 (SE for genotypes within a depth is 0.0026 cm and depths within a genotypes is 0.0056 cm) and (b) at 95 (SE for genotypes within a depth is 0.0038 cm and depths within a genotype is 0.0081 cm) days after sowing in a deep Vertisol, ICRISAT Asian Center, postrainy season 1993/94. (UL and LL indicate the upper and lower limits of available soil water)

Table 1. Differences among chickpea root-trait entries in shoot biomass, grain yield, and harvest index in a deep Vertisol, ICRISAT Asia Center, postrainy season 1993/94.

Chickpea	Shoot mass (t ha^{-1})	Seed yield (t ha^{-1})	Harvest index (%)
5-x-4-1-x-x-x	3.29	1.92	58.2
5-x-6-3-x-x-x	3.26	1.67	51.0
13-x-6-4-x-x-x	3.26	1.60	48.9
Annigeri	3.29	1.84	55.7
ICC 4958	3.36	1.88	56.0
SE±	0.135	0.131	2.42

From this study we were able to draw further conclusions on the plant and soil water relationships. The two early selections and the parent ICC 4958 were capable of producing large root length density and a higher shoot biomass early and extracting relatively more soil moisture from the surface soil layers. This favors maximizing of water loss through transpiration, compared to evaporation from soil surface. A large amount of soil moisture below 60 cm depth was left unextracted at maturity due to limited root length density at lower depths. Early prolific growth of root and shoot is advantageous in producing a similar amount of biomass or yield in spite of a shorter growth duration. Further improvement in prolificity of root and shoot growth should enhance yield stability under short-duration conditions, as in peninsular India.

ICRISAT-ICARDA Project: Adaptation of Chickpea in WANA Region

This was a joint project of the erstwhile Legumes Program and Resource Management Program of ICRISAT and the Legume and Farm Resource Management Program of ICARDA. Activities of this project were coordinated by N.P. Saxena during his sabbatic and secondment to ICARDA between Nov 1990 and Mar 1994. The objectives were:

- to use geographical information systems (GIS) technology to plot chickpea distribution in WANA countries in relation to major soil, climate, and soil factors,
- identify and map important biotic, abiotic, and socioeconomic limitations to chickpea production in WANA,
- identify potential new areas for chickpea cultivation,
- compare the constraints to, and prospects for, chickpea production between WANA and the semi-arid tropics (SAT),
- identify and prioritize future research efforts needed to alleviate the major constraints, and develop appropriate action plans.

Countries included in this project work are Algeria, Egypt, Ethiopia, Iran, Iraq, Jordan, Morocco, Sudan, Syria, Tunisia, and Turkey. A hands-on workshop was held in Nov 1992 to present and discuss the findings of case studies for these countries, followed by a critique and synthesis. Prior to the meeting, relevant information from each country was entered on the GIS at ICRISAT Asia Center. The papers presented were refined and finalized as case studies and regional synthesis was made. The proceedings is currently being edited at IAC and is expected to be published in early 1995.

Enhancing Nitrogen Fixation in Legumes *(LL-920)*

Selecting nodulation variants from medium- and long-duration chickpea lines at IAC

Previous studies suggested that released varieties and/or landraces though pure for several traits, have plants of grossly different nodulation capacities. High- and low-nodulating plants selected from ICC 4948, a selection from a landrace released in 1940s in the Indian state of Punjab and ICC 5003, a bred variety released in early 1970s in another Indian state of Uttar Pradesh have retained their nodulation traits since 1988. High-nodulating selections from ICC 4948 and ICC 5003 produced 4 to 31% higher grain yield than the low-nodulating selections of their respective varieties when grown on low N (<15 mg N kg^{-1}) Vertisol under irrigated conditions in the 1991/92 postrainy season. In the 1993/94 postrainy season the high-nodulating selection of ICC 4948 produced 10% higher grain yield than its low-nodulating selection when grown on low-N Vertisol with irrigation. ICC 4948 is a long-duration and ICC 5003 a medium-duration line and therefore not well adapted to the agroclimate at IAC where these trials were conducted. Unless the crop is irrigated, this location is suitable only for short-duration materials. In the 1993/94 postrainy season we planned to evaluate the performance of these selections under nonfavorable soil moisture conditions.

The trial was conducted on a long-term ^{15}N plot that was initiated in the 1992 rainy season. This plot had two main treatments to represent low-soil N (N1) and high-soil N (N2) status. The treatments were introduced in the 1992 rainy season after depleting soil fertility by growing cover crop of sorghum for at least five seasons. The N1 plots received 10 kg N ha^{-1} and N2 plots received 100 kg N ha^{-1} as ammonium sulfate applied to millet grown in the rainy season. The N application was repeated in the 1993 rainy season. Millet was sown on 24 Jun 1993 and ploughed in on 13 Aug 1993. Chickpea was sown on 6 Nov 1993 and provided one irrigation for emergence and the trial was subsequently maintained as rainfed. The twelve entries, that formed subplot treatments in split plot design, were low nodulating, high nodulating, and nonselected bulk each of three cultivars ICC 4948 (=G130), ICC 5003 (=K850) and ICC 14196, and three nonnodulating selections, one each of ICC 4918 (= Annigeri), ICC 4993 (=Rabat) and ICCV 6 (=ICCC 32). The subplots comprised 4 rows of 4 m length (4.8 m^2).

The level of mineral N in the N1 and N2 treatments at sowing of chickpea was similar in the 0-15 cm soil profile. Therefore the nodulation of chickpea at N1 and N2 was similar.

The high nodulating selections produced 19 to 49% higher nodule mass (significant at $P<0.05$) compared to their parent lines (**Table 2**). The high nodulating selection of ICC 14196 identified in 1991/92, produced only 4% greater nodule mass at N1 but 19% lower nodule mass at N2 than its parent line. Interactions between N-level and cultivars were statistically significant ($P<0.05$).

Yield of most entries was less than 1 t ha^{-1}. This was because all entries except the Nod line of ICC 4918, were medium-to-long duration types not adapted to the environment at ICRISAT Asia Center. The grain yield data is therefore not discussed here. The high-nodulating selections of ICC 4948 and ICC 5003 yielded 17-28% greater dry matter (stover + grains) than their parent lines. Dry matter yield was similar for high- and low- nodulation selections of cultivar ICC 14196 (**Table 2**). The data on ^{15}N analysis is awaited from the International Atomic Energy Agency (IAEA), Austria.

The low-nodulating selection of ICC 14196 produced 12% less nodule mass and fixed 32% less N2 at 41 DAS than its high-nodulating version. In previous nonreplicated observations the difference between the high- and low-nodulating selections of ICC 14196, a kabuli line suited to mediterranean climates, was substantial. This result therefore suggests the need to sufficiently test a material in replicated trials before advancing it. High yield of the high-nodulating selections of the two medium- and long-duration types, even in short-duration environments, suggested that at least preliminary evaluation for BNF traits can be done at IAC. Final evaluation of such selections should obviously be done in appropriate environments.

Table 2. Nodule number, nodule mass, shoot mass, root mass, acetylene reduction activity (ARA) of chickpea lines at 41 days after sowing, and grain yield and total dry matter (TDM) yield at final harvest, ICRISAT Asia Center, postrainy season 1993/94.

Lines	Nodule number plant^{-1}	Nodule mass (mg plant^{-1})	Shoot mass (g plant^{-1})	Root mass (g plant^{-1})	ARA (µM plant^{-1} h^{-1})	Grain yield (t ha^{-1})	TDM yield (t ha^{-1})
ICC 4948 HN	41	131	1.3	0.14	9.5	0.79	2.37
ICC 4948 LN	10	68	1.3	0.13	8.4	0.49	2.05
ICC 4948 Bulk	12	88	1.1	0.12	9.2	0.46	2.02
ICC 5003 HN	40	187	1.8	0.16	22.0	1.27	2.96
ICC 5003 LN	3	36	1.2	0.15	4.3	0.84	2.15
ICC 5003 Bulk	40	157	1.4	0.14	21.9	0.97	2.31
ICC 14196 HN	21	182	2.5	0.27	24.1	0.54	2.43
ICC 14196 LN	21	162	2.4	0.25	18.2	0.45	2.45
ICC 14196 Bulk	26	198	2.3	0.21	24.0	0.57	2.42
ICC 4918 Nod$^-$	0	0	0.9	0.09	0	0.37	0.92
ICC 4993 Nod$^-$	0	0	0.9	0.14	0	0.23	0.96
ICCV 6 Nod$^-$	0	0	0.5	0.09	0	0.02	0.38
SE	±2.1	±8.8	±0.10	±0.009	±1.9	±0.085	±0.121
CV (%)	33	25	19	16	45	41	18
F-test	***	***	***	***	***	***	***

Identification of Genotypic Traits for Resistance to Abiotic Stress Factors in Groundnut *(LG-704)*

ACIAR-ICAR-ICRISAT collaborative project on water-use efficiency in grain legumes

As a component of the collaborative project, genotypic variation in water-use efficiency (WUE) was examined in selected genotypes of groundnut and chickpea at the University of Agricultural Sciences, Bangalore. In groundnut, WUE ranged from 2.91 to 4.02 g dry matter kg^{-1} water transpired under irrigated conditions and from 3.4 to 6.8 g kg^{-1} under water-deficit conditions, reconfirming the significant variation. There was a significant positive correlation (r^2 = 0.9) between net assimilation rate per unit leaf area and WUE, which supports earlier observations that the photosynthetic capacity is the basis of genotypic variation in WUE in groundnut.

The WUE in the 10 chickpea genotypes, ranged from 1.2 to 2.1 g kg^{-1} with irrigation and from 1.6 to 2.3 g kg^{-1} under water-deficit conditions. It was interesting to note that the WUE in general was lower in chickpea compared to groundnut. Reasons for the low WUE in chickpeas require further investigation.

During the 1994 rainy season a common experiment involving 68 selected groundnut genotypes with contrasting WUE is being conducted at five collaborating centers, i.e., Vriddhachalam, Tirupati, IAC, Jalgoan, and Durgapura.

Plant growth parameters, assimilate partitioning, and seed quality as affected by soil temperature

The experiment was conducted twice in a greenhouse with plants in pots having a mixture of Alfisol, sand, and vermiculite. The groundnut cultivars used in the experiment were the spanish types Comet, TMV 2, and AH 6179. The potting medium was maintained at four day/night temperature regimes 20/14 (T1), 26/20 (T2), 32/26 (T3), and 38/32°C (T4), by immersing the pots in water baths. The temperature treatments were introduced at 75% flowering

(53 DAS) and continued until the harvest time. Effect of soil temperature on translocation of photosynthates was examined by the $^{14}CO_2$ feeding technique.

In general, concentration of ^{14}C was less in the vegetative than in the reproductive plant parts. At 72 DAS, concentration of ^{14}C in leaves and stems increased with increasing soil temperature with a corresponding reduction in translocation of ^{14}C to the roots. This effect was reflected in an increase in shoot/root ratio from T1 to T3. There was no difference in the shoot/root ratio in treatments T3 and T4. The ^{14}C concentration in the stems was very low in comparison to other plant parts indicating that the stems had no particular importance for storage of assimilates.

Because low soil temperatures lowered the shoot/root ratio the ^{14}C concentration in the roots was highest in T1 at the first two harvests, which could be one reason for the development of the highest nodule mass in T1. The ^{14}C concentration in the nodules was always higher than in the roots. The ^{14}C concentration ratio of nodules/root was favored by increasing soil temperature at harvest 1 and 2; increasing temperature may have enhanced sink activity of the nodules at these stages.

The pods were separated into juvenile, immature, and mature pods and subsequently shelled. At 72 and 86 DAS, increasing soil temperature from T1 to T3 enhanced the assimilate transport into each immature pod. At T4, where the single mature seed mass was lower than at the intermediate temperatures, the assimilate translocation to each mature seed was lowest of all treatments. This indicates that the lower single mature seed mass at T4 was not the consequence of lesser maturation. In immature as well as mature pods the ^{14}C concentration was higher in the seeds than in the shells.

The oil content of the mature seeds increased from T1 to T3, but there was no change from T3 to T4. The starch content decreased from T1 to T4. The protein content was higher at the warmer (T3 and T4) than at the colder temperature (T1 and T2) treatments. Among the fatty acids, oleic and linoleic acid increased sharply from T1 to T2, slightly from T2 to T3 and there was no change from T3 to T4.

Nitrogen Dynamics in Legume-based Cropping Systems in Relation to Root Development and Soil Water Status *(LL-918, GOJ Project)*

Fertilizer application methods and N-utilization efficiency in sorghum/pigeonpea intercropping

An intercrop of sorghum and medium-duration pigeonpea is more productive than its separately sown sole crops on Alfisols of the semi-arid tropics. The yield advantage has been attributed to the efficient use of soil resources, light, and N_2 fixation. Fertilizer- N use efficiency (NFUE) of sorghum/pigeonpea intercropping could be improved by the method, rate, and time of fertilizer application. Efficient and economic methods of fertilizer-N application in this intercropping system is specially of interest on shallow Alfisol where (i) compaction layers restrict the downward movement of roots leading to competition for N in the top soil and (ii) high rainfall occurs prior to active crop uptake. The study was undertaken in an Alfisol field RCE 4B to find a suitable method of N-fertilizer application and to evaluate the effect of application methods on yield, NFUE, and N_2 fixation. At a low rate of N-fertilizer application (25 kg ha $^{-1}$ as urea).

A medium-duration pigeonpea cultivar (ICP 1-6) and a grain sorghum hybrid (CSH 5) were sown on 22 Jun 1992. Three methods of N-fertilizer application, basal broadcast, basal band and split band (hereafter referred to as broadcast, band and split, respectively) were used. With the exception of the split, where N was applied 3 times at the different growth stages of sorghum (0, 40, and 60 DAS), all fertilizers were applied before sowing. The N-fertilizer was applied only to sorghum rows in the case of band and split treatments.

The experimental lay-out was a latin-square design with three replications and 3 treatments. Each plot size was 7.2 m X 14 m. Microplots of 2.4 m^2 (1 m X 2.4 m) for the ^{15}N-labelled fertilizer treatments were made at the center of each plot and the labelled urea (10.2 atom %) was then applied to the plots, at the same rate as the surrounding ^{14}N urea. Six plants of each species were sampled from the ^{15}N-treated microplots for the ^{15}N enrichment analysis with an emission spectrometer (JASCO N-150). Another set of 4 plants were also taken from the surrounding area, which was reasonably distant from the microplot, for the measurement of ^{15}N natural abundance ($\delta^{15}N$) with a mass spectrometer (Finnigan Mat 251).

Intercrop pigeonpea and sorghum yielded over 2 t and 3.5 t ha^{-1}, respectively. Split application recorded the lowest total dry matter (TDM) and grain yields (GY) in both pigeonpea and sorghum at maturity. Placing fertilizer N in a band increased the grain yield of sorghum (4.2 t ha^{-1} compared to 3.6 t ha^{-1} for the split treatment). However, these differences were not large enough to be statistically significant.

The fractional contribution of N derived from air (%Ndfa) was not significantly affected by the method of fertilizer application (**Table 3**). Around 90% of the nitrogen accumulated by pigeonpea was derived from air. Thus, in this study, pigeonpea in intercrop fixed 115-120 kg ha^{-1} of atmospheric N throughout the season regardless of the method of fertilizer application.

The fractional contribution of N derived from fertilizer (%Ndff) and the NFUE were estimated by the ^{15}N isotope dilution technique (**Table 4**). For sorghum grain, %Ndff and Ndff were significantly higher in banding than broadcast and split treatments. The %Ndff and Ndff in grain were much higher in sorghum than in pigeonpea, clearly demonstrating the higher dependency on the fertilizer N in the nonleguminous plant. Slightly higher (though not significant) Ndff values were recorded for pigeonpea in the broadcast than in the band and split treatments. This could be due to the fertilizer N initially applied to pigeonpea only in the broadcast treatment.

The NFUE in sorghum grains ranged between 12.4 and 25.4%, whilst that in pigeonpea ranged between 3.1 and 4.5%. Banding at sowing significantly increased the NFUE in sorghum. Through banding, sorghum had the most efficient acquisition of fertilizer N for its grain production compared to broadcast and split.

To achieve higher N-use efficiency and higher grain yield in semi-arid environments where nitrate losses prior to crop uptake is bound to be high, split application of fertilizer N seems to be advantageous to ensure a sufficient supply of available mineral N throughout the growing season and more importantly to reduce risk in capital losses at the time of crop failure. However, our results suggest that split application of fertilizer N, especially when the fertilizer rate is low, may not be necessary for sorghum intercropped with pigeonpea on Alfisols. In this study split application neither improved the N-use efficiency nor grain yield. Thus, for intercropping sorghum with pigeonpea on Alfisols in India where fertilizer of 25 kg ha^{-1} is recommended, the optimum management practices for the conservation of N, energy, time, and labor, would be to apply the fertilizer N by banding at sowing time.

Table 3. Fractional contribution and amount of N derived from air in pigeonpea in the intercrop, calculated with $\delta^{15}N$ values.

Treatment	$\delta^{15}N$ values[1]		%Ndfa[2]	Ndfa[3] (kg ha^{-1})
	Sorghum	Pigeonpea		
Broadcast	+3.63	-1.00	87.0	121.1
Band	+3.47	-1.10	90.2	117.1
Split	+4.80	-1.27	94.1	115.7
SE (±)	1.05	0.20	4.91	7.35
Statistical significance	NS	NS	NS	NS
CV (%)	28	31	9	11

1. Measured for grains (per millagewise).
2. Fractional contribution of N derived from air.
3. Amount of N derived from air.

Table 4. Fractional contribution and amount of plant N derived from fertilizer and fertilizer-use efficiency of intercrop sorghum and pigeonpea calculated from atom % excess value in grains.

	Sorghum				Pigeonpea			
Treatment	Atom% excess	%Ndff[1]	Ndff[2] (kg ha^{-1})	NFUE[3]	Atom% excess	%Ndff[1]	Ndff[2] (kg ha^{-1})	NFUE[3]
Broadcast	0.84	8.51	3.11	12.4	0.14	1.44	1.13	4.53
Band	1.47	15.0	6.35	25.4	0.15	1.51	0.99	3.98
Split	0.79	8.03	3.36	13.5	0.11	1.12	0.78	3.13
SE(±)	0.03	0.26	0.20	0.80	0.03	0.3	0.14	0.57
Statistical significance	***	***	***	***	NS	NS	NS	NS
CV (%)	6	6	2	2	22	22	15	15

1. Fractional contribution of N derived from fertilizer.
2. Amount of N derived from fertilizer.
3. Nitrogen fertilizer-use efficiency.

Cropping Systems

Agroforestry *(R-302)*

Three agroforestry trials were conducted during the 1994 rainy season. One trial aimed to quantify the value of the agroforestry component to a low-input sorghum-based system. The trial consisted of a split plot design with sole and intercrop plots being the main plots and nutrient treatments being the sub-plots. Nutrients were applied at two levels (O and 20 kg N ha^{-1}) and two levels of leucaena residue (residue produced by leucaena and no residue). These nutrient sources were applied separately or in combination. The results from this study are under analysis.

The second agroforestry trial was to determine the temporal trends in production of a sorghum/gliricidia agroforestry system. This trial has been underway since 1989 and will be completed on a final harvest at the end of the 1995 summer season. The results will then be prepared for publication.

The third agroforestry trial examined the effect of pruning height on a leucaena/sorghum agroforestry system. Measurements are still being made and final conclusions are yet to be drawn. Pruning height was observed to have an enormous effect on sorghum grain and fodder yields. The sorghum rows adjacent to leucaena grew poorly when pruned to 0.8 m height. In contrast, little effect was found when leucaena was pruned to ground level.

Variation in Soil Factors and Their Effect on Crop Establishment *(R-241)*

A field trial was conducted to determine the effect of sowing depth on the performance of a line with and without seedling vigor. Substantial emergence occurred even when lines were sown to a depth of 14 cm. Lines with a long mesocotyl exhibited higher percentage emergence when deeply sown. Favorable conditions allowed lines without seedling vigor to emerge but several days later when sown at depth. Much of the data has still to be analyzed.

Income-generating Production Systems *(R-321)*

The main purpose of this project is to identify promising pigeonpea-based income-generating production systems suitable for an Alfisol and a Vertisol under rainfed conditions. Results from a 4-year (1990 to 1994) on-station study on a Vertisol have been summarized and being prepared for formal publication. In this study, a medium-duration pigeonpea cv ICPL 87119 was strip intercropped with several cash crops (green gram, sunflower, soybean, safflower, and cotton) independently in five replacement series of four strip widths (1.5, 3, 4.5 and 6-m strip) under three land configuration systems (flat; ridge and furrow, RF at 0.75 m; and broadbed and furrow, BBF at 1.5 m). Each crop was rotated with an associated intercrop in a 2-year rotation cycle.

Results indicated that all strip intercropping systems were more productive and profitable than sole pigeonpea or sole green gram + sunflower sequential systems. However, the sole cotton or sole soybean + safflower sequential system were the most profitable systems compared to any of the strip intercropping combinations. Land configuration or cropping system by land configuration interaction effects on individual crop yields or cropping systems economic returns were nonsignificant during all the four years. Sole cotton gave the maximum gross (Rs. 19 870 ha^{-1}) and net returns (Rs. 9 970 ha^{-1}) with the lowest gross (Rs. 10 480 ha^{-1}) and net returns (Rs. 6 250 ha^{-1}) obtained in the sole green gram + sunflower sequential system. Benefit:cost (B:c) ratio varied widely among cropping systems and between years. A combination of 1.5-m pigeonpea and 4.5-m soybean + safflower strip intercropping gave the maximum B:C ratio of 2.65 followed by a sole cotton or sole soybean + safflower sequential system with a B:C ratio of 2.57 in each system. The lowest B:C ratio of 1.57 was obtained in the sole green gram + sole sunflower sequential system.

Collaborative Research

NAWAB (Nutrient And Water Balance study on an Alfisol)

This is the final year of the NAWAB experiment. Measurements of light interception, dry matter production, leaf area and transpiration were made as in previous years. These data will now be analyzed as complete set. This information will be used to examine options for improved management of these systems. The developed databases will be used in research on sustainability.

Staffing

K.C. Mouli, Research Associate, separated under the Voluntary Retirement Scheme on 30 Sep to join the Agricultural and Water Research Institute, Saudi Arabia.

Staff Travel

Travel within India

Period	Staff name(s)	Organization[1]/ Location	State(s)/ Region	Purpose
03-06 Jul	Saxena, N.P. Johansen, C.	IIPR Kanpur	Uttar Pradesh	Collaborative research planning
06-09 Jul	Sharma, S.K.	Govt. Livestock Farm, Warangal	Andhra Pradesh	To arrange intercultivation in on-farm trials
14 Jul	Potdar, M.V.	Indo-Swiss Proj. Buchannapet	Andhra Pradesh	To visit an on-farm trial with Dr James Lang
20-22 Jul, 10-11 Aug	Sharma, S.K.	Govt. Livestock Farm, Warangal	Andhra Pradesh	To arrange top dressing in on-farm trials
22-31 Jul	Rao, R.C.N.	Various ICAR stations	Tamil Nadu, Andhra Pradesh, Karnataka	To visit collaborative experiments in WUE project
11-19 Aug	van Oosterom, E.J.	RAU, Fatehpur-Shekhawati	Rajasthan	To evaluate physiology and breeding trials
2-9 Sep	Anders, M.M.	Indo-Swiss Proj. Jodhpur	Rajasthan	To monitor pearl millet on-farm trials
13 Sep	Saxena, N.P. Johansen, C. Rao, R.C.N.	IARI	New Delhi	Collaborative research planning
15-16, 25-29 Sep	Sharma, S.K.	Govt.Livestock Farm, Warangal	Andhra Pradesh	To arrange harvesting in on-farm trials
19 Sep	Rupela, O.P.	IARI	New Delhi	To strengthen collaboration with Indian national program
26 Sep	John Bob, V.P.	Indo-Swiss Proj. Buchannapet	Andhra Pradesh	Sample harvesting in on-farm trials

1. IARI = Indian Agricultural Research Institute, ICAR = Indian Council of Agricultural Research, IIPR = Indian Institute of Pulses Research; IIT = Indian Institute of Technology, RAU = Rajasthan Agricultural University.

Travel outside India

Period	Staff name(s)	Organization[1]/ Location	Country(s)	Purpose
13 Jul- 02 Aug	Johansen, C.	ISC IITA	Niger Nigeria	RPRC/RCC Meetings and tour of ICRISAT research sites in West Africa
10-17 Sep	Bidinger, F.R.	EARCAL Nairobi	Kenya	To finalize project documents and CIRAD activities
19-25 Sep	Chauhan, Y.S.	FCRDI Maha Illuppallama	Sri Lanka	To participate in the planning of agronomy experiments
23 Sep- 12 Oct	Anders, M.M.	ISC Niamey	Niger	To finalize the MCSP 1 project
27 Sep- 08 Oct	Flower, D.J.	ISC Niamey	Niger	To attend a joint meeting of MCSP leaders

1. EARCAL = Eastern Africa Regional Cereals and Legumes Program, FCRDI = Food Crops Research and Development Institute, IITA = International Institute of Tropical Agriculture, ISC = ICRISAT Sahelian Center.

Workshops, Meetings, and Conferences Attended

Period	Workshop/ Meeting	Organizer[1]/ Location	Country	Staff name(s)
10-16 Jul	International Congress of Soil Science	ISSS Acapulco	Mexico	Ito, O.
12-15 Sep	Rabi Groundnut Group Meeting	IIT Kharagpur	India	Rao, R.C.N.
15-18 Sep	Rabi Pulses Group Meeting	ICAR RAU, Bikaner Rajasthan	India	Saxena, N.P. Johansen, C. Rupela, O.P.

1. ICAR = Indian Council of Agricultural Research; IIT = Indian Institute of Technology, ISSS = International Society of Soil Science; RAU = Rajasthan Agricultural University.

Visitors

Period	Name of visitor(s)	Organization[1]/ Location	Country(s)	Purpose
7 Jul	Col. Rao Ram Singh	Ministry of Rural Development	India	To learn about watershed research activities
20 Jul	Agrl. Field Officers	Allahabad Bank Hyderabad	India	To learn about watershed research activities

Contd.

Visitors Contd.

Period	Name of visitor(s)	Organization[1]/ Location	Country(s)	Purpose
28 Jul	Nancy Bourgeois -Luthi & Rudolf Luthi	Pidow-Myrada Gulbarga	India	To discuss watershed research management activities
1-2 Aug	Wright, G.C.	ACIAR, QDPI	Australia	To visit/discuss collaborative project on WUE in groundnut
2 Aug	Frederic Renard	Belgium Embassy New Delhi	India	Visited agroforestry experiments and discussed watershed research activities
10 Aug	Trainees (41)	SCTC, Bijapur, Karnataka	India	To learn about watershed research activities
19 Aug	Minami, K. Nishikawa, Y. Fukushima, M.	JIRCAS Japanese Embassy New Delhi	Japan India	To review the Government of Japan Special Project
22, 30-31 Aug	Ando, S.	JIRCAS	Japan	To collect legume nodules and explore collaboration on BNF research
25 Aug	Mathew Nelson	Glasgow University	UK	To discuss the watershed research
29 Aug	Zeigler, R.S.	IRRI	Philippines	To discuss IRRI-ICRISAT collaboration
05 Sep	Tyagi, N.K.	CSSRI Karnal	India	To discuss collaboration, MCSP 4 and Rice - Wheat Consortium
05-08 Sep	Azam Ali, S.	Nottingham University	UK	To develop/finalize ODA proposal on groundnut modeling
8 Sep	Officers	NIRD Rajendranagar	India	To discuss watershed management research activities
14 Sep	20 PG students of Agri.College	APAU Bapatla	India	To learn pigeonpea physiology work and watershed research activities
23 Sep	Josey, D.P.	HRI,Wellesbourne Warwick	UK	To explore collaborative possibilities on topics of mutual interests
27 Sep	Srivastava, S.	NGLIP, Rampur	Nepal	To update BNF research at IAC

1. ACIAR = Australian Centre for International Agricultural Research, APAU = Andhra Pradesh Agricultural University, CSSRI = Central Soil Salinity Research Institute, HRI = Horticultural Research International, IRRI = International Rice Research Institute, JIRCAS = Japan International Research Center for Agricultural Sciences, NGLIP = National Grain Legume Improvement Program, NIRD = National Institute of Rural Development, QDPI = Queensland Department of Primary Industries, SCTC = Soil Conservation Training Centre.

Soils and Agroclimatology Division

Agroclimatology

Weather at IAC, Patancheru

Weather during July to September remained generally wet. Total rainfall received during this period was 406 mm, which was 84% of the normal rainfall (480 mm). There was no significant change in the mean maximum and minimum temperatures, solar radiation, and open-pan evaporation during the season; however, some increase in solar radiation and maximum temperature was observed towards the end of the season. Minimum temperature and wind velocity decreased as the season progressed (**Table 1**). Because of well distributed rainfall during the season, the growth of most crops was excellent.

Modeling Growth and Yield of Legumes *(R-341)*

Groundnut modeling

ICRISAT has developed several short-duration groundnut varieties (physiological maturity ≤100 days), which have the potential for adoption in various groundnut-based production systems in the semi-arid tropics (SAT). Their adaptability shall depend mainly on soil, climatic, and biotic environment to express their yield potential. Groundnut model can be used as a tool to make first-hand assessment of their yield potential and limitations, provided the genetic coefficients for these cultivars have been determined. We grew six promising short-duration cultivars (ICGVs 91116, 91123, 91124, 91129, 93392, and 93397) during the 1994 rainy season at IAC. Robut 33-1 was used as a control. Sowing was done on 21 June 1994. The crop received fertilizer at sowing at the rate of 18 kg N, 40 kg P_2O_5,

Table 1. Weather at IAC during July-September 1994.

Standard week	Period	Rainfall (mm)		Temperature (°C)		Solar radiation (MJ $m^{-2}d^{-1}$)	Open-pan evaporation (mm day^{-1})	Wind velocity (km h^{-1})
		Actual	Normal	Max	Min			
27	02-08 Jul	49.6	31.8	29.6	22.1	15.6	5.2	16.4
28	09-15 Jul	24.6	32.1	27.5	22.1	10.4	3.2	21.6
29	16-22 Jul	19.4	43.2	30.7	22.8	14.8	6.1	19.0
30	23-29 Jul	40.3	45.6	29.6	22.5	14.5	4.2	13.8
31	30-05 Aug	9.3	38.5	29.1	22.6	13.0	4.3	13.2
32	06-12 Aug	37.0	27.0	29.9	22.3	16.3	5.5	12.2
33	13-19 Aug	54.2	27.1	29.1	21.9	14.4	3.9	11.7
34	20-26 Aug	88.4	34.9	28.6	22.1	14.8	4.0	10.3
35	27-02 Sep	17.5	38.1	27.8	21.8	13.4	3.9	16.1
36	03-09 Sep	12.5	37.9	30.0	21.6	15.7	4.9	14.8
37	10-16 Sep	11.0	43.9	30.9	21.9	21.7	5.5	7.8
38	17-23 Sep	36.0	37.9	29.5	19.7	19.0	4.4	9.1
39	24-30 Sep	6.0	42.9	31.5	19.8	19.2	4.8	5.1
Mean		405.8[1]	480.9[1]	29.6	21.8	15.6	4.6	13.1

1. Total rain.

and 60 kg K_2O ha^{-1} as diammonium phosphate, single superphosphate, and muriate of potash, respectively. Gypsum was applied @ 500 kg ha^{-1} at pegging. The crop was grown under rainfed conditions, except for an irrigation of 50 mm at sowing to facilitate crop emergence. We recorded phenology of crop at every 2 days intervals. Growth analysis was done at weekly intervals to determine dry matter partitioning and leaf area development. Canopy height and width and light interception were recorded twice a week. Soil moisture changes were recorded at weekly intervals using a neutron probe. The crop was harvested on 26 September 1994 and the yield determination is still in progress. Short-duration varieties took 23 days to reach 50% flowering and 85 days to reach harvest maturity (80% of pods mature). On the other hand, Robut 33-1 took 27 days to reach 50% flowering and 95 days to reach harvest maturity under rainfed situation. Maximum LAI produced was 3.7 for Robut 33-1 and 2.6 to 3.1 for various short-duration genotypes. Based on growth analysis of samples, total dry matter production at 85 DAS ranged from 5.8 to 6.5 t ha^{-1} for short-duration cultivars and 7.0 t ha^{-1} for Robut 33-1. The pod yields ranged from 2.3 to 3.0 t ha^{-1} for short-duration cultivars, whereas it was 3.1 for Robut 33-1. These data sets will be used to calibrate genetic coefficients for these cultivars and for extrapolation of results to other environments.

Pigeonpea modeling

Extra-short, short- and medium-duration pigeonpea genotypes vary considerably in their growing durations and hence are expected to use different amounts of light and water resources for their growth. A precise quantification of this variation can be used for modeling of pigeonpea growth. Also if such quantification is made at different levels of soil moisture availability, this can provide information on the relative advantage of these maturity groups for different moisture availability situations. We conducted a field experiment on an Alfisol to quantify the resource use, phenology, and growth of pigeonpea under rainfed and irrigated conditions, which will form the basis to model the pigeonpea growth and development. The genotypes selected were ICPLs 84023, 87, and 227. Sowing was done on 20 June 1994. Plant geometry maintained was 30 x 10 cm for short-duration, and 60 x 30 cm for medium- duration pigeonpeas. Observations were taken on phenological stages, vegetative and reproductive growth, soil moisture dynamics, and light interception. The crop is near maturity and will be harvested in late-October. The data collected will be used to quantify resource use and for modeling of pigeonpea genotypes of varying durations and other characteristics.

Soil Biology

Genotypic Differences in Waterlogging Tolerance of Extra-short- and Short-duration Pigeonpea *(LP-405)*

Following identification of some sources of tolerance to waterlogging in pigeonpea germplasm mostly from medium- and long-duration groups (ICRISAT Legumes Program Annual Report 1993, p. 64), we initiated screening of lines from the two duration groups for tolerance to waterlogging. Using the pot screening method developed at IAC (ICRISAT Legumes Program Annual Report 1991, p. 38), we screened 34 pigeonpea lines which include 4 released cultivars (Prabhat, ICPL 87, UPAS 120, and Manak), 27 breeders' promising lines, and tolerant (ICP 8379 and ICP 14199) and 1 susceptible (ICP 7035) controls.

The tolerant and susceptible control genotypes proved consistent in their response to waterlogging (**Table 2**). Waterlogging for 8 days resulted in significant reduction in shoot dry mass (mean 24.4%, range 6.4 to 45.3%), roots + nodule dry mass (mean 63.8%, range 48.5 to 80%), and total plant biomass (mean 32.4%, range 16.5 to 50.5%) of pigeonpea germplasm tested. Nineteen out of 31 genotypes tested were tolerant to waterlogging. Among them, two genotypes—ICPL 87113 and ICPL 91031—were found promising as they suffered relatively less loss in plant dry matter compared to other tolerant genotypes.

Screening of some more promising extra-short- and short-duration pigeonpea lines for tolerance to waterlogging is in progress.

Table 2. Effect of waterlogging for 8 days on plant survival (%) and total plant dry matter of extra-short- and short-duration pigeonpea genotypes grown in pots containing a Vertisol in a greenhouse at ICRISAT Asia Center, Jul-Aug, 1994.

Genotype	Plant survival[1](%)		Total plant dry mass[1] (g plant^{-1})		% loss due to waterlogging
	Control	Waterlogged	Control	Waterlogged	
ICPL 86023	100 (90)[2]	67 (60)	2.30	1.61	29.8
ICPL 87113	100 (90)	100 (90)	2.30	1.92	16.5
ICPL 90002	100 (90)	100 (90)	2.27	1.41	37.5
ICPL 90016	100 (90)	100 (90)	2.36	1.84	21.3
ICPL 90023	100 (90)	92 (80)	2.31	1.45	34.5
ICPL 91002	100 (90)	100 (90)	2.48	1.37	44.9
ICPL 91031	100 (90)	100 (90)	2.19	1.75	19.2
ICPL 91052	100 (90)	100 (90)	2.38	1.68	28.2
ICPL 92030	100 (90)	100 (90)	2.30	1.75	23.5
ICPL 92049	100 (90)	100 (90)	2.03	1.53	25.1
ICPL 93072	100 (90)	100 (90)	2.00	1.57	20.4
ICPL 93074	100 (90)	100 (90)	2.57	1.56	38.8
ICPL 93083	100 (90)	67 (60)	2.96	1.60	44.0
ICPL 93085	100 (90)	100 (90)	2.51	1.86	24.4
ICPL 93091	100 (90)	58 (50)	2.49	1.81	27.3
ICPL 93104	100 (90)	100 (90)	2.32	1.51	34.8
Prabhat	100 (90)	83 (70)	2.44	1.63	32.5
ICPL 87	100 (90)	75 (65)	2.27	1.57	30.9
UPAS 120	100 (90)	92 (80)	2.03	1.59	21.4
Manak	100 (90)	92 (80)	2.26	1.42	36.9
ICPL 85010	100 (90)	100 (90)	2.93	1.82	37.4
ICPL 88009	100 (90)	100 (90)	3.24	1.73	44.9
ICPL 90008	100 (90)	50 (45)	3.19	1.55	50.5
ICPL 87095	100 (90)	100 (90)	2.67	1.40	46.7
ICPL 88039	100 (90)	100 (90)	3.06	1.76	42.3
ICPL 84071	100 (90)	100 (90)	3.06	1.66	45.4
ICPL 84031	100 (90)	100 (90)	2.42	1.64	31.0
ICPL 85012	100 (90)	92 (80)	2.69	1.51	43.9
ICPL 88034	100 (90)	100 (90)	2.70	1.79	33.4
ICPL 90011	100 (90)	42 (40)	2.97	1.61	45.4
ICPL 87105	100 (90)	33 (30)	2.27	1.53	32.8
Control					
ICP 8379	100 (90)	100 (90)	1.47	1.22	15.3
ICP 14199	100 (90)	100 (90)	1.72	1.40	18.4
ICP 7035	100 (90)	0 (0)	2.41	1.84	23.6
Mean	100 (90)	87 (77)	2.46	1.61	32.4
SE Treatment(T)		± (0.208)		± 0.042	
Genotype (G)		± (6.013)		± 0.090	
TxG		± (8.380)		± 0.133	
		± (8.503[3])		± 0.128[3]	
CV (%)		(17.6)		10.9	

1. Mean of 3 replications, each replication has 4 plants pot^{-1}.
2. Values in parentheses are after angular transformation.
3. For comparing means with same level of treatment.

Effect of Organic Manure and Micronutrient Amendment on Pigeonpea Growth

As reported earlier the reduced pigeonpea yields in different crop rotation plots were neither due to increased incidence of *Fusarium* or parasitic nematodes. To understand the causes for reduced pigeonpea yields in long-term trial plots, a greenhouse experiment was conducted to study the effects of organic matter and micronutrient amendments on yield of pigeonpea grown in soil collected from long-term rotation plots. Pigeonpea cv ICP 1-6 was grown in pots filled with surface soil (0-20 cm) samples collected from sorghum/pigeonpea (S/PP)-S/PP, S/PP-sorghum+CP, cowpea/PP-sorghum+safflower (S+SF), S/PP, S+SF, Fallow + Sorghum (F+S)-F+S. Fifteen days before sowing amendments with 0.5% (W/W) farm yard manure (FYM), 0.5% Bioearth (a compost prepared from organic wastes of sugarcane factories, distilleries, coffee plantations, etc.) (W/W), and 1500 mL full strength of micronutrient solution containing $MnSO_4$, H_3BO_3, $ZnSO_4.7H_2O$, $CuSO_4.5H_2O$, $COSO_4.6H_2O$, $Na_2MoO_4.2H_2$ were used. Pigeonpea plants were grown up to 100 days. Total plant dry matter of pigeonpea was significantly increased in case of soils amended with 0.5%. Bioearth by 15.5% over nonamended control soil. In case of soils amended with FYM or micronutrients, pigeonpea plant dry matter yield was marginally increased over nonamended control. Amongst the rotation treatments highest pigeonpea plant dry matter yield was observed in case of F+S-F+S plot soil followed by >S/PP-S/PP, COP/PP-S+SF >S/PP-S+SF, S/PP-S+CP. Biological nitrogen fixation measured by acetylene reduction assay was not affected due to amendments with FYM, Bioearth or micronutrients. Nitrogen fixation in pigeonpea was significantly higher in case of plants grown in soil from COP/PP-S+SF (16.6 µmol C_2H_4 $plant^{-1}$ h^{-1}) and S/PP-S/PP (14.76 µmol C_2H_4) $plant^{-1}$ h^{-1}) than with the plants grown in F+S-F+S plot soil (7.36 µmol C_2H_4 $plant^{-1}$ h^{-1}).

Further, mycorrhizal infection in pigeonpea was reduced by FYM and Bioearth application as compared to mycorrhizal infection of pigeonpea grown in nonamended and micronutrient-added soil treatments. Mycorrhizal infection of pigeonpea roots was also lower in case of plants grown in soil from S/PP-S+CP, COP/pp-S+SF, and S/PP-S+SF (21-24%) plots than the plants grown in S/PP-S/PP and F+S-F+S (32-36%) plots.

At the time of harvesting of pigeonpea plants, mineral N (NH_4-N and NO_3-N) in soil was less (5.6 µg N g^{-1} soil) in case of soil amended with micronutrients than the FYM, Bioearth amended, and nonamended soilS (8-9.2 µg N g^{-1} soil). Mineral N content in soil from F+S-F+S plot was lowest (4.8 µg N g^{-1} soil). A positive net N mineralization was observed in soils amended with FYM, Bioearth or micronutrients (1.9-3.64 µg N g^{-1} soil lod^{-1}) as compared to immobilization of mineral N (0.7 µg g^{-1} soil lod^{-1}) in case of nonamended soil.

These results indicated that amendment with 0.5% Bioearth increased the pigeonpea plant yield, and amendment with FYM or micronutrients had no effect on pigeonpea yield. More pronounced effects of crop rotation treatments than the soil amendment treatments were observed. Soil amendments with FYM, Bioearth or micronutrients increased net N mineralization in soil, however, soil amendment treatments had no effect on biological nitrogen fixation. These results suggest that continued presence of pigeonpea in the system reduced pigeonpea plant yield and the cause was not the reduced BNF.

Soil Physics

Conservation Effects of Porous and Vegetative Barriers *(R-243)*

We conducted experiments to measure the effect of porous barriers (viz., vetiver, lemon grass, and stone bunds) on runoff and soil loss. Recently, we assessed the extent of termite activity in vetiver and lemon grass hedges using 'toilet roll technique'. We found that termite activity was higher in lemon grass hedges than in vetiver hedges (**Table 3**). Incidentally, there are more gaps in lemon grass hedges than in vetiver hedges. It is apparent that the termite activity contributes to formation of gaps in hedges.

Table 3. Comparison of toilet roll damage (%) by termites in vetiver and lemon grass hedges during 26 May to 18 July 1994.

Hedge	Extent of damage (%)	
	Range	Mean
Vetiver	20.7-26.2	23.6
Lemon grass	24.9-44.0	33.4

Variation in Soil Factors and Their Effect on Crop Establishment *(R-241)*

I. Effect of soil compaction on imbibition of chickpea seeds was studied by keeping the seeds in soil (collected from BW 5) at different moisture contents (10.6—24.5%) and then compressing the soil to different levels of bulk density. We observed that moisture gained by seeds was greater at a higher bulk density compared to at lower bulk density for soils at 20.3 and 24.5% moisture contents. Differences in seed moisture due to density effects were significant ($P \leq 0.05$), at 48 h for soil at 24.5% moisture and at 72 h for soil at 20.3% moisture (**Fig. 1**). However, the soil density effect on moisture gained by chickpea seeds was not significant for soils at 10.6 and 16.9% moisture, throughout the hydration period.

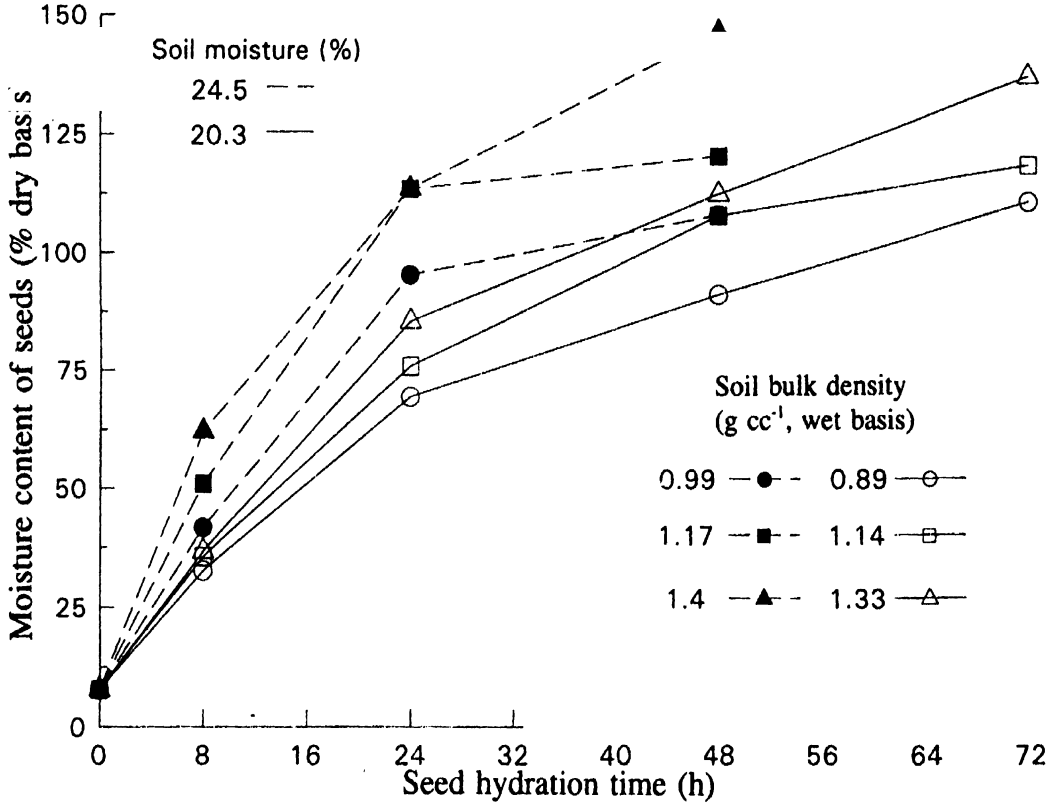


Figure 1. Soil density effect on imbibition of chickpea seeds.

II. Soil compactibility depends on soil type, structure, and moisture content. It has been used to study soil management effects on agricultural soils in the past. Experiments were conducted to study compactibility of soil taken from different plots of an experimental field (RM 19B - Modification of soil structure of an Alfisol). The plots have been under a combination of two tillage treatments (depth of tillage 100 and 200 mm) and two management practices (no FYM and 15 t ha^{-1} FYM), for the last 5 years.

Soil was passed through 2 mm sieve and samples were prepared with 11% moisture content. The test samples were compressed under a plunger in a cylinder. The force needed for compression and the corresponding displacement of the plunger were measured, and used to draw graphs between applied pressure and the density of soil samples. Results show that the soil with no FYM has higher compressibility compared to the soil that received FYM at a rate of 15 t ha^{-1}, under both the tillage treatments (**Fig. 2**). The differences in soil bulk density (wet basis) are statistically significant at higher levels of applied pressure. Further experiments are in progress.

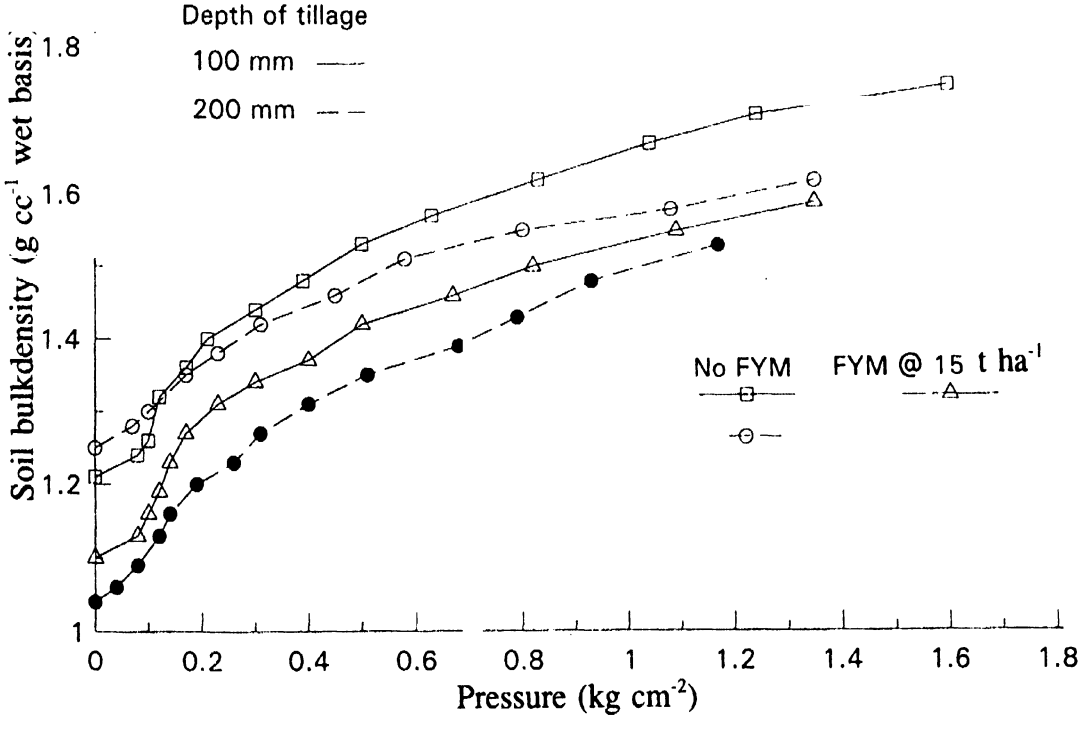


Figure 2. Compactibility of an Alfisol under two management practices.

Response of Soil Processes to Modification of Soil Structure of an Alfisol *(R-240)*

The work was started in 1988 under a collaborative project between ICRISAT and the Queensland Department of Primary Industries (QDPI), Australia to compare tillage, organic and biologically based systems for ameliorating soil structure. The experiment consists of three tillage depths (0, 10, and 20 cm) and three amendments (bare, 15 t ha^{-1} $year^{-1}$ FYM, 5 t ha^{-1} $year^{-1}$ rice straw) in a factorial combination and perennial systems of pigeonpea, *Cenchrus ciliaris*, and *Stylosanthes hamata* as sole and mixed systems. The perennial systems were removed during 1992 and were put under annual cropping. The surface of the soil was protected with rice straw in perennial systems during 1992 and 1993. However, no straw was applied in 1994 to these plots.

In 1994 test sorghum var CSH 9 was sown on 16 June. A total of 383 mm rain was received at the experimental site on 25 rainy days. Rainfall was well distributed during this period and there were no dry spells of more than 10 days duration. Germination and crop stand were good. As in the earlier years seedlings from FYM-applied plots were vigorous and healthy. Both plant height (62 DAS) and leaf area index (64 DAS) were found to be low in bare plots under all tillages (**Table 4**). Among the perennials Pigeonpea (P) + *Cenchrus ciliaris* (C) + *Stylosanthes hamata* (S) and S systems recorded lower LAI.

Runoff during the period was low, mainly because of small size of the storms (**Table 4**). Bare plots under all tillages produced higher runoff compared to the amended plots. The trends are very similar to those observed in earlier years. Slightly higher runoff was observed in prior perennial plots compared to the systems amended with FYM and straw. Stylo plots produced very little runoff compared to the other perennials. Low runoff from the prior perennial plots indicate the beneficial effects of the systems on soil structure.

Table 4. Runoff under different soil management systems, ICRISAT Asia Center, rainy season 1994.

Soil management systems[1]	Runoff (mm)	Plant height (cm) at 62 DAS	LAI at 64 DAS
Zero tillage bare	44.1	65	2.4
Zero tillage FYM	1.7	109.4	3.6
Zero tillage straw	1.2	120.7	3.9
10-cm deep tillage bare	35.7	79.2	2.2
10-cm deep tillage FYM	2.0	117.7	3.8
10-cm deep tillage straw	1.1	116.7	4.1
20-cm deep tillage bare	25.0	79.7	2.2
20-cm deep tillage FYM	0.8	111.1	3.7
20-cm deep tillage straw	0.0	123.1	3.4
Prior perennials			
P	5.0	116.4	3.6
P+S	5.5	111.5	3.0
P+C+S	3.9	98.9	2.9
C	4.4	121.0	3.7
C+S	6.1	107.6	3.6
S	0.7	104.3	2.8

FYM = Farmyard manure applied @ 15 t ha^{-1} $year^{-1}$, Straw = Rice straw applied @ 5 t ha^{-1} $year^{-1}$, P = Perennial pigeonpea, C = *Cenchrus ciliaris*, S = *Stylosanthes hamata*.

An analysis of previous years data was done to quantify the changes in infiltration and runoff with time under different management options. The relationship between runoff as percent of control (zero tillage bare) and rainfall since tillage. is given in **Figure 3**. A sharp reduction in infiltration and increase in runoff was observed up to 100 mm rainfall since tillage. Most of the tillage benefits were lost with 350 mm rainfall since tillage. Thereafter runoff from tilled plots was very similar or more than that of control plots. There was no difference in the trends under shallow (10-cm deep) and deep (20 cm) tillages. This supports the argument that runoff in these soils is mainly associated with the formation of surface seals. Application of straw and FYM amendments reduced runoff (**Fig. 4**). An improvement in the structural condition of the soil can be inferred from the gradual decline in runoff over the years. These results clearly indicate that the benefits of tillage are of short term and the benefits of amendments are of both short and long term.

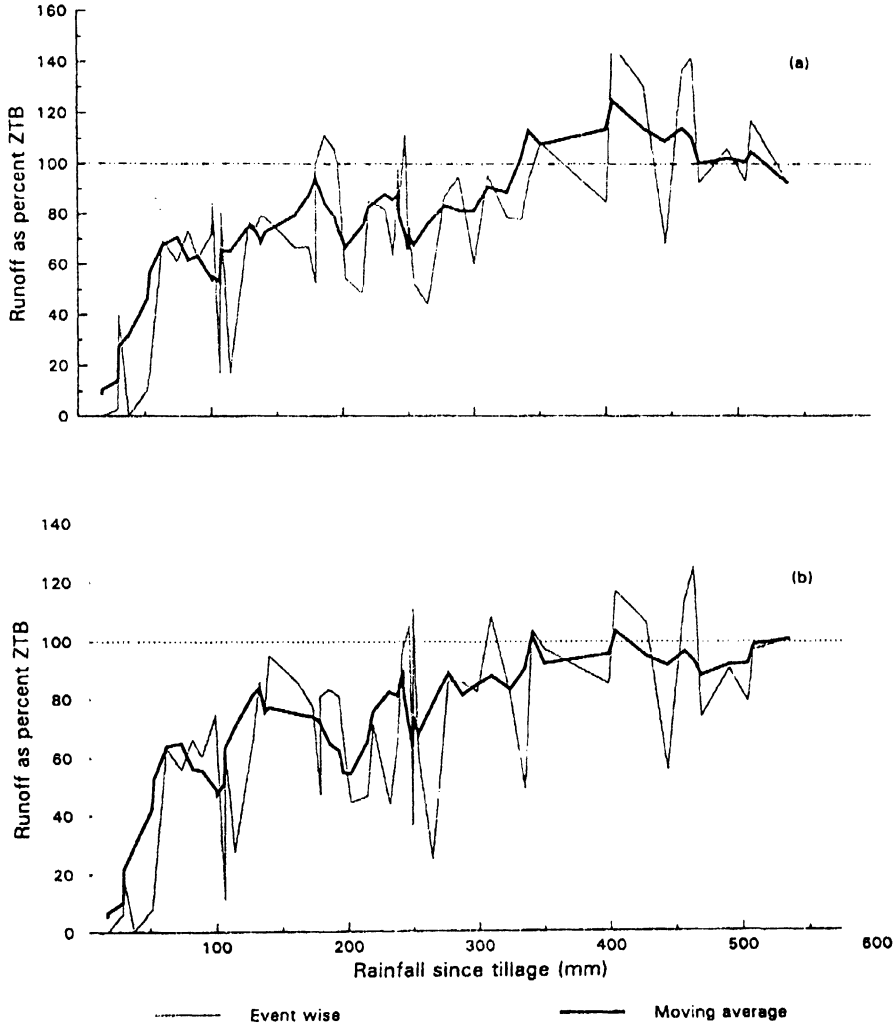


Figure 3. Effect of rainfall since tillage on runoff from a) Shallow tillage b) Deep tillage, ICRISAT Asia Center, rainy season 1994.

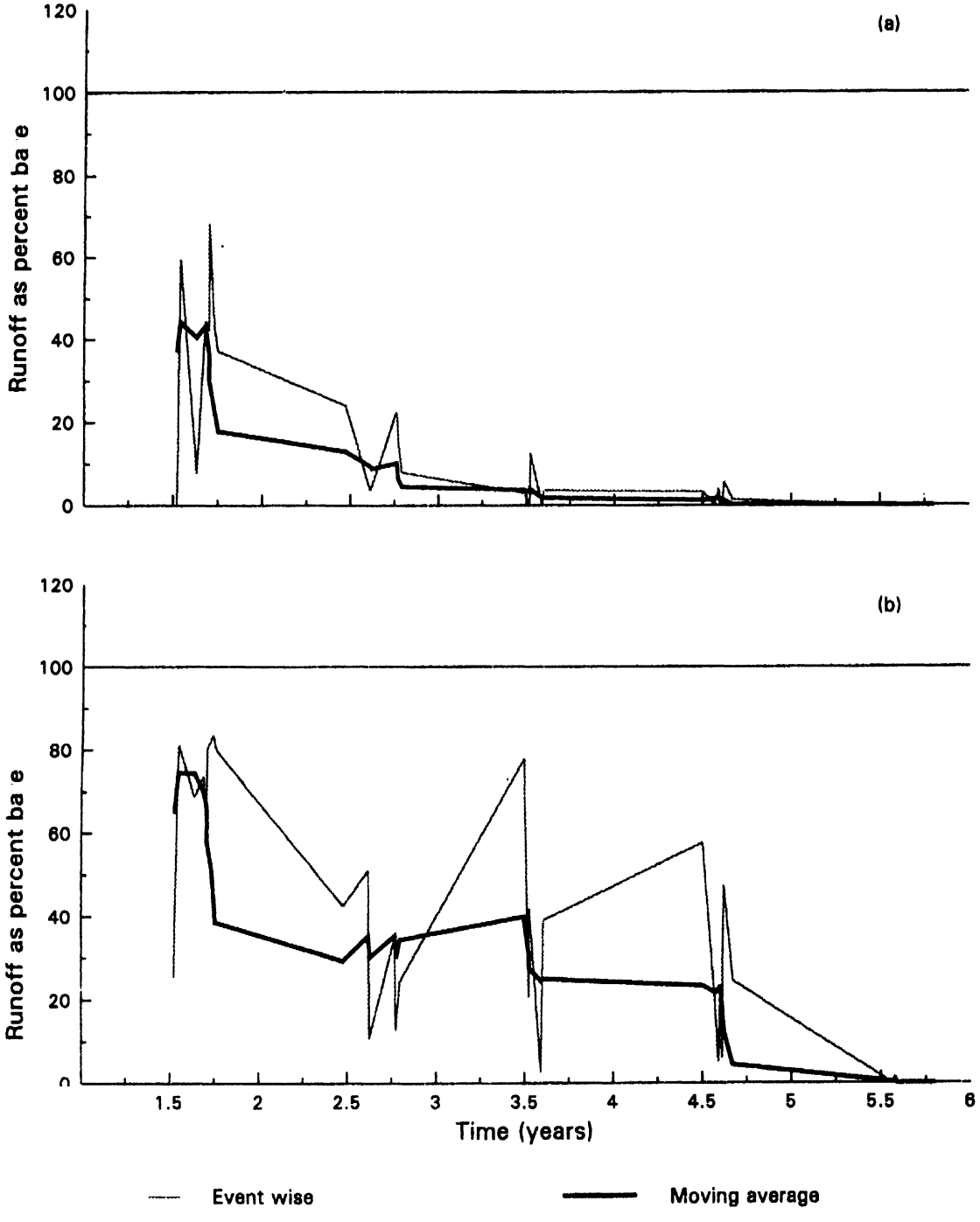


Figure 4. Cumulative effect of a) Straw mulching and b) FYM application on runoff, ICRISAT Asia Center, rainy season 1994.

Staffing

Debabrata Midya, Research Associate II separated from the services under Voluntary Retirement Scheme effective 8 Sep.

Staff Travel

Travel within India

Period	Staff name(s)	Organization/ Location	State(s) Region	Purpose[1]
12-14 Aug	Virmani, S.M.	New Delhi	New Delhi	To finalize ICAR-ICRISAT symposium proceedings

1. ICAR = Indian Council of Agricultural Research.

Travel outside India

Period	Staff name(s)	Organization[1]/ Location	Country(s)	Purpose
18-27 Jul	Virmani, S.M.	LASAS Griffin	USA	To visit the Georgia Experimental Station, University of Georgia
04-09 Jul	Wani, S.P.	Univ. of Alberta	Canada	To visit the Soil Department, University of Alberta

1. LASAS = Laboratory for Sustainable Agriculture Systems.

Workshops, Meetings, and Conferences Attended

Period	Workshop/Meeting	Organizer[1]/ Location	Country	Staff name(s)
08-17 Jul	15th International Congress of Soil Science	ISSS Acapulco	Mexico	Virmani, S.M. Wani, S.P.
24 Sep-08 Oct	Workshop on preparation of an action Plan for Soil, Water, and Nutrient Management Research	DSE/ZEL Zschortau	Germany	Virmani, S.M.
	Multiple Commodity System Projects Team Leaders meeting	ISC Niamey	Niger	Virmani, S.M.

1. ISSS = International Society of Soil Science, DSE/ZEL = German Foundation for International Development, ISC = ICRISAT Sahelian Center.

Visitors

Period	Name of visitor(s)	Organization[1]/ Location	Country	Purpose
07 Jul	Hon. Col. Rao Ram Singh	GOI, N. Delhi	India	To discuss soils and agroclimatology research
29 Aug	Zeigler, R.S.	IRRI, Manila	Philippines	To discuss about upcoming IRRI/ ICRISAT workshop on Geographical Information Systems
05 Sep	Tyagi, N.K.	Soil Salinity Res. Institute Karnal	India	To discuss about agroclimatology work
	Chaudhary, T.N.	ICAR, N. Delhi		
08 Sep	Agricultural Officers	NIRD, Hyderabad	India	To discuss management of watershed programs

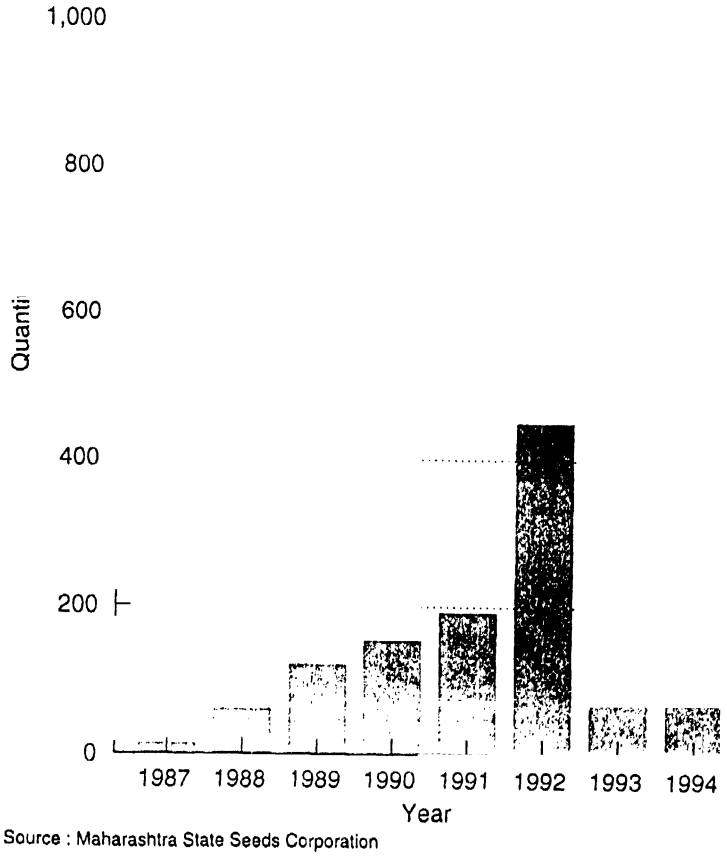
1. GOI = Government of India, ICAR = Indian Council of Agricultural Research, IRRI = International Rice Research Institute, NIRD= National Institute of Rural Development.

Socioeconomics and Policy Division

Research Evaluation and Impact Assessment

Niches of ICPL 87 in two SAT States of India

ICPL 87, a short-duration variety released as "Pragati" in central India in 1986, has found niches in Western and Marathwada regions of Maharashtra covering the districts of Ahmednagar, Dhule, Nasik, Pune, Solapur, Jalgaon, Osmanabad, Latur, Beed, Aurangabad and Jalna. Sales of ICPL 87 seeds by the Maharashtra State Seeds Corporation (MSSC) have risen significantly from 13.2 t in 1987 to 1003.5 t in 1994 (**Figure 1**). It's share out of MSSC's total pigeonpea seed sale has risen from 31% to 78% during the 5-year period from 1989 to 1993. Considering MSSC's estimate that 45% of total seed demand is met by the corporation (other sources are private seed companies and seed-producing farmers) and that farmers' average seed rate for short-duration pigeonpeas is 15 kg ha^{-1}, the area grown to ICPL 87 has reached about 148 700 ha in 1994. This is considered as a lower limit estimate as the seed replacement rate for ICPL 87 may actually be lower than assumed.



Source : Maharashtra State Seeds Corporation

Figure 1. ICPL 87 seed sales in Maharashtra by the Maharashtra State Seeds Corporation, 1987/94.

ICPL 87, which is mostly grown as a sole crop, has found its way mostly in drought-prone areas where rainfall averages around 600 mm in medium deep-black and well-drained soils. Farmers in these areas prefer this variety as it facilitates growing a second crop during the postrainy season; its ability for multiple flushes allows escape from total crop failure due to *Helicoverpa armigera* or erratic and low rainfall; it is observed to maintain soil fertility; it provides good fodder; and it is also harvested early and sold as vegetable. It is also grown in areas where protective irrigation is available so that farmers can harvest a ratoon crop as well. The variety has found its niche in the fallow lands and in crop rotation with sugarcane; it has mostly replaced the pearl millet and minor millets in sugarcane-growing areas of western Maharashtra. For instance, the area under pigeonpea in Ahmednagar has doubled from 11 387 ha in 1985 to 23 309 ha in 1992; and in Solapur from 22 011 ha in 1985 to 44 839 ha in 1992. It has also replaced medium-to-long duration pigeonpeas in some districts like Dhule and Jalgaon. ICPL 87 is also finding increasing acceptance by farmers in northern Karnataka covering the districts of Gulbarga and Bidar where seed sales of this variety was 17.3 t in 1993.

Success of ICP 8863 (Maruti) in Peninsular India

Large-scale adoption of ICP 8863 among farmers in the wilt-endemic areas of Karnataka, Maharashtra, and Andhra Pradesh is confirmed in recent reconnaissance surveys by the Research Evaluation and Impact Assessment (REIA) team of ICRISAT.

ICP 8863, more popularly known to farmers as "Maruti", is a wilt-resistant medium-duration pigeonpea released in Karnataka in 1986. It now dominates the large pigeonpea tracts of Karnataka covering the districts of Gulbarga, Bidar, Dharwar, Belgaum, Bijapur, Raichur, Bellary, and Mysore. While the sale of Maruti seeds by the Karnataka State Seeds Corporation (KSSC) increased significantly from 49 t in 1990 to 140 t in 1994 (**Figure 2**), the KSSC reports that it supplies only 14.7% of total seed used by farmers across the state; seed production and distribution

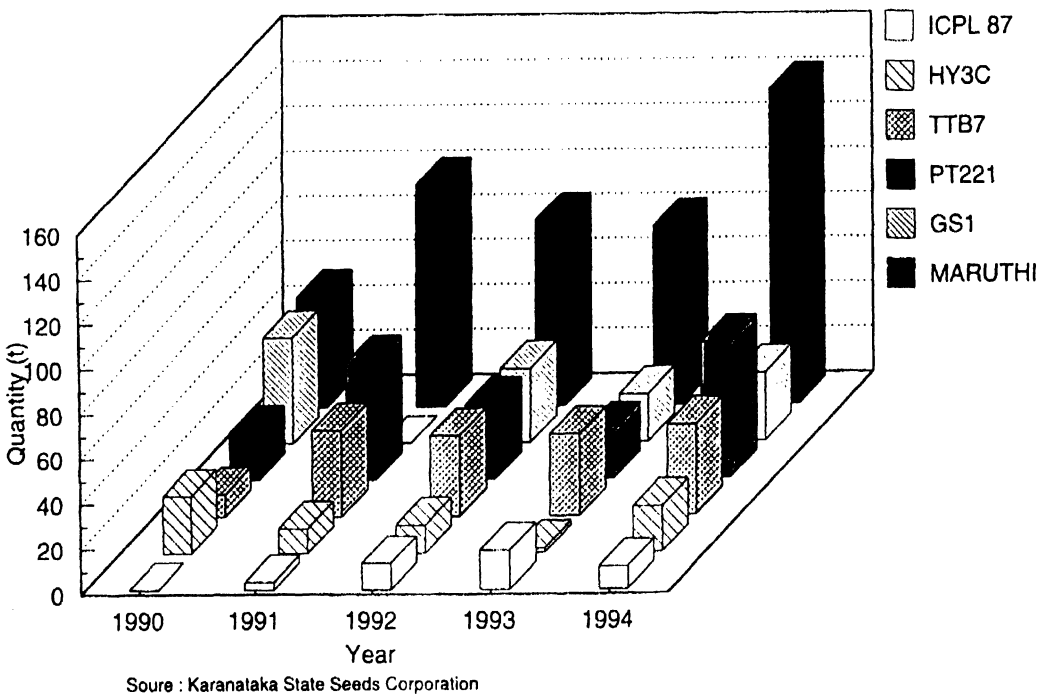


Figure 2. Pigeonpea seed sales in Karnataka by the Karnataka State Seeds Corporation, 1990/94.

among farmers remain to be the main source of Maruti seeds. Maruti's share in KSSC's total sale of all pigeonpea varieties increased from 32% in 1990 to 47% in 1994. A conservating estimate of the area grown to this variety in the above mentioned districts of Karnataka (using farmers' average seed rate of 10 kg ha^{-1}) is approximately 95 238 ha. Reports of subject matter specialists of the various Principal Agriculture Offices of the Ministry of Agriculture in this state indicate that about 116 120 ha area was sown under Maruti in the eight major pigeonpea-growing districts of Karnataka.

To confirm these estimates a systematic sampling scheme was developed. At first stage, Gulbarga and Bidar districts of Karnataka were selected (**Table 1**) as these are top ranking districts with respect to pigeonpea area. Pigeonpea in these two districts is grown over 298 876 ha which represents 55% of total pigeonpea area in Karnataka and about 8% in India. In the next stage, talukas were selected on the basis of relative importance of pigeonpea area to gross cropped area. Sedam and Chitapur talukas in Gulbarga district, and Bhalki and Humanabad talukas in Bidar districts were selected. Two highest pigeonpea-growing villages from each taluka were selected. At final stage, 10 pigeonpea-growing farmers from each villages were randomly selected, which formed a sample of 80 farmers, to estimate area under different pigeonpea varieties grown by them.

On the basis of a sample of 80 farmers, it was observed that about 52.5% farmers grew ICP 8863, covering about 58% of all pigeonpea area in two districts (**Table 1**).

Maruti has also become popular in adjoining districts of Maharashtra and Andhra Pradesh, particularly in Vidarbha region of Maharashtra, although the variety is not released in these states. The Maharashtra State Seeds Corporation is unable to sell Maruti in Maharashtra as it is not released in this state. Farmer-to-farmer seed distribution was a major source of widespread adoption of Maruti in Maharashtra. Besides, one private seed company, namely Mahesh Seeds, is multiplying and distributing this variety for the Vidharbha area. This year, the company produced about 25 t of Maruti seeds; of this 16.9 t are certified and the rest truthfully labelled. Similar sampling scheme as adopted in Karnataka was followed in Maharashtra to estimate adoption of ICP 8863 in Maharashtra. Preliminary results from a sample of 119 farmers from Akola, Amravati, Buldhana, Wardha, Yavatmal, Nanded, and Parbhani who were interviewed during the first round surveys indicate that Maruti was sown in 61% of total sample pigeonpea area in 1993, increasing from 46% in 1991.

Table 1. Estimated adoption of ICP 8863 in two sample districts of Karnataka.

			Area (%) under	
District	Taluka	Village	ICP 8863	Other varieties
Gulbarga	Sedam	Malkhed	83	17
		Adiki	52	48
	Chitapur	Hosur	34	66
		Malag(n)	58	42
Bidar	Bhalki	Ambesangir	47	53
		Dongpur	78	22
	Humnabad	Sultanabad	26	74
		Nandgaon	62	38
Total	*4*	*8*	*58*	*42*

Adoption of sorghum varieties ICSV 745 and ICSV 112 in Andhra Pradesh

An earlier survey conducted in November 1993 revealed that about 93% of sample farmers who sowed ICSV 745 and ICSV 112 in Warangal District of Andhra Pradesh were convinced of their performance. The grain characteristics most liked by them, ranked in the order of importance are: 1) easy threshability, 2) high yield, 3) large panicles, and 4) white grain. Respondents overwhelmingly expressed their willingness to continue this technology in the future. In fact, 92% of sample farmers predicted to increase their present area under these two varieties by 41.4% in the 1994 rainy season.

To confirm farmers' adoption expectations in the 1994 rainy season, we undertook a supplementary survey in September this year which covered a sub-sample of 125 respondents in two of the eight study villages (Bachannapet and Pochannapet). The follow-up interviews indicated that farmers' expectations last year regarding these two varieties were not met partly due to pre-harvest rains and consequent grain molds. This aggravated the low market potential for these varieties.

So, farmers this year decided to grow sesame instead of sorghum with expectations of high returns and possibility of sowing a second crop, i.e., sunflower. Unfortunately, lack of rains during this year did not give them expected yields.

The Indo-Swiss Project made available for sale sufficient quantities of ICSV 745 and ICSV 112 sorghum seeds for the 1994 rainy season to Bachannapet farmers. We found during our follow-up visit that some of these seeds were unsold. Farmers did not completely understand the hike in price from Rs. 14 to Rs. 30 for a package of 4 kg sorghum and 1 kg pigeonpea by the Indo-Swiss Project. Some farmers also did not fully appreciate why their produce last year was not bought by the Project as seeds.

Breeding of Pearl Millet for Rajasthan *(CM-171)*

The 1994 On-farm Trials

Farmers' preferences for cultivar traits

In contrast to 1993 which was a drought-stress season in most of Rajasthan, 1994 had more normal levels of rainfall and good to excellent distribution of rains for most farmers, particularly in western Rajasthan. The on-farm trial locations in Jodhpur (Aagolaie), Bikaner (Khichiyasar), and Barmer (Bharka) districts were continued this season. In order to evaluate preferences in a wider range of western Rajasthan environments, additional sites were included in Churru (Krejada), northwest Jodhpur (Malunga), eastern Jodhpur (Chandella), and eastern Barmer (Samdari) districts.

Twenty farmers participated at each location (five farmers per genotype). The genotypes used this year represent the following range of characteristics:

HHB 67	:	very early grain type
West Raj	:	improved Rajasthan population
CZ-IC 912	:	high fodder
89111AxTCP	:	very high tillering and drought resistant

In each of the new villages, a village investigator was chosen and trained. A household census was taken, which formed the basis for selection of participating farmers.

Seed was distributed to participating farmers in June. Village investigators visited each plot on a bi-weekly basis, taking measurements on crop growth. Mid-season and final (pre-harvest) evaluations were conducted collaboratively by ICRISAT staff, local contact people from the collaborating NGO/GO, and village investigators. At mid-season they visited each plot and discussed differences in crop growth and characteristics between the experimental genotype

and the farmer's own millet. The final evaluation included both individual discussions with each participating farmer and some group discussions. Unfortunately the final evaluation was cut short due to the incidence of plague in northern India. A follow-up visit to complete the final evaluations and look at grain and fodder quality differences is planned for November.

In addition to the on-farm preference studies, varietal demonstrations and fertilizer trials were conducted at the KVK farm at Bharka, Barmer. The varietal demonstrations included a wide range of genotypes. The fertility trials included several genotypes, fertility levels, and timing of applications. The purpose was to evaluate the performance of the genetic material and the fertilizer strategies in the Barmer environment, and to assess farmers' responses through group visits by farmers prior to harvest.

Finally, in eastern Rajasthan the previous on-farm trials with RCB-IC 911 culminated this year with its state registration and distribution of almost 5 t of seed to farmers in the Ajmer area. These farmers are familiar with the performance of RCB-IC 911 from the on-farm trials in their villages. The purpose was to make available a significant quantity this season and to track its spread. Farmers purchased the seed at Rs.10 kg^{-1}, slightly more than the market price for local millet as seed. P.K. Joshi is following up with an adoption study.

Research Collaboration with IARCs

Alternative Indicators of Food and Nutrition Security in the Indian SAT

Results

Recent results have shown that alternative indicators may be used to identify food insecure communities, households, and individuals. Some lessons learned from our analysis include:

Conventional indicators of food insecurity are not always strong ones. Our results indicate that conventional indicators of food security (such as low per capita household expenditure) are not always successful at identifying the food insecure. The relatively poor performance of the conventional indicators underscores the potential for putting some alternative into operation.

Simple alternative indicators of food insecurity exist. We found several simple-to-collect indicators that were successful at identifying food insecure households. Some examples include:

high household dependency ratio
village where the household is located
household has at least one child with diarrhea
household purchases many foods on a daily or weekly basis

We also found alternative indicator that were capable of identifying households with vitamin A deficient preschoolers or women:

high household dependency ratio
household has at least one child with diarrhea

Village-level indicators may be the best indicators. We found great potential for using indicators to rank villages according to their food security status. This method requires more validation, but if successful implies that 'food insecure' communities or regions may be identified using simple, alternative indicators gleaned from existing data sets.

Methodological issues: qualitative and quantitative methods were complementary. For the purposes of identifying indicators, our experience indicates that qualitative methods are more flexible than survey methods, more respectful of indigenous knowledge, and quicker to establish rapport between investigators and villagers. In contrast to survey methods, qualitative methods are able to quickly uncover the "hows" and "why's" associated with a given phenomena. They are therefore useful for devising research questions, designing surveys, interpreting survey results, and writing case studies.

Survey methods, on the other hand, provided the statistical reliability needed to determine the indicators, although they lacked depth of information on the dynamics of decision-making and behavior. Surveys, however, are time consuming and expensive. Under today's austere budget this study concludes that much work may be successfully conducted using qualitative research techniques.

More work continues on this project as we characterize the importance of our mandate crops to food insecure households.

Gender Analysis of Select Technologies of SAT Agriculture in India

The Fellowship Program of Dr K. Rama Devi with the International Center for Research on Women (ICRW) at Washington D.C. was continued till the first week of August. A draft of the research paper on "Impact of groundnut crop technologies on intra- and inter- household dynamics : a case study of Maharashtra in SAT India" was completed during this fellowship period and the draft paper was submitted to the RDD of SEPD for his review. The revision of the paper is under progress after receiving the comments and suggestions from the RDD.

The analysis of data collected for the second case study in Karnataka was completed. A draft research paper related to this study is being started.

Participated in the week-long division meetings in early August to discuss about the gender analysis activities and labor allocation in projects covering the MTP period. The responsibility of negotiating and allocating SEPD resources to various groundnut projects/activities was entrusted to Dr K. Rama Devi which was completed by the end of September. Besides this, participated in the IPM working party meetings to clarify SEPD's interests in this program.

Staffing

P. Tanuja and **T. Vasantha** were appointed as Field Investigators on 1 Jul.
K. Geeta Devi, Data Entry Operator, joined on 23 Sep.

The contracts of the following employees were extended as under:
R. Padmaja, Economic Investigator, up to 31 Jul.
M. Srikanth, Data Entry Operator, up to 31 Jul.
M.V. Ramalakshmi, Data Entry Operator, up to 31 Jul.
K.R. Radha Vani, Data Entry Operator, up to 31 Dec.
B. Seshanjani, Data Entry Operator, up to 30 Nov.

Staff Travel

Travel within India

Period	Staff name(s)	Organization/ Location	State(s)/ Region	Purpose
4-13 Jul	Raju, P.S.S.		Karnataka	To collect pigeonpea district data
7-9 Jul	Mohan Rao, Y.	Aurepally, Dokur	Andhra Pradesh	To collect data for CPR project
7-9 Jul	Nageswara Rao, G.D.	Aurepally, Dokur	Andhra Pradesh	To collect data for CPR project
14-15 Jul	Kelley, T.G.		New Delhi	To review the Ford Project
18-23 Jul	Bantilan, M.C.S. Joshi, P.K. Chopde, V.K.	Various	Maharashtra	Impact assessment
19-22 Jul	Mohan Rao, Y. Nageswara Rao, G.D.	Aurepally	Andhra Pradesh	To collect data for CPR project
25-27 Jul	Ladole, V.B.	Shirapur	Maharashtra	To assist Anjini in village survey
26-28 Jul	Mohan Rao, Y. Nageswara Rao, G.D.	Nizamabad	Andhra Pradesh	To collect information for REIA project
1-6 Aug	Parthasarathy Rao, P.	Bijapur, Bagalkot	Karnataka	Pre-test and taluka data for village selection and surveys
2-6 Aug	Mohan Rao, Y. Nageswar Rao, G.D.	Mahabubnagar Kurnool	Andhra Pradesh	To collect information for REIA project
8-9 Aug	Raju, P.S.S.	Aurepally	Andhra Pradesh	To study cropping groups
16-18 Aug	Mohan Rao, Y.	Aurepally	Andhra Pradesh	To collect information from cropping groups
26 Aug-7 Sep	Arif Ali, Md.		Rajasthan	Mid-season evaluation of pearl millet trials
28 Aug-3 Sep	Ladole, V.B. Chopde, V.K.	Various	Maharashtra	Adoption and impact survey of ICP 8863
5-7 Sep	Nageswara Rao, G.D.	Aurepally	Andhra Pradesh	To collect information on soil water conservation
8-23 Sep	Kerr, J.M.	Various	Rajasthan	Data collection
18 Sep-1 Oct	Arif Ali, Md.		Rajasthan	On-farm pearl millet trials

Contd.

Travel within India Contd..

Period	Staff name(s)	Organization/ Location	State(s)/ Region	Purpose
19-22 Sep	Asokan, M.	Various	Karnataka	Pigeonpea adoption survey
19-30 Sep	Raju, P.S.S.	Various	Karnataka	Pigeonpea adoption survey and impact study
23-28 Sep	Joshi, P.K.	Pune	Maharashtra	To visit demonstration plots
24 Sep-8 Oct	Whitaker, M.L.		Rajasthan	On-farm pearl millet trials
26-27 Sep	Asokan, M.	Bachannapet	Andhra Pradesh	To collect information for REIA project
26-30 Sep	Valasayya, S. Nageswara Rao, G.D. Mohan Rao, Y.	Various	Andhra Pradesh	To collect information for REIA project
27-30 Sep	Kerr, J.M.	Bangalore	Karnataka	Winrock work

Travel outside India

Period	Staff name	Organization/ Location	Country	Purpose
10 Aug-30 Sep	Kerr, J.M.	Winrock Intl.	USA	Winrock work

Visitors

Period	Name of visitor(s)	Organization[1]/ Location	Country	Purpose
5 Sep	Tyagi, N.K. Chaudhary, T.N.	CSSRI ICAR	India	Field visit
20 Sep	Almeida, Joel	WHO	India	SEPD research activities

1. CSSRI = Central Soil Salinity Research Institute, ICAR = Indian Council of Agricultural Research, WHO = World Health Organization.

Research Support

Farm and Engineering Services Program

General

The major activities during the quarter were the 1994 rainy-season sowing, post-sowing operations including interculture, irrigation, pest surveillance, and plant protection, and maintenance of facilities and equipment. Rain started on time in June (rainfall:144 mm) and the cumulative rainfall until September end was 550 mm as against 673 mm of the average rainfall. Only 66 mm rain was received in September which necessitated frequent irrigations to the rainy-season crops. Solar radiation was less in the month of July and August compared to long-term average solar radiation.

Operation and Services

General and Mechanical Engineering Services

A total of 365 work orders (WO) and 2633 maintenance requests (MR) were completed during the period as shown below:

General Engineering Services			Mechanical Engineering Services		
Unit	WO	MR	Unit	WO	MR
Air Conditioning	19	106	Fabrication	66	132
Carpentry	85	283	Heavy & Farm Machinery	31	366
Civil	16	37	Auto	31	352
Electronics and Instrumentation	48	531	Tyre	0	300
Electrical	58	389			
Plumbing	8	114			
Design and Development	3	2			
Janitorial	0	21			
Total	237	1483	Total	128	1150

General Engineering Services

- Nonfiltered waterline to Bldg. 308 root wash area in place of cold waterline, installation of tele-conference facility in our EPABX with four special instruments, one-half of GRD screenhouse, communication center at ISRC, shower facility at Bldg. 309 gents toilet, increasing wall height of security check post at ISRC, installation of refrigerated illuminated incubator shaker for CPD (Legume Pathology), dewatering and cleaning silt and debris from underground tanks of Bldgs. 400 and 810 were completed.
- Periodic preventive maintenance of seed dryers and boilers at Bldg. 308 and Manmool, printers, UPS, photocopiers, telephone exchange, spray pool, boiler, filtration plant, gasline, cold waterline for OSSH, hydropneumatic system at Bldg. 400, sluice valve and vertical turbine pumps at bldgs. 400 and 802 were completed.
- Providing lighting facility for photoperiod experiment in the field RP 17, electrical maintenance of three greenhouses, and breakdown maintenance of water supply were completed.

Mechanical Engineering Services

- Servicing of 88 buses, 10 tractors, 18 threshers, and 33 other machines such as fork lift truck, generators, dumpers, dozer, crane, graders, sprayers, and engines were completed.
- Fabrication and repair of rain-out shelters, fabrication of pheromone traps, ramp for linear irrigation boom, safety flap for peanut thresher, were completed.
- Servicing and repair of lake pumps, lawn movers, sprayers for CPD, soil augers and auger pullers, land leveller and other miscellaneous jobs were completed.
- Modification of one flail shredder for improved operational efficiency was done.

Warehouse

Six hundred and ten requests for city IRS houses for various jobs were attended.

Farm Services

Farm Machinery

Eighty-nine hectares of the 1994 rainy-season experiments were sown in June. An area of 65.3 ha was sown in July (30.0 ha), August (5.9 ha), and September (29.4 ha). Top dressing, intercultivation, initial land preparation of the 1994/95 postrainy season crops, especially for chickpea, for control of weeds and moisture conservation, sowing of cover crops and seasonal maintenance of seed drying facilities and seed processing equipment were taken up during the period. A total of 5849 machine hours were used and 1133 requests were attended for various farm operations during the period as under:

Operation	No. of requests	Operation	No. of requests
Tillage	453	Plant protection	215
Harvest & postharvest	114	Landscaping	2
Irrigation	131		
Labor operations	218		

Pest Surveillance and Plant Protection

Insect pests and weeds were regularly monitored and timely measures were taken to minimize infestation. A total of 435.5 ha (cropped area x no. of sprays) were sprayed to control pests. Infestations of stem borer on sorghum during July, aphids on sorghum during July and August, leaf miner on groundnut during July, *Helicoverpa* and *Spodoptera* larvae on groundnut during August were high. Low incidence of shoot fly and *Mythimna* on sorghum, thrips, and aphids on groundnut, leaf webber and bristle beetle on pigeonpea were observed during the period. However, *Helicoverpa* incidence on pigeonpea increased during September. *Helicoverpa* incidence on *Lagascea* was low during the period.

Greenhouses were regularly monitored and timely pest control operations were undertaken. Chemical spraying for mites and other insect control measures were undertaken at the end of close season for each of the three greenhouses. Rodent control in laboratories and campus building were taken up as a routine operation.

Pre and postemergence herbicides were applied on 68.4 ha. Groundnut (23.0 ha) received maximum herbicide application followed by pigeonpea (20.6 ha) and sorghum (15.6 ha).

Helicoverpa daily adult population was recorded on nine traps fixed at different points on the farm. An average of 5 adults in mid July, 13 in last week of August, and 17 again in last week of September were trapped.

Irrigation, Labor, and Farm Maintenance

A total of 200.2 ha (cropped area x no. of irrigations) of cropped area was irrigated. Most of the irrigations were applied in September, when only 66 mm rain was received. A total of 9455 TFL person-days was used for various manual farm operations. Weeding constituted 65.3% of TFL person-days used. The other operations included birdscaring, gypsum application, volunteer removal, and irrigation, etc. Pigeonpea required an average of 67.0 TFL person-days followed by 65.8 for groundnut, and 45.3 for sorghum. An average of 72.4 TFL person-days were used for birdscaring operation for pearl millet and sorghum. A total of 365.3 ha was chopped to maintain the farm.

Farm Development, Farm Structure, and Landscaping

Repair and maintenance of underground irrigation system, culverts, waterways, roads, fence and other farm facilities, and other structures were carried out. ICRISAT Lake was deepened and its spillway height was raised by 0.25 m to increase its water storage capacity.

Greenhouse and Controlled Environment (GCE) Facilities

GCE facilities were maintained and services were provided for 77 experiments in greenhouses, 3 in plant-growth chambers, 12 on pot-culture areas, and 6 in plastic houses. Various equipments were used for 1845 h to provide services to various experiments and supply demineralized water to laboratories. Annual maintenance of all installations and insect sanitation was completed on three greenhouses. After completion of glazing of the greenhouse no.2, experiments of the greenhouses 2 and 4 were relocated. Trial modification for covering insect drain on the greenhouse # 2 was initiated to collect rain water without debris, grass and algae. Automatic diversion system to rain-water sump for rain water from greenhouse roofs was completed and it is working satisfactorily.

Development Jobs

- Modification of a flail shredder for better operational efficiency, safety flap on feed hopper of one peanut thresher and energy saving device for H&FS were completed.
- An automatic device to divert rain water collected from greenhouses roof to rain-water sump was developed which worked satisfactorily during the last phase of rainy period.
- ICRISAT Lake was deepened to increase its storage capacity and its spill way height was also increased by 0.25 m for the same purpose.

Quality Improvement and Cost Reduction

- Root wash area in CWA 308 was provided with nonfiltered waterline instead of cold water line to conserve treated water.
- In-house cable jointing job at chiller plant pond was done.
- Imported electrical switch combination was replaced with indigenous one to save on cost and improve maintenance quality.
- Modification on insect trap on the greenhouse no. 2 was initiated to cover it and facilitate clean rain-water collection.

Plant Quarantine Unit

Exchange of Seed and Other Products

During the quarter we assisted the Plant Quarantine Regional Station of the National Bureau of Plant Genetic Resources (NBPGR) in clearing 15 674 seed samples of our mandate crops for export to 40 countries. The seed samples comprised of various international trials for multilocational testing, breeding lines, and germplasm accessions.

NBPGR released 1289 accessions of imported seeds (seedlings in case of groundnut) after growing them in the Plant Quarantine Isolation Area (PEQIA) for utilization by ICRISAT.

Crop-wise details of seed samples exchanged through IAC and NBPGR during the quarter include:

Crop	Exports (from IAC)	Imports (through NBPGR)
Sorghum	2 859	565
Pearl millet	252	180
Chickpea	11 408[1]	-
Pigeonpea	186	290
Groundnut	969	221
Minor millets	-	33
Total	15 674	1 289

1. Mostly consisted of international trials for multilocational testing.

The samples exported to different countries, in addition to seeds for sowing purpose include:

- One seed sample of groundnut to UK for laboratory studies;
- Five hundred and fifty-one samples of chickpea grain ground powder, stover, linseed grain, and stover to Austria for ^{15}N analysis;
- Five soil samples to Germany for mycorrhizal studies;
- Seventy samples of nodules of soybean, pigeonpea, black gram, and green gram to Japan; and
- Thirty *Rhizobium* strains of chickpea and groundnut to Japan, Kenya, Sri Lanka, Uganda, and Vietnam.

Seed Health Testing Studies

Four seed samples of pigeonpea and 30 of groundnut infested with storage insect pests were salvaged.

Twenty-five seed samples of sorghum, 2 of pearl millet, 79 of chickpea, 27 of pigeonpea, and 25 seed samples of groundnut were detained by NBPGR due to pathological reasons.

Greenhouse Activities

The two non-mandate crop species of ICRISAT, mung bean (2 accessions from Philippines) and soybean (3 from Vietnam, and 4 from China) and groundnut (4 from Vietnam and 1 from Malaysia) imported into the country were sown in PQU greenhouse. These accessions are needed by a crop physiologist at IAC to demonstrate their biological nitrogen fixing abilities to the participants of the International Atomic Energy Agency's sponsored workshop proposed to be held at IAC in the 2nd week of November 1994. Some 102 accessions of wild *Arachis* spp from Brazil were released by NBPGR as 4-week seedlings. These were transplanted in pots in the greenhouse no. 6, bay no. 3 and will be jointly inspected by NBPGR and PQU staff for 3 months before they are released to the concerned scientist.

Post-Entry Quarantine Isolation Area (PEQIA)

The following activities were undertaken during this quarter:

- Weekly surveillance of standing crops of sorghum, pearl millet, pigeonpea and wild relatives of *Cajanus*, and groundnut jointly by scientists of NBPGR and ICRISAT;
- Plant protection measures against *Helicoverpa* in pigeonpea; *Spodoptera*, leaf hopper, and thrips in groundnut; and shoot fly in sorghum;
- Harvesting of groundnut from Brazil (26 accessions), USA (5), Uganda (2), and Pakistan (2); and pearl millet from Zimbabwe (238) was completed and healthy seeds released to the concerned scientists;
- Refreshing of vacant fields and other clean-up operations with the help of FESP staff;

Sowing of imported seed consignments of mandate crops in PEQIA are presented in **Table 1**.

Table 1. Details of sowing of different crop species in the post-entry Quarantine Isolation Area, ICRISAT Asia Center, Jul-Sep 1994.

Crop	Consignee	Country	No. of seed samples	Date of sowing	Field number
Pearl millet	KNR	USA	200	7 Jul	Q01 A1
Pigeonpea	LS	Kenya	19	7 Jul	Q01 A1
Groundnut (as seedlings)	OPR	Vietnam, Malaysia	5	26 Jul	Q01 A1
Groundnut (as seedlings)	MHM, RCNR	Brazil, Niger	111 3	31 Aug	Q01 A2
Sorghum	FRB	USA	18	2 Sep	Q01 A2
Sorghum	FRB	USA	4	2 Sep	Q01 A2
Sorghum	FRB	USA	99	2 Sep	Q01 A2
Sorghum	FRB	Mali	19	2 Sep	Q01 A2
Sorghum	GAS	Sudan	3	15 Sep	Q01 C1
Sorghum	SAR	Uganda	131	15 Sep	Q01 C1
Sorghum	SAR	USA	115	15 Sep	Q01 C1
Sorghum	SAR	Uganda	69	15 Sep	Q01 C1
Pigeonpea	PR	Uganda	32	8 Sep	Q01 A2
Pigeonpea	PR	South Africa	22	8 Sep	Q01 A2
Rhyncosia spp	PR	Australia	250	15 Sep	Q01 E2
Finger millet	SAR	Uganda	47	15 Sep	Q01 C1
Finger millet	SAR	Uganda	33	15 Sep	Q01 C1
Pearl millet	SAR	Uganda	5	15 Sep	Q01 C1

1. FRB = F.R. Bidinger, GAS = G. Alagarswamy, KNR = K.N. Rai, LS = Laxman Singh, MHM = M.H. Mengesha, OPR = O.P. Rupela, PR = P. Remanandan, RCNR = R.C. Nageswara Rao, SAR = S. Appa Rao.

Geographic Information Systems

AEZ map of India was prepared for SEPD with the district map of India overlaid on it. The percentage of respective AEZ's in each district was calculated using GIS and Dbase.

ATLAS GIS was loaded in our machine by FESP to help transfer some of their database files to arc/info. Since the software was only partially loaded the import/export components were not available to do the file conversions. However we were able to print the database maps in our designjet 650cc plotter through serial port.

Maps of West, central, southern and eastern Africa; South and South-east Asia; China; and Korea were plotted with country names for the use of DDG's office.

A global map showing *Sclerotium rolfsii* induced stem and pod rots in groundnut was made for CPD. Distribution of nematodes in Uttar Pradesh was also plotted for CPD (Nematology). A training course on Digitization and plotting of maps for 19 members from various research divisions was organized from 12-19 Sep 1994. The results obtained were very encouraging and we plan to hold such training courses in future. We are presently attempting to characterize district-wise production systems for India. We hope to complete the draft report by the end of November 1994.

Visitors

Period	Name of visitor(s)	Organization[1]/ Location	Country(s)	Unit visited/ Impression about the Unit
Farm and Engineering Services Program				
12 Jul	Shukla	Central Insecticide Lab.	India	Plant Protection
12 Jul	Pawan Kumar, S. Murali, K.J.	Battliboy & Co., Madras	India	Mech & Eng. Services
22 Jul	Fariduddin Mia	BARI, Dacca	Bangladesh	Mech & Eng. Services
18 Aug	18 officer-trainees	NPPTI	India	Plant Protection
22 Aug	Baba Shree	Entomologist	Nepal	Plant Protection
26 Aug	Nelson Mathew	Glascow University, Scotland	UK	Plant Protection
08 Aug	Ramakrishna, C. David, P.S.	J.K. Industries, Bangalore	India	Mech & Eng. Services
19 Aug	Nageshwar Rao Ramaiah, N.C.	Tribology India Ltd., Hyderabad	India	Mech & Eng. Services
22 Sep	Gupta, S.C. and three colleagues	Ballarpur Industries Ltd., Bangalore	India	Tillage, irrigation, and GCE
07 Sep	Thirty students	Govt. Polytechnic, Hyderabad	India	Mech & Eng. Services
15 Sep	Sarada Devi, D.	Western Insulation Hyderabad	India	Mech & Eng. Services
Plant Quarantine Unit				
27 Jul	Demski, J.W.	Univ. of Georgia Griffin, GA	USA	I am very impressed with the thorough operation, both the work and the people
12 Aug	Pradhan, S.B.	NARC	Nepal	Very much impressed with work facilities and with people
18 Aug	Masato Fukushima	Embassy of Japan in India	India	I am greatly impressed with the work here

1. BARI = Bangladesh Agricultural Research Institute, NARC = Nepal Agricultural Research council, NPPTI = National Plant Protection Training Institute.

Technology Exchange

Sorghum

Adoption of ICSV 745 and ICSV 112 in Andhra Pradesh

An earlier survey conducted in November 1993 revealed that about 93% of sample farmers who sowed ICSV 745 and ICSV 112 in Warangal District of Andhra Pradesh were convinced of their performance. The grain characteristics most liked by them, ranked in the order of importance are: 1) easy threshability, 2) high yield, 3) large panicles, and 4) white grain. Respondents overwhelmingly expressed their willingness to continue this technology in the future. In fact, 92% of sample farmers predicted to increase their present area under these two varieties by 41.4% in the 1994 rainy season.

To confirm farmers' adoption expectations in the 1994 rainy season, we undertook a supplementary survey in September this year which covered a sub-sample of 125 respondents in two of the eight study villages (Bachannapet and Pochannapet). The follow-up interviews indicated that farmers' expectations last year regarding these two varieties were not met partly due to pre-harvest rains and consequent grain molds. This aggravated the low market potential for these varieties.

Pearl Millet

On-farm Trials in Rajasthan, India

In order to evaluate preferences in a wider range of western Rajasthan environments, additional sites than the 1993 season were included in Churru (Krejada), northwest Jodhpur (Malunga), eastern Jodhpur (Chandella), and eastern Barmer (Samdari) districts.

Twenty farmers participated at each location (five farmers per genotype). The genotypes used this year represent the following range of characteristics:

HHB 67	:	very early grain type
West Raj	:	improved Rajasthan population
CZ-IC 912	:	high fodder
89111AxTCP	:	very high tillering and drought resistant

In each of the new villages, a village investigator was chosen and trained. A household census was taken, which formed the basis for selection of participating farmers.

In addition to the on-farm preference studies, varietal demonstrations and fertilizer trials were conducted at the KVK farm at Bharka, Barmer. The purpose was to evaluate the performance of the genetic material and the fertilizer strategies in the Barmer environment, and to assess farmers' responses through group visits by farmers prior to harvest.

Chickpea

International Trials and Nurseries

Results of international trials/nurseries received from 80 cooperators were analyzed and tabulated, and selections were made for constituting the nurseries for 1994/95. The seeds of such entries were cleared and prepared for despatch. The seed requests for other materials, such as germplasm, advanced breeding lines, segregating populations etc., were also met. Details of various trials/nurseries and other materials supplied to cooperators are presented in a table under "Seed Exchange" in page 125.

A brief report of the Nineteenth International Chickpea Trials and Nurseries organized by ICRISAT was prepared and distributed at the Annual Rabi Pulses Workshop of AICPIP held at Bikaner, 15-18 September.

Transfer of Information and Technology

The ICRISAT chickpea cultivars have become popular with farmers in several countries and it is getting difficult to meet all the seed requests. ICCC 37, ICCV 2, ICCV 10, and ICCV 88202 are in great demand in Andhra Pradesh, Maharashtra, and Gujarat in India and also in Myanmar. We could meet these requests only partially and were able to supply 320 kg of ICCV 2, 710 kg of ICCV 10, 138 kg of ICCC 37, 200 kg of ICCV 88202, and 150 kg of ICCC 42. We also supplied 90 kg seed of ICCV 93122, a line resistant to pod borer and soilborne diseases, for on-station and on-farm trials in Andhra Pradesh.

Collaborative Activities with Asian NARS

Consultancy with the Crop Diversification Programme (CPD) of CIDA in Bangladesh

Dr Jagdish Kumar was invited to review Pulses research for 1993/94 and plan experiments for 1994/95 by the Crop Diversification Programme of CIDA in Bangladesh during 3 Jul to 4 Sep 1994. This consultancy was in continuation of his earlier assignments since 1991. He participated in BARI Pulses and Oilseed Reviews and helped in developing plans and CDP budgets for 1994/95.

Of particular interest to ICRISAT is the increased emphasis for chickpea, pigeonpea, and groundnut research and extension of chickpea in the Barind region. Good results were obtained in the development of disease-resistant materials, particularly with botrytis gray mold (BGM) field screening. A mist-system for creating humidity in the field was installed with CDP support. This facility is now being used for BARI-ICRISAT collaborative BGM studies.

Three new promising lines of chickpea ICCL 85222, ICCL 83149, and RBH 228 were found superior in seed yield to local varieties. These have fusarium wilt resistance and have relatively larger seed size. The draft proposals for release of these as varieties were left with BARI for submission to the Bangladesh National Seed Board.

Two groundnut promising lines ICG(E) 11 and ICG(E) 55 developed with ICRISAT collaboration are in the pipeline for release by BARI in 1995.

In his earlier consultancy Dr Jagdish Kumar had proposed a National Workshop on Pulses in Bangladesh in 1995. CIDA has approved a budget of CDN $30 000 (1 US$ = 1.35 CDN). ICRISAT may be invited to participate.

Chickpea in Barind Region

Bangladesh and ICRISAT collaborate in the extension of chickpea in rice fallows in Barind region of Bangladesh. The data presented during the Pulses Research Reviews indicated that the area sown to this crop increased nearly

three fold in 1993/94 over that of 1992/93. This increase was attributed to availability of good seed particularly Nabin, a chickpea variety released with ICRISAT collaboration and efforts of the CDP.

Varietal release

FLIP 86-5C was identified for release for commercial cultivation in low rainfall areas of Syria. This line has a seed size of over 45 g 100 seeds^{-1} and thus will meet a long demand from the farmers for large-seeded chickpea.

FLIP 86-5C was also identified for on-farm testing and release in Iraq. Under their conditions, this line was proved to be high yielding besides having large seed.

A report from Myanmar indicates that ICCV 2 and ICCC 42 have been released to the farmers, although a formal notification has yet to be issued.

Bangladesh Institute of Nuclear Agriculture (BINA), released a chickpea variety BINA SOLA 2. This entry ICC 4998 was supplied as part of ICRISAT coordinated trial (ICCT-DL) to BINA.

Pigeonpea

On-farm Trials

Drs Laxman Singh, M.V. Reddy, and T.G. Shanower visited on-farm trials in Warangal District in the northern Telangana region of Andhra Pradesh. Three short-duration pigeonpea lines (ICPLs 85010, 84031, and 88034) are being tested in the prevalent cropping systems and are being compared with other rainy season crops. Good plant stand was noticed in most trials. Some plots at Pallagutta and Macherla were partly waterlogged.

The seed plots of 0.2-0.3 ha each of ICPL 85010 were in good condition at Mr Y. Ramachandra Rao's farm at Alia (sown on 8 Jul '94) and Dr Prasad's farm at Ghanpur (sown on 16 Aug '94).

On-station trials on cropping systems and varietal evaluation at the Agricultural Research Station (ARS), Warangal were also monitored. The cropping systems trial sown on 18 Jun had four each rainy-season crops to be followed by postrainy-season crops. It was disappointing to note that pigeonpea in this trial had been sprayed thrice (Jul 18, Jul 28, and Aug 9) including the one at flowering on 9 Aug. It was pointed out that prior to flowering, pigeonpea does not require insecticides. The insecticides had been applied for leaf webbers and thrips. Blister beetle was also a problem at this time.

The salient observations and aspects of discussions with the farmers and scientists were:

- Two farmers sprayed insecticide on the crop, in spite of clear instructions not to spray till 50% flowering/early podding is achieved. Farmers are accustomed to spraying cotton weekly, beginning 10 days after sowing. Need for judicious use of insecticides was explained.

  A considerable amount of on-farm education for proper use of insecticides is essential. NARS scientists decided to hold a Field Day at two sites in cooperation with the Department of Agriculture to acquaint with on-farm research and insect pest management.
- The field books (English and Telugu) were provided to each farmer and scientist by Dr M.V. Reddy during first week of September. Data recording and direct monitoring of above trials will be done by Dr C. Cheralu and his associates.
- The need for judicious use of insecticides at the research station was also emphasized.

Seed supply

Twelve sets of international trials were supplied within India. In addition, 128 samples including 21 released varieties, 46 advanced lines, 6 hybrids, 9 male steriles, 26 segregating materials, 12 germplasm accessions, and 8 others were supplied to 7 countries during this period.

Groundnut

The use of weather-disease relationships to advise on chemical control of foliar diseases

On-station trials

Experiments to test our weather-based scheme to advise on fungicide control of leaf spots are being carried our at three sites: Dryland Farming Agriculture Research Station (DFARS), Anantapur; Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad; and IAC, Patancheru. Automatic weather stations with leaf wetness sensors are being operated at all sites and, in the nonsprayed plots, detailed disease assessments are being carried out weekly to provide information on natural disease development.

On-farm trials

Together with entomologists from CPD, we are carrying out collaborative on-farm trials to evaluate the feasibility of weather-based forecasting scheme to advise on fungicide control of leaf spots in the Gudipadu National Watershed, Kurnool District, Andhra Pradesh with the staff of the Agricultural Research Station at Anantapur. In this site it is not feasible to use leaf wetness sensors, so we have provided our collaborators with a "user-friendly" program to estimate leaf wetness periods from daily temperature and humidity readings. The leaf wetness values are needed to compute the cumulative leaf wetness index crucial to the weather-based forecasting scheme.

Varietal release

ICG 273, a groundnut accession sent to Ethiopia from ICRISAT in the early 1980s, has now been officially released in Ethiopia. It is a landrace originally from Argentina, and was sent to ICRISAT by the North Carolina State University, USA, under the pedigree name PI 121520. The cultivar is short-to-medium-duration, and gives a pod yield of 3.2 t ha^{-1} under irrigated conditions.

Research Evaluation and Impact Assessment

Niches of ICPL 87 in two SAT States of India

ICPL 87, a short-duration variety released as "Pragati" in central India in 1986, has found niches in Western and Marathwada regions of Maharashtra covering the districts of Ahmednagar, Dhule, Nasik, Pune, Solapur, Jalgaon, Osmanabad, Latur, Beed, Aurangabad and Jalna. Sales of ICPL 87 seeds by the Maharashtra State Seeds Corporation (MSSC) have risen significantly from 13.2 t in 1987 to 1003.5 t in 1994.

ICPL 87, which is mostly grown as a sole crop, has found its way mostly in drought-prone areas where rainfall averages around 600 mm in medium deep-black and well-drained soils. The variety has found its niche in the fallow lands and in crop rotation with sugarcane; it has mostly replaced the pearl millet and minor millets in sugarcane-growing areas of western Maharashtra.

ICPL 87 is also finding increasing acceptance by farmers in northern Karnataka covering the districts of Gulbarga and Bidar where seed sales of this variety was 17.3 t in 1993.

Success of ICP 8863 (Maruti) in Peninsular India

Large-scale adoption of ICP 8863 among farmers in the wilt-endemic areas of Karnataka, Maharashtra, and Andhra Pradesh is confirmed in recent reconnaissance surveys by the Research Evaluation and Impact Assessment (REIA) team of ICRISAT.

ICP 8863, more popularly known to farmers as "Maruti", is a wilt-resistant medium-duration pigeonpea released in Karnataka in 1986. It now dominates the large pigeonpea tracts of Karnataka covering the districts of Gulbarga, Bidar, Dharwar, Belgaum, Bijapur, Raichur, Bellary, and Mysore. While the sale of Maruti seeds by the Karnataka State Seeds Corporation (KSSC) increased significantly from 49 t in 1990 to 140 t in 1994, the KSSC reports that it supplies only 14.7% of total seed used by farmers across the state; seed production and distribution among farmers remain to be the main source of Maruti seeds. Reports of subject matter specialists of the various Principal Agriculture Offices of the Ministry of Agriculture in this state indicate that about 116 120 ha area was sown under Maruti in the eight major pigeonpea-growing districts of Karnataka.

Cereals and Legumes Asia Network

General

The first CLAN Advisory Committee Meeting was held on 18 Aug 1994 to review network activities, and provide guidance for future activities.

As per the recommendations of the CLAN Consultative Meeting held in October 1993, the half-yearly progress report (Jan-Jun 1994) of CLAN was sent to all the CLAN Country Coordinators for their information, and for receiving feedback and suggestions for future network activities. Responses from Country Coordinators are being received. The report was also sent to 930 CLAN cooperators to keep them updated on the network activities. A few cooperators have responded and requested for additional information and publications.

ICRISAT was given the responsibility of executing the Asian Grain Legumes On-farm Research (AGLOR) as a part of the FAO/RAS/89/040 Project activity. One of the objectives of the AGLOR project was to share the information and technology among all the member countries of the RAS Project. CLAN/ICRISAT was requested to produce a video on AGLOR activities for exchanging research methodologies with other member countries. This video has now been produced with the help of IMEP/ICRISAT and staff of AGLOR Project countries. The video is now being distributed to the member countries of FAO/RAS/89/040 project and to the donors (UNDP/FAO).

Sorghum Working Groups

The Asian Sorghum Researchers' Consultative Meeting held during Sep 1993 had recommended the formation of Working Groups for collaborative research. The following Working Groups were proposed and the Technical Coordinators identified:

Working Group	Technical Coordinator
Drought	H.F.W. Rattunde (Genetic Enhancement Division, IAC)
Shoot pests	H.C. Sharma (Crop Protection Division, IAC)
Grain mold	J.W. Stenhouse (Genetic Enhancement Division, IAC)
Forage sorghum	G.P. Lodhi (C.C.S. Haryana Agricultural University, Hisar, India)

The technical coordinators were requested to prepare tentative work plans for each working group. In addition to the above Working Groups, a 'Study Group' (lead by Umaid Singh and T.G. Kelley, of IAC was formed to prepare a status report and work plan on alternative uses of sorghum.

The proposed work plans for the working groups, and the status report of the study group on alternative uses of sorghum have been sent to all sorghum scientists (on CLAN database) for comments and suggestions for collaborative research.

Workshops and Meetings

Review and Work Plan Meeting, 1-2 Jul 1994, Beijing, China

A meeting was held at the Chinese Academy of Agricultural Sciences (CAAS), Beijing to review activities of the previous work plan (1992-94) and to finalize the work plan for collaborative research during 1994-96. The new work plan (1994-96) was signed by the President of CAAS and the Director General of ICRISAT on 2 July.

Third Groundnut Bacterial Wilt Working Group Meeting, 4-5 Jul 1994, Wuhan, China

The Third Working Group Meeting on groundnut bacterial wilt was organized during 4-5 Jul 1994 at the Oil Crops Research Institute, Wuhan, China. The meeting was co-sponsored by CAAS, Beijing and ICRISAT. The Vice-President of CAAS Prof. Liang Keyong inaugurated the meeting, and ICRISAT's Dy. Director General Dr Y.L. Nene described meeting objectives. The keynote address was delivered by ICRISAT Director General, Dr J.G. Ryan. Thirty-nine participants from different institutions in China, Australia, Indonesia, Malaysia, Thailand, Vietnam, United Kingdom, FAO/RAPA, and ICRISAT participated in the meeting.

Participating working group members presented results of the research on bacterial wilt pathogen (*Pseudomonas solanacearum*), its detection and diagnosis using both conventional and molecular techniques, progress in host-plant resistance, cultural control, and biological control of the disease. After review of the research conducted, the group discussed future needs and priorities for research. The following major items of Work Plans were identified:

- Production of monoclonal antibodies specific to *P. solanacearum* and improvements in the use of molecular techniques (e.g., PCR) for detection of pathogen.
- Documentation and collection of virulent isolates for research.
- Establishing an international groundnut bacterial wilt nursery.
- Bacterial wilt management through improved farming practices, biological control, and host-plant resistance.
- Training in different aspects of bacterial wilt research.

Consultative Group Meeting on Cytoplasmic Male Sterility (CMS) in Pigeonpea, 26-27 Jul 1994, ICRISAT Asia Center

The meeting was organized to review current research on CMS in pigeonpea, develop research strategies to achieve viable CMS systems, and establish a collaborative work plan for future research endeavors. Eight scientists from different universities and research institutes in India and 15 ICRISAT scientists reviewed past research, present status, and the proposed plans for future research on CMS in pigeonpea. The following priority issues were identified for future research:

- Characterization of available CMS sources using cytological, DNA markers, and field testing;
- Identification and testing for stability of new cytoplasmic sources.

IAC scientists were requested to coordinate activities of this new working group.

Consultation with NARS on ICRISAT Project Formulation, Sep 1994

As a part of its Medium Term Plan (MTP) project formulation, ICRISAT had interacted with the national programs to identify priority constraints and research opportunities. A consultation meeting with senior research administrators from Asian NARS was held during 9-10 Jun 1994 at IAC. The NARS research administrators had suggested that this consultation should continue with scientists in the national programs for their input in project formulation. Accordingly, several meetings were organized in Asian countries during Sep 1994 to discuss the proposed projects, to get suggestions, and feedback on the relevance of projects to our partners as given below.

Country	Projects	Particulars
India	Sorghum	5-6 Sep 1994, NRCS, Rajendranagar, Hyderabad
	Pearl Millet	By correspondence with concerned scientists. Meeting proposed for a latter date.
	Chickpea and pigeonpea and systems Project 4	15-18 Sep 1994, Bikaner (during the All-India Rabi Pulses Group Meeting)
	Systems Project 1	Second week of Sep 1994, discussion during ICRISAT staff visit to Fatehpur and Jodhpur
	Systems Project 2	27 Sep 1994, CRIDA, Hyderabad
	Systems Project 3	21 Sep 1994, CRIDA, Hyderabad
	Economics Project	Second week of Oct 1994, discussions during ICRISAT staff visits to concerned institutions
Bangladesh	All concerned projects	22 Sep 1994, BARI, Joydebpur
Nepal	All concerned projects	20 Sep 1994, NARC, Kathmandu
Thailand	All concerned projects	20 Sep 1994, FCRI, Bangkok
Myanmar	All concerned projects	27 Sep 1994, MAS, Yangon
Vietnam	All concerned projects	21 Sep 1994, MAFI, Hanoi
Indonesia	All concerned projects	22 Sep 1994, CRIFC, Bogor
Pakistan	All concerned projects	Planned for 21-22 Sep 1994 (since postponed to late Oct 1994)

Feedback, comments, and suggestions from NARS scientists at these meetings have been forwarded to concerned project team leaders at IAC for incorporation in revised project planning documents.

Monitoring Tours

Monitoring of AGLOR Groundnut Trials, Nepal, 24 Sep–2 Oct 1994

The on-farm research (OFR) trials on groundnut in six districts of Nepal—Sarlahi, Siraha, Dhanusha, Mohattari, Nawalparasi, and Routahat were monitored jointly by a multidisciplinary group of scientists from the Oilseeds Research Program (ORP), District Agricultural Development Officers of the concerned districts, and ICRISAT. The improved production package (further divided into 'low input' and 'high input') was compared with farmers' practices on 1 katha each (333 m^2) to analyze and assess the economic advantage of improved practices over farmers' practices.

The trials were well managed with minimal problems of insect and diseases. Groundnut growth including podding appeared better in high-input and low-input production practices over farmers' practice. Farmers' Days are to be held at selected locations in each district. A traveling seminar was organized during 30 Sep-1 Oct for the Agricultural Development Officers, Crop Production Officers, and other extension personnel of groundnut-producing districts in Nepal.

Sri Lanka Pigeonpea Project

K.B. Saxena joined as Resident Scientist for the Sri Lanka-ADB-ICRISAT Pigeonpea Project (Phase II) on 1 Aug 1994. Plans for the various on-station and on-farm trials, seed multiplication, processing, and training activities were prepared jointly with the concerned staff of the Department of Agriculture.

N. Jayantha, Head of Farm Machinery Training Centre, Maha Illuppallama and Lakshmi Jayasekera, Food Technologist, Soybean Food Technology Centre, Kandy were Visiting Scholars during 23 Aug to 14 Sep 1994 at IAC. They worked at IAC in pre-processing and processing technology for pigeonpea *dhal* making. They also visited the commercial *dhal* mills in Hyderabad, the Central Food Technology Research Institute, Mysore; the agricultural universities at Bangalore and Hyderabad to study various pre-processing and processing research and technology. Mr Jayantha also visited the *dhal* mill manufacturers in Patna to learn about the machines. Necessary material and supplies have been ordered for repairing the existing *dhal*-making machines in Sri Lanka.

Training Activities Related to CLAN

Training Course on Diagnosis and Detection of *Pseudomonas solanacearum* and for Resistance Screening against Groundnut Bacterial Wilt, 6-9 Jul 1994, Wuhan, China

The above training course was co-sponsored by the Chinese Academy of Agricultural Sciences (CAAS), Beijing and ICRISAT. Thirteen scientists from different institutions in China, two from Vietnam, and one each from Malaysia and Thailand attended the training workshop. Resource faculty to the training course included specialists from Australia (1), China (3), Malaysia (1), United Kingdom (3), and ICRISAT (1). The 4-day training workshop included lectures and demonstrations to provide hands-on training on isolation, identification, and differentiation of biovars of *Pseudomonas solanacearum* using conventional techniques, and detection and identification using ELISA, PCR, BACTID, and Biolog techniques. The resource faculty from Australia and UK brought the necessary equipment and reagents to demonstrate the different procedures to the trainees, including use of PC-based software to identify and differentiate the races and biovars of *P. solanacearum*. In addition, inoculation techniques for resistance screening against groundnut bacterial wilt, technologies for isolation and identification of virulent and avirulent cultivars of *P. solanacearum*, and infectivity titration tests were demonstrated. A 1-day field visit to Hong-An county provided an opportunity to the trainees to observe field screening of groundnut for bacterial wilt resistance and on cultural management of the disease. The final test given to the trainees indicated that they have learnt the techniques and they highly appreciated the course.

Human Resource Development

Human resource development participants pertaining to Asia region during this quarter include:

Visiting Scholars

M.P. Thakur (India), S.P. Srivasatava (Nepal), K. Lertprasertrat (Thailand) joined as Visiting Scholars during the period. M.P. Thakur (India), B. Yadav and S.B. Pradhan (Nepal); and T.S.G. Peiris, Lakshmi Jayasekera, and H.M. Nimal Jayantha (Sri Lanka) completed their visiting scholarship during the period. Farid Uddin Mia (Bangladesh) continued his program.

Research Fellows

Himani Bhatnagar and T. Satyanarayana (India) continued their fellowship programs.

Research Scholars

M. Nivedita (21 Jul), T. Rupa Singh (15 Sep), and V. Anita (26 Sep) from India started working as Research Scholars. Five Research Scholars from India (S. Jayanty, D. Nandini, O.P. Jhovar, S. Halim, and N.P.K. Jayawant) and one from Vietnam (Do Thi Dung) completed their program. Five research scholars from India continued their scholarship programs.

In-service Trainees

M.A. Khaleque (Bangladesh), Li Yu (China), Khin Mar Yee (Myanmar), B. Yadav (Nepal), L.A. De Guzman (Philippines), and Tran Thi Trung (Vietnam) continued their 6-month in-service training program which commenced from 22 May 1994.

Staff Travel

Travel by IAC staff to CLAN-member countries other than India

Period	Staff name(s)	Organization[1]/ location	Country	Purpose
25 Jun-12 Jul	Mehan, V.K.	OCRI, Wuhan	China	To participate in the Third Working Group meeting and Training Workshop on Bacterial Wilt of Groundnut
26 Jun-12 Jul	Gowda, C.L.L.	SPRI, Laixi CAAS, Beijing OCRI, Wuhan	China	To participate in work plan signing, visit to the Peanut Research Institute, Shandong, and to attend the Working Group Meeting on Bacterial Wilt of Groundnut
26 Jun-5 Jul	Nene, Y.L.	SPRI, Laixi CAAS, Beijing OCRI, Wuhan	China	To visit the Peanut Research Institute, Shandong and participate in the Working Group Meeting on Bacterial Wilt of Groundnut
26 Jun-12 Jul	Nigam, S.N.	CAAS, Beijing OCRI, Wuhan	China	To discuss a project proposal on groundnut research in China and participate in the Working Group Meeting on Bacterial Wilt of Groundnut
30 Jun-5 Jul	Ryan, J.G.	CAAS, Beijing OCRI, Wuhan	China	To sign work plan with China and participate in the Working Group Meeting on Bacterial Wilt of Groundnut
4 Jul-4 Sep	Kumar, J.	CDP, Dhaka	Bangladesh	Consultancy on pulses breeding and selection
12-19 Sep	Mengesha, M.H.	CAAS, Beijing OCRI, Wuhan	China	To discuss germplasm exchange
18-21 Sep	Haware, M.P. Jain, K.C.	NARC, Kathmandu	Nepal	To consult with Nepalese scientists on ICRISAT project formulation
19-24 Sep	Chauhan, Y.S.	FCRDI, Maha Illuppallama	Sri Lanka	To plan pigeonpea agronomy research activities
20-22 Sep	Stenhouse, J.W. Upadhyay, H.D.	FCRI, Bangkok	Thailand	To consult with Thai scientists on ICRISAT project formulation
21-23 Sep	Reddy, L.J.	CRIFC, Bogor	Indonesia	To consult with Indonesian scientists on ICRISAT project formulation
21-24 Sep	Haware, M.P. Jain, K.C.	BARC, Dhaka	Bangladesh	To consult with Bangladeshi scientists on ICRISAT project formulation

Contd..

Staff Travel. Contd..

Period	Staff name(s)	Organization[1]/ location	Country	Purpose
20-27 Sep	Dwivedi, S.L.	MAFI, Hanoi OPI/IAS, Ho Chi Minh City	Vietnam	To consult with Vietnamese scientists on ICRISAT project formulation
26-28 Sep	Renard, C. Onkar Singh	CARI, Yezin	Myanmar	To consult with Myanma scientists on ICRISAT project formulation
26-30 Sep	Rai, K.N.	Chiang Mai	Thailand	To participate in the Asia and Pacific Seed Association Conference
22 Sep-4 Oct	Ramakrishna, A.	ORP, Nawalpur	Nepal	Monitoring of AGLOR groundnut trials

BARC = Bangladesh Agricultural Research Council, CAAS = Chinese Academy of Agricultural Sciences, CARI = Central Agricultural Research Institute, CDP = Crop Diversification Programme, CRIFC = Central Research Institute for Food Crops, FCRI = Field Crops Research Institute, FCRDI = Field Crops Research and Development Institute, IAS = Institute of Agricultural Science, MAFI = Ministry of Agriculture and Food Industry, NARC = Nepal Agricultural Research Council, OCRI = Oil Crops Research Institute, OPI = Oil Plants Institute, ORP = Oilseeds Research Programme, SPRI = Shandong Peanut Research Institute.

Visitors

Period	Name of visitors(s)	Organization/ Location	Country	Purpose
26 Jul	Demski, J.W.	University of Georgia Griffin	USA	To discuss arrangements for a virus training course and working group meeting on viruses in 1995
29 Aug	Zeigler, R.S.	International Rice Research Institute Manila	Philippines	To discuss ecoregional research initiative, and a training workshop on GIS application in 1995

Training and Fellowships Program

Research Fellows

J.J. Adu-Gyamfi (Ghana), Research Fellow with the GOJ Project in Agronomy Division has concluded his fellowship on 15 Sep 1994. His research study was on the rooting behavior and nitrogen dynamics in sorghum-pigeonpea intercropping on Alfisols.

Eight Research Fellows (**Table 1**) are continuing their studies in different Research Divisions at IAC (5 in CPD, 2 in AD, and 1 in SACD).

Table 1. Research Fellows on board during Jul-Sep 1994.

Name	Country	Research Division	Study area
Susan Cowgill	UK	CPD	Legumes Entomology
Mitsuru Yoshida	Japan	CPD	Legumes Entomology
Himani Bhatnagar	India	CPD	Legumes Pathology
T. Satyanarayana	India	CPD	Legumes Pathology
Ali Nur H. Duale	Somalia	CPD	Cereals Entomology
Erik J. van Oosterom	Holland	AD	Cereals Physiology
Sabine Ditta Golombek	Germany	AD	Legumes Physiology
Bjorn Seeling	Germany	SACD	Soil Fertility

Visiting Scholars

The following eight Visiting Scholars concluded their study programs during this quarter.

Name	Country	Period	Research Division	Study area
T.S.G. Peiris	Sri Lanka	31 Jul-08 Aug	SACD	Agroclimatic data analysis
S.B. Pradhan	Nepal	31 Jul-27 Aug	CPD	IPM in legumes
V.K. Dutta	Nepal	31 Jul-29 Aug	AD	Water-use efficiency in groundnut
Mohamed H.I. El-Bakry	Egypt	16 Aug-24 Sep	GED	Sorghum improvement research
Michael F.A. Saba	Egypt	16 Aug-24 Sep	GED	Sorghum improvement research
Lakshmi Jayasekera	Sri Lanka	22 Aug-14 Sep	CMBD	Pigeonpea processing and utilization
H.M. Nimal Jayantha	Sri Lanka	22 Aug-14 Sep	CMBD	Pigeonpea processing and utilization
M.P. Thakur	India	31 Aug-14 Sep	CPD	Methods of detection of bud necrosis virus

The following nine scientists from different national programs came to take up their study programs in different Research Divisions at IAC during this quarter.

Name	Country	Period of study	Research Division	Study area
,Ketema Belete	Ethiopia	12 weeks from 06 Aug	GED	Sorghum and pearl millet improvement research
Kanoktip Lertpra-sertrat	Thailand	06 weeks from 10 Aug	CPD	Sorghum grain mold resistance screening techniques
Mohamed Saleh Al-Nassiri	Yemen	06 weeks from 26 Aug	CPD	Insect vectors and sorghum diseases
Hazza A.G. Abdulla	Yemen	06 weeks from 26 Aug	GED	Sorghum improvement research
Faozi Nehme Bedwel	Syria	06 weeks from 07 Sep	GED	Sorghum improvement research
Abdel S.E.D. El-Shahawy	Egypt	06 weeks from 10 Sep	GED	Sorghum improvement research
Nabeel Suliman Beig Ahmed	Syria	06 weeks from 14 Sep	CPD	Sorghum shoot fly and stem borer resistance screening
S.P. Srivastava	Nepal	03 weeks from 15 Sep	SACD	Soils and plants analyses
Ibrahim Noreldin Elzein	Sudan	06 weeks from 15 Sep	GED	Breeding for midge and grain mold in sorghum

Research Scholars

Do Thi Dung, a Ph.D. scholar from Vietnam completed her thesis research on genotype and environment interaction on pigeonpea in the Agronomy Division.

O.P. Jhorar, a Ph.D. scholar from the Punjab Agricultural University, India concluded his 2-month study in the Crop Protection Division on crop-environment-disease interactions on ascochyta blight of chickpea.

M.P.K. Jayawant of India, a Ph.D. scholar from the Stanford University, USA completed his research study on changes in cropping patterns and resource-use efficiency in the semi-arid tropics of India in the Socioeconomics and Policy Division.

The following three Ph.D. scholars started their thesis research in different Research Divisions.

Name and University	Country	Date of joining	Research Division	Study area
M. Nivedita Andhra Pradesh Agricultural University (APAU)	India	21 Jul	SACD	Effect of soil structure modification of an Alfisol profile on water storage, deep percolation and solute movement
T. Rupa Singh (Osmania University)	India	15 Sep	SACD	Studies on vesicular arbuscular micorrhizae in pigeonpea
V. Anita (APAU)	India	26 Sep	CPD	Management of whitegrubs as pests of groundnut

Fourteen Research Scholars **(Table 2)** are continuing their degree-related thesis research (11 for Ph.D. and 3 for M.Sc. courses) in different Research Divisions (4 in AD, 3 each in CPD, CMBD, and 1 each in GED/CPD, SACD, and SEPD).

Table 2. Research Scholars on board during Jul-Sep 1994.

Name	Country	Research Division	Degree program	Study are
A.A. Maria Buiel	Holland	CPD	Ph.D.	Legumes Virology
K.G. Kausalya	India	CPD	Ph.D.	Cereals Entomology
C. Prasanna Latha	India	CMBD	Ph.D.	Legumes Cell Biology
S.S.C.M.J. Sastry	India	CPD	Ph.D.	Cereals Pathology
Uma Krishnan	India	CMBD	Ph.D.	Crop Quality
T. Srinivas	India	GED/CPD	Ph.D.	Groundnut Breeding/ Legumes Pathology
Ashok Kumar Chhabra	India	GED	Ph.D.	Millet Breeding
G. Suresh Babu	India	CMBD	M.Tech.	Cereals Cell Biology
K.L.N. Prasad	India	AD	M.Sc.	Legumes Agronomy
O.N. Birgitte	Denmark	SACD	Ph.D.	Soil Fertility
Claudia Sanetra	Germany	AD	M.Sc.	Legumes Agronomy
Barbara R.M. Adolph	Germany	SEPD	Ph.D.	Economics
M.D.Sh. Abdurahman	Somalia	AD	Ph.D.	Soil Fertility
Elasha, A. Elasha	Sudan	AD	Ph.D.	Production Agronomy

In-service Participants

Maria S. Gabba (Tanzania) and **Tran Thi Truong** (Vietnam), participants in In-Service 6-month Training Program returned to their home countries in August as they were called back by their family members to attend some urgent family problems.

Sixty-five field experiments laid out by the 28 in-service participants recorded an excellent crop growth following well distributed rainfall during July-September. Harvesting of pearl millet in 7 experiments was completed. Sorghum is nearing maturity. Though *Helicoverpa* damage is considerably less in pigeonpea, there was some damage due to blister beetles.

Apprentices

Three Apprentices came and started their project work as mentioned below.

Name	Country	Period	Research Division	Study area
A. John Peter	India	6 months from 18 Aug	CPD	Identification of resistance factors in crops against insect pests
Albertine A. Karsies	Holland	3 months from 18 Aug	CPD	Groundnut breeding and viruses
Nathalie Anne Seghers	Belgium	4 months from 21 Sep	CPD	Research methodologies on control and damage by shoot fly and stem borer in sorghum

The following four Apprentices have completed their project work.

Name	Country	Period	Research Division	Study area
D. Nandini	India	10 weeks from 5 May	CPD/Statistics	Modeling in disease epidemiology studies
Shahista Halim	India	12 weeks from 07 Jun	CMBD	Molecular techniques on pearl millet seed physiology and genotype identification
R.J.P. Sebastien	Belgium	15 weeks from 02 Jul	CPD	Study on the incidence of root parasitic fungus *Polymyxa graminis* in the spread of peanut clump virus
G.B. Laryea	Ghana	12 weeks from 11 Jul	Finance Division	Accounting and financial procedures at ICRISAT

Human Resource Development (*Division/Program Activities*)

Research Fellows, Visiting Scholars, Research Scholars, In-service participants, and Apprentices attached to various Divisions/Programs arranged through the Training and Fellowships Program (TAFP) are listed under TAFP in pages 114–117 in this report. In addition:

Genetic Resources Division

In-service National Scientists/Trainees

Md. Farid Uddin Mia, Principal Scientific Officer, Bangladesh (18-19 Jul); Yee Daw Khim Mar, Myanmar (12-16 Sep); Lina Fouad Adra, Syria (16 Sep); Anajali Bhagwat, Scientific Officer, Bhabha Atomic Research Centre (BARC), Bombay (19 Sep) were received orientation on groundnut genetic resources.

Genetic Enhancement Division

In-service National Scientist/Trainee

Jerobean Iileka, Namibia was given practical training in pearl millet breeding during 8-19 Aug and 5-9 Sep.

Agronomy Division

In-service National Scientists/Trainees

Yu Li from China participated in a field experiment on water-use efficiency in groundnut during 16 Aug - 02 Sep.

Helen Kasalu, Visiting Scholar from Zambia, joined the Production Agronomy and Cereal Physiology Units for 3 months on 5 Jul to study the effects of land forms and fertility on pearl millet and green gram.

Farm and Engineering Services Program

Training activities

- Two in-service trainees from TAFP underwent training on various farm operations during July-September.
- Four in-service trainees in two batches underwent orientation on various farm operations for 1 week.
- In-house training on repair and maintenance of washing machines was conducted for 4 technicians.
- MV sub-station technicians underwent training on repair and maintenance of electrical equipment.
- In-house training was imparted to two electrical technicians on basic air-conditioning system.

Training course

G. Hanumantha Rao, Secretary has been nominated to attend a training course on "How to be a successful secretary" at Bangalore, conducted by ITMS, New Delhi during 26–30 Jul.

Geographic Information Systems

Training course

A course on digitization and plotting of maps for 19 members from various research divisions was organized during 12–19 Sep.

Seminars

Date	Staff name(s)	Organization[1]/ Location	Title	Presented to:
Genetic Resources Division				
12 Aug	Pundir, R.P.S.	ARI, Ukiriguru Tanzania	Chickpea genetic resource activities at ICRISAT	Members of the faculty
23-26 Aug	Pundir, R.P.S.	PGRC, Arusha Tanzania	1. The evaluation results of the world chickpea collection 2. Mutagenesis and its role to increase diversity in the improvement of chickpeas	The staff of PGRC
Genetic Enhancement Division				
05 Sep	Onkar Singh	APAU, Hyderabad India	Chickpea breeding at ICRISAT	25 M.Sc. Plant Breeding students
26 Sep	Rai, K.N.	FAO, Chiang Mai Thailand	Applications of biotechnological tools to the improvement of ICRISAT mandate crops (poster)	Participants of a Conference of Asia & Pacific Seed Association
Cellular and Molecular Biology Division				
19-22 Sep	Sastry, J.G. et al.	New Delhi India	Use of DNA finger printing for the detection of genetic variability in pearl millet downy mildew pathogen (*S. graminicola*)	Participants of the XVI International Conference of Bio-chemistry and Molecular Biology
	Seetharama, N.	IAC, Patancheru India	Biotechnological approaches to crop improvement	In-service trainees
Crop Protection Division				
14 Jul	Armes, N.J.	Nanjing Agri. University, China	Insecticide resistance in the cotton bollworm in India	Staff and students of the university
28 Sep	Mehan, V.K.	IAC, Patanchru India	Seed and seedling diseases of groundnut	In-service trainees
30 Sep	Mehan, V.K.	IAC, Patanchru India	Foliar fungal diseases of of groundnut	In-service trainees

Continued

Seminars Contd.

Date	Staff name(s)	Organization[1]/ Location	Title	Presented to
Agronomy Division				
09 Aug	Rupela, O.P.	IAC, Patancheru India	Role of biological nitrogen fixation in crop production and improvement	Trainees of TAFP
Soils and Agroclimatology Division				
08 Sep	Srivastava, K.L.	NIRD, Hyderabad India	Soil and water conservation techniques	Participants of a training program on watershed planning and management
Socioeconomics and Policy Division				
	Rama Devi, K.	Institute of Administration	Women in the informal sector—some issues	Middle level officers of the Govt. of Andhra Pradesh

1. APAU = Andhra Pradesh Agricultural University, ARI = Agricultural Research Institute, FAO = Food and Agriculture Organization of the United Nations, NIRD = National Institute of Rural Development, PGRC = Plant Genetic Resources Center.

Publications

Summary Proceedings

Sharma, S.B., and **McDonald, D.** (eds.) 1994. International agricultural research on diseases caused by nematodes—needs and constraints: summary and recommendations of a satellite meeting of the International Congress of Plant Pathology, 6 Aug 1993, Montreal, Canada. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 24 pp. Order Code: CPE 093.

Plant Material Description

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1994. Cold-tolerant chickpea varieties ICCV 88503, ICCV 88506, ICCV 88510. Plant Material Description no. 53. Patancheru 502 324, Andhra Pradesh, India: ICRISAT. 4 pp. (PME 053)

Annual Report

Legumes Program, ICRISAT. 1994. Annual Report 1993. Patancheru 502 324, Andhra Pradesh, India: Legumes Program, International Crops Research Institute for the Semi-Arid Tropics. 260 pp. (Semi-formal publication.)

Books

Sehgal, J., Batta, R.K., Virmani, S.M., Nagabhushana, S.R., and **Sarma, V.A.K.** (eds.) 1994. International Seminar on Managing Red and Lateritic Soils for Sustainable Agriculture—Highlights, 24–28 Sep 1993, Bangalore, India. New Delhi, India: Oxford & IBH Publishing Co. 72 pp.

Virmani, S.M., Katyal, J.C., Eswaran, H., and **Abrol, I.P.** (eds.) 1994. Stressed ecosystems and sustainable agriculture. Proceedings of an International Symposium on Agroclimatology and Sustainable Agriculture in Stressed Environments, 15-20 Feb 1993, ICRISAT Asia Center, Patancheru, India. New Delhi, India: Oxford & IBH Publishing Co. 441 pp.

Book Chapters

Taneja, S.L., and **Nwanze, K.F.** 1994. Current status and strategies for management of insect pests in sorghum and millets. Pages 162-168 *in* Trends in Agricultural Insect Pest Management (Dhaliwal, G.S., and Arora, R., eds.). New Delhi, India: Commonwealth Publishers.

Wright, G.C., and **Nageswara Rao, R.C.** 1994. Groundnut water relations. Pages 281–336 *in* The groundnut crop: a scientific basis for improvement (Smartt, J. ed.). London, UK: Chapman & Hall. (JA 1457)

Journal Articles

Di Vito, M., Greco, N., Halila, H.M., Mamsoute, L., Labdi, M., Beniwal, S.P.S., Saxena, M.C., Singh, K.B., and **Solh, M.B.** 1994. Nematodes of cool-season food legumes in north Africa. Nematologea Mediterranea 22:3–10.

Johansen, C., Krishnamurthy, L., Saxena, N.P., and **Sethi, S.C.** 1994. Genotypic variation in moisture response of chickpea grown under line-source sprinklers in a semi-arid tropical environment. Field Crops Research 37:103–112. (JA 1487)

Lee, K.K., Wani, S.P., Yoneyama, T., Trimurtulu, N., and **Harikrishnan, R.** 1994. Associative N_2-fixation with pearl millet and sorghum: levels and response to inoculation. Soil Science and Plant Nutrition 40(3):477–484. (JA 1283)

Mahalakshmi, V., Bidinger, F.R., Rao, K.P., and **Wani, S.P.** 1994. Use of the senescing agent potassium iodide to simulate water deficit during flowering and grain filling in pearl millet. Field Crops Research 36:103–111. (JA 1622)

Rajeshwari, R., Sivaramakrishnan, S., Smith, R.L., and **Subrahmanyam, N.C.** 1994. RFLP analysis of mitochondrial DNA from cytoplasmic male-sterile lines of pearl millet. Theoretical and Applied Genetics 88: 441–448. (JA 1416)

Subramanian, V., Hoseney, R.C., and **Bramel-Cox, P.** 1994. Shear thinning properties of sorghum and corn starches. Cereal Chemistry 71:272–275 (JA 1248).

Subramanian, V., Hoseney, R.C., and **Bramel-Cox, P.** 1994. Factors affecting the color and appearance of sorghum starch. Cereal Chemistry 71:275–278 (JA 1208).

Sylvie Marche, Charles Roth, Surya Krishna Manohar, Michel Dollet, and **Theo Blatz** 1993. RNA virus-like particles in pathogenic trypanosomatids. Molecular and Biochemical Parasitology 57:261–268.

Wani, S.P., McGill, W.B., Haugen-Kozyra, K.L., and **Juma, N.G.** 1994. Increased proportion of active soil N in Breton loam under cropping systems with forages and green manures. Canadian Journal of Soil Science 74:67–74. (JA 1108)

Wani, S.P., McGill, W.B., Haugen-Kozyra, K.L., Robertson, J.A., and **Thurston, J.J.** 1994. Improved soil quality and barley yields with faba beans, manure, forages and crop rotation on a Gray Luvisol. Canadian Journal of Soil Science 74:75-84. (JA 1403)

Conference Papers

Hash, C.T., and **Witcombe, J.R.** 1994. Pearl millet mapping populations at ICRISAT. Pages 69-75 *in* Use of molecular markers in sorghum and pearl millet breeding in developing countries: Proceedings of an ODA Plant Sciences Research Programme Conference, 29 Mar-1 Apr 1993, Norwich, UK (Witcombe, J.R., and Duncan, R.R., eds.). London, UK: Overseas Development Administration. (CP 869).

Howarth, C.J., Cavan, G.P., Skot, K.P., Layton, R.W.H., Hash, C.T., and **Witcombe, J.R.** 1994. Mapping QTLs for heat tolerance in pearl millet. Pages 80-85 *in* Use of Molecular Markers in Sorghum and Pearl Millet Breeding in Developing Countries, Proceedings of an ODA Plant Sciences Research Programme Conference, 29 Mar-1 Apr 1993, Norwich, UK (Witcombe, J.R., and Duncan, R.R., eds.). London, UK: Overseas Development Administration. (CP 864).

Jones, E.S., Witcombe, J.R., Hash, C.T., Singh, S.D., Gale, M.D., Shaw, D.S., and **Liu, C.J.** 1994. Mapping QTLs controlling resistance to downy mildew in pearl millet and their application in plant breeding programmes. Pages 76-79 *in* Use of Molecular Markers in Sorghum and Pearl Millet Breeding in Developing Countries, Proceedings of an ODA Plant Sciences Research Programme Conference, 29 Mar-1 Apr 1993, Norwich, UK (Witcombe, J.R., and Duncan, R.R., eds.). London, UK: Overseas Development Administration. (CP 893).

Liu, C.J., Witcombe, J.R., Hash, C.T., Busso, C.S., Pittaway, T.S., Nash, M., and **Gale, M.D.** 1994. Construction and application of RFLP-based genetic maps in pearl millet. Pages 57-64 *in* Use of Molecular Markers in Sorghum and Pearl Millet Breeding in Developing Countries, Proceedings of an ODA Plant Sciences Research Programme Conference, 29 Mar-1 Apr 1993, Norwich, UK (Witcombe, J.R., and Duncan, R.R., eds.). London, UK: Overseas Development Administration. (CP 892).

Seed Exchange (*Jul-Sep 1994*)

Crop/ Country	Number of samples: Trials and nurseries — Sets	Trials and nurseries — Entries	Breeder seed	Advanced lines	Segregating populations	Released material	Germplasm accessions	Others	Total
Sorghum									
Asia									
India	0	0	0		196		994	0	1190
Iran	2	150	0		18		0	10	178
Myanmar	0	0	0		320		0	0	320
Saudi Arabia	1	75	0		0		0	0	75
Africa									
Egypt	1	25	0		0		0	0	25
Ethiopia	1	25	0		16		0	0	41
Kenya	0	0	500		0		0	0	500
Nigeria	0	0	0		0		7	0	7
Sudan	1	25	0		0		7	0	32
Europe									
Belgium	0	0	0		0		0	1	1
Germany	0	0	0		0		30	0	30
The Americas									
Dominican Rep.	0	0	0		0		0	24	24
Peru	0	0	0		0		10	0	10
Uruguay	0	0	0		0		30	0	30
USA	0	0	0		0		1	0	1
Total	*6*	*300*	*500*		*550*		*1079*	*35*	*2464*
Pearl Millet									
Asia									
India	31	558	158		1465		693	0	2874
Africa									
Algeria	0	0	0		0		5	0	5
Ethiopia	3	75	0		0		0	0	75
Niger	0	0	0		9		0	0	9
Europe									
France	0	0	0		0		39	0	39
UK	0	0	0		0		0	175[1]	175[1]
The Americas									
Paraguay	0	0	0		30		0	0	30
USA	0	0	0		3		0	0	3
Total	*34*	*633*	*158*		*1507*		*737*	*175*	*3210*

Continued

Crop/ Country	Number of samples								
	Trials and nurseries		Breeder seed	Advanced lines	Segregating populations	Released material	Germplasm accessions	Others	Total
	Sets	Entries							
Chickpea									
Asia									
Bangladesh	13	231	0	0	0	0	3	0	234
Bhutan	7	121	0	0	0	0	0	0	121
China	0	0	0	16	0	0	0	0	16
India	98	1798	0	46	0	2	0	497	2343
Iran	6	102	0	0	0	0	0	0	102
Laos	0	0	0	4	0	3	0	3	10
Myanmar	19	361	0	0	0	0	0	0	361
Nepal	3	57	0	0	0	0	0	9	66
Pakistan	48	854	0	36	12	0	0	0	902
Philippines	6	114	0	0	0	0	0	0	114
Africa									
Egypt	4	76	0	0	0	0	0	0	76
Ethiopia	9	171	0	0	0	0	0	0	171
South Africa	4	60	0	0	0	0	0	0	60
Sudan	2	38	0	0	0	0	0	0	38
Europe									
Germany	0	0	0	2	0	0	0	0	2
Portugal	9	145	0	0	0	0	0	0	145
Slovakia	0	0	0	0	0	1	0	0	1
The Americas									
Mexico	2	38	0	0	0	0	0	0	38
USA	2	38	0	0	0	0	0	0	38
Oceania									
Australia	12	204	0	0	0	0	0	0	204
Total	*244*	*4408*	*0*	*104*	*12*	*6*	*3*	*509*	*5042*
Pigeonpea									
Asia									
Bangladesh	0	0	0	7	0	0	1	0	8
India	12	245	0	26	26	6	1299	36	1638
Laos	0	0	0	3	0	3	0	0	6
Malaysia	0	0	0	0	0	0	3	0	3
Nepal	0	0	0	3	0	1	6	4	14
Africa									
Ethiopia	0	0	0	6	0	2	0	0	8
Guinea Bissau	0	0	0	1	0	2	0	1	4
The Americas									
Bolivia	0	0	0	0	0	0	0	2	2
Total	*12*	*245*	*0*	*46*	*26*	*14*	*1309*	*43*	*1683*

Continued

Crop/ Country	Number of samples								
	Trials and nurseries		Breeder seed	Advanced lines	Segregating populations	Released material	Germplasm accessions	Others	Total
	Sets	Entries							
Groundnut									
Asia									
India	0	0	9[2] 54[3]	228	0	10	423	0	724
Myanmar	5	87	0	10	0	0	0	0	97
Philippines	4	67	0	40	0	0	0	0	107
Vietnam	0	0	0	41	23	0	300	150[4]	514
Africa									
Ethiopia	6	92	0	0	0	0	0	0	92
South Africa	3	45	0	0	0	0	0	0	45
Zimbabwe	0	0	0	221	0	0	0	0	221
Europe									
UK	0	0	0	0	0	0	8	0	8
The Americas									
USA	0	0	0	73	0	0	0	3	76
Total	*18*	*291*	*63*	*613*	*23*	*10*	*731*	*153*	*1884*

1. Tissue samples of pearl millet for DNA extraction.
2. Groundnut cvs ICGS 11 (300 kg), ICGS 44 (100 kg), ICGS 1 (300 kg), ICGS 76 (150 kg), ICG(FDRS) 10 (150 kg), ICGV 86325 (500 kg), and ICGV 86590 (400 kg) to different seed-producing agencies.
3. Small samples of 2-4 kg of groundnut totalling 114 kg to 54 farmers on request.
4. Rust and/or late leaf spot resistant genotypes to the National Institute of Agricultural Science, Hanoi.

Visitors Services

During this quarter, total number of visitors to IAC was 1714, of whom 415 were women, rising the total number of visitors to 5589 during the year. The second meeting of the Farmers' Day Committee was held on 28 Sep and it was decided to hold the event on 29 Jan 1995.

Visitors during the quarter

Type of visitors	No. of visitors	No. of groups
Farmers	279	20
Students	658	31
Extension personnel	331	40
National scientists	101	45
Overseas scientists	33	29
Administrators	32	28
VIPs	5	5
Others	275	77
Total	1714	275
Women	415	
Men	1299	

Some Important Visitors

- Hon'ble Col. Rao Ram Singh, Minister of State, Ministry of Rural Development, Government of India (7 Jul)
- Dr. Gudrun Vogel, The Consul General of the Federal Republic of Germany, Madras (25 Jul)
- Mr. Frederic Renard, Counsellor, Belgium Embassy, New Delhi (3 Aug)
- Dr, Katsuyuki Minami, Director of the Environmental Resources Division, JIRCAS, Japan (19 Aug)
- Dr. K.V.Devaraj, Vice Chancellor, University of Agricultural Sciences, Bangalore (23 Sep)

Administrative Activities

General Administration

Transport Unit

General

During this quarter appropriate transport arrangements were made on several occasions to members attending PTL Meetings, Executive Committee of the Board, visits of consultants, etc. Total number of service requests entertained increased to 1473 during this quarter as agaist 1307 in the last quarter. In addition to regular scheduled transportation services, the mileage logged towards additional services rendered to various Divisions/Support Service Units during this quarter is 125 800 km.

The vehicle operational charges were reviewed and revised upward keeping in view the increased cost of fuel and spares.

As a part of motivation to D/GAs, the safe driving awards were distributed to 36 eligible D/GAs.

Several D/GAs opted for separation under VRS and normal pool operations were seriously affected. In order to overcome the problem, one of the steps taken was to pool all D/GAs under Transport Unit for more flexibility and optimum utilization.

Vehicle Accidents

During the quarter 18 ICRISAT vehicles were involved in road accidents and the Accident Review Committee reviewed the cases and appropriate action as recommended and approved by ED's Office was initiated.

Liaison

Necessary assistance was provided to the staff and IRS for renewal/obtaining fresh RTA driving licenses.

Fitness Certificates for a few vehicles were renewed during the quarter. New vehicles purchased under DB scheme were registered and handed over to the concerned staff.

Necessary arrangements were made to obtain the pollution check tokens for about 45 vehicles during the quarter.

Vehicle Insurance

Two insurance claims were submitted during this quarter for reimbursement of the damage repair cost.

Changes in the Vehicle Assignment/Procurement/Disposal

One each of sedan and station wagon identified as surplus were disposed off to STC at New Delhi.

A detailed review was made for the replacement of vehicles and appropriate recommendations were forwarded for capital allocation of vehicles.

Vehicle Repairs and Maintenance

During the period about 140 vehicles were handled by the Transport Unit for routine maintenance and servicing.

Operational Budget Allocation

A thorough review of the operational budget was carried out and requested for an additional allocation to meet the minimum expenditure without hampering the services. Approximately 85% of the allocation has been spent till end of Sep 1994.

Communications Unit

Pending Fax Requests

Efforts are still on in pursuing with the Hyderabad Telecommuni-cations for getting three telephone lines connected to Fax via Saifabad Exchange for use at IAC.

New Telephone Connection

A spare line available in Secunderabad Exchange has been connected at the residence of Mr V.S. Swaminathan on 21 Sep.

Rectification of Faulty Telephones

Seventeen ICRISAT EPABX telephone lines which were working via electro-mechanical exchange have been connected via electronic exchange. These were changed to 59 level in the first week of August, and the remaining 5 lines of EPABX will be changed to 59 level some time in October.

More than a dozen telephone complaints reported by ICRISAT residential staff were rectified.

Fax machine at DG's Office has been reset on time.

DDG's residential telephone has been interchanged with ICRISAT telephone.

Telephone Calls from Operator's Console

About 4070 STD/ISD calls, 28 000 local calls, and about 100 000 incoming calls were handled by telephone operators on only two consoles, providing 24-hour service.

Mail Room

A total of 522 parcels, 627 Registered letters, and 30 329 letters/publications were mailed to various locations during the quarter.

An amount of Rs.3143 has been collected from "**pay phones**" during the quarter and deposited with the Finance Division.

Kilburn franking machine's licence has been renewed.

Staffing

G.V.S. Gurunath, Secretary, has resumed his duties on 1 Sep after completion of his leave.

Campus Housing

General

About 85 visitors/guests/workshop participants stayed in dormitories and flatlets during the quarter for different periods. Twenty-four trainees also arrived during this quarter. The following workshops/seminars/group meetings were held and service was provided to the participants.

24-28 Jul 9 participants attending NARS scientists' meeting.
24-27 Aug 7 participants attending CPD workshop.
14-16 Sep 13 participants attending Entomologist's group meeting.

Housekeeping

Housing assets joint verification by PSD, Finance and Housing was completed. About 12 items are not traced, and it needs reverification. Terrace drain outlets in all buildings were cleaned. Public areas, basements, and plant room areas of all buildings were cleaned. Regular cleaning/washing and maintenance of vacant dormitories/flatlets/lounges and control measures to prevent ants and mosquitoes around the campus residential areas, dormitories/flatlets areas were carried out. All electrical fixtures and fittings were cleaned.

Swimming Pool

Scrubbing/cleaning of pool side walls and floor with suction sweeper machine was carried out. Change room halls, toilet/ bathroom floors have been scrubbed with the scrubbing machine. About 10 nos. of sunbath chairs have been repaired and kept for Pool users. Chlorine plant servicing was done.

Laundry

During this period servicing of steam boiler was done. Regular laundry services were rendered on schedule for trainees, visitors/guests and workshop participants. Similar services as scheduled were also provided to other research Programs/Divisions for washing linen and uniforms of staff and RWF.

ISH/ESH/OSSH

Upon request, maintenance and repair jobs were done through FESP. ESH house no.12 was vacated and it is now ready to be alloted to an essential staff. Though there was some operational problems, we managed to supply domestic gas to Campus residents.

Personnel Division

Personnel Actions

During the quarter, the following separations have taken place:

Resignations	:	20 (VRS - core)
		3 (1 core and 2 time-scale contract)
Superannuation	:	1 (core)
Terminations	:	2 (1 core, 1 contract)
Death	:	4 (core)
Expiry of contract	:	3 (consolidated status)

The contracts of 9 staff members were extended during the quarter. Four staff members were granted leave without pay (LWOP) under Clause VII(C)-1(c), and another staff member was granted extension of LWOP under Clause VII(C)-1(c) for 3-1/2 months.

During the quarter, four members were recruited to complementary positions.

The person power strength (staff and RWF) during the quarter is as follows:

Status	1 Jul	1 Aug	1 Sep	30 Sep
Regular staff	1233	1231	1231	1206
Contract	29	28	27	26
Ad-hoc/consolidated	19	21	22	19
Total	1281	1280	1280	1251
RWF	477	477	477	474

Training

One in-house training program on "Employee Development" was conducted for RWF members. In addition, 12 staff members were sponsored for various external training programs.

Benefits

Leave travel assistance

Sixty-five staff members have availed LTA during the quarter, raising the total to 1223 for 1994.

Leave encashment

Twenty-two staff members have availed encashment of earned leave.

Group Personal Accident Insurance Scheme

Twenty-eight accidents were reported during the quarter (staff - 21 and RWF - 7). Twenty-five claims were settled for an amount of Rs.90 273 which includes one claim pertaining to 1993.

Hospitalization

Staff/RWF claims processed during the quarter are as follows:

i) Staff	Rs. 254257.99
ii) RWF	Rs. 24123.31

Comprehensive medical check up

(a) Staff	Jul: 6	Aug: 5	Sep: 5
(b) RWF	Jul: 6	Aug: 5	Sep: 5

Placement

Thirteen "JOB" Bulletins carried information on 94 position announcements (75 overseas and 19 within India) and 37 requests were received for 30 positions. Applications made by 13 staff members for positions were forwarded.

General

During the quarter two selection committees met for selecting candidates for two different positions. The details are as under:

Date	Position
20 Sep	RA I (Quarantine) (The selected candidate was offered the position)
26 Sep	Editor (None was found suitable)

Advance for Purchase of Vehicles

As surplus funds were available due to cancellation of some vehicle loan offers, advance for one more car was released.

Overseas Medical Insurance

Overseas Medical Insurance Policies were provided to 7 staff members costing Rs.14 874/- in aggregate.

Food Services

Food Arrangements for Dignitaries

- Dr. Gudren Vogel, the Counsel General of Germany, Madras on 25 Jul.
- Mr. Frederic Renard, First Attache, Belgium Embassy on 3 Aug.
- Mr. Peter Whiten, Acting Deputy High Commissioner, British High Commission, Madras on 9 Sep.
- Drs. Derek Byerlee and S.K. Thirot, Economists and Dr. Wael Zakour, GIS Specialist, World Bank on 4 Oct.

Computerization

The Menu Costing System (MCS) developed with the help of Computer Services is ready, but we are unable proceed with the system due to technical difficulties.

Promotional Activity

- Konkan Food Festival at 204 dining hall on 7 Jul.
- Special Scechwan Food at Swimming Pool on 17 Jul.
- Special "Tamil Sapad" at 205 Dining Centre on 3 Aug.
- Special Dinner for 150 persons from S.B.H at 205 Dining centre on 10 Aug.
- Special Lunch for 125 persons arranged at 205 Dining Centre on 28 Aug.
- Traditional "Onam Lunch" at 205 Dining Centre on 15 Sep.

Staff Training

Food Services conducted an in-house training program on "Safe food and hygiene practices" for all the food handling staff in three batches on 7 and 23 Aug and 10 Sep. Also a 3-hour program on "Simple methods of food preservation" was conducted on 17 Sep at 212 Conference Centre for staff and spouses of IAC staff staying at the Campus.

Details of Different Services

Number of units catered for requests received from Programs/Divisions and Staff thru' Request for Catering arrangements (RCAs) other than usual lunch, dinner, breakfast, tea services in 204, 205, and 700 are as follows:

Type of Request	No. of requests	No. of persons served
Tea/coffee	22	443
Tea/coffee/snacks	44	1030
Special buffet lunch/dinner in 204 snack bar	34	997
Executive Dining Room (EDR) lunch	7	49
Take away bulk food orders	13	
Beverages - soft drinks	2	12

Direct Material Cost and Recoveries of Service Centers

IAC Campus

Service center	Material cost (Rs.)	Recoveries (Rs.)
204 Dining Center	363114.27	548420.70
205 Dining Center	203343.39	251028.05
Rendezvous Lounge	34636.62	37465.0
700 Snack Bar	5673.81	36263.30
Official parties at Kaliva and site (No. of parties-5)	8309.57	34925.94

Guesthouse

Number of units available	Percentage of occupancy	Direct material cost (Rs)	Recoveries (Rs)
6	18%	5608.44	112348.00

Recoveries include the sale of food and accommodation.

Improvement on Equipments and Facilities

"Sona Energy Saving Device" for two LPG stoves was installed at 205 Dining Centre, with the help of FESP.

Security Unit

Manpower

During the quarter one security guard was terminated, another was resigned, and the third one was expired.

During the period special security arrangements were made as requested by programs to safeguard costly and important scientific equipment placed at different locations of the farm. Nine such requests for special protection were processed.

Vehicles going out through the main gate, were checked on a random basis. The total number of vehicles checked during the period were 131.

Report of Unusual Events

One hundred and fifty-nine cases of unusual events were reported to various programs viz., lights left on, doors unlocked, windows kept open, unauthorized parking, etc., after close of work.

Random Bus Check

Baggage check of employees commuting in buses was carried out on a random basis on all working days. During the quarter, 267 buses were checked on 77 working days.

Material Security

Entry and exit of material is regulated by non-returnable, returnable gate passes, sale vouchers, and material inward passes.

Material inward passes are also issued to employees who bring in personal items to the campus. These passes are issued at the time of entry to facilitate easy identification of the material while going out. During the quarter, 896 material inward passes were issued.

During the period, the Security Unit handled 555 non-returnable gate passes and 371 returnable gate passes.

Theft and Pilferage

Theft and pilferage incidents reported during the period were six as per details given below:

Date	Program/Division	Property Lost	Action taken
11 Jul	FESP	Aluminum ladders (2 Nos.) (CR's residence)	Undetected. A report was sent to DSB
19 Jul	GED	Spare wheel of (AAB 3120)	Undetected
02 Aug	FESP	Money from locker	Undetected. A report was sent to the Program
12 Jul	Transport	Petrol pilferage	Investigated and a report has been sent to Sr. Transport Officer
14 Sep	GED	Horn of AAB 4619 HH	Undetected. A report has been sent to the Division
14 Sep	SACD	Breaking of lock of G I box	Undetected. A report has been sent to the Division

Lost and Found

During the quarter total lost and found items brought to the notice of security office were 64, of which 36 items were restored to rightful owners.

Bundh/Rasta Roko Calls

A call for Bharat bandh was given by opposition parties on 26 and 29 Sep and the procedure of surveying the roads since 0400 was carried out and the situation remained peaceful and there was no interruption to the activities of the institute.

Removal of Stray Dogs and Snakes

Security undertakes the responsibility of removing poisonous snakes and stray dogs from the campus. During the period, 4 snakes were caught, a few were killed since catching them live was risky.

Telephone Operations

During the period, 196 security person-days were spent on performing telephone operation duties.

Doors and Locks

During the period, the Security Unit made 30 copies of keys besides making duplicate keys for vehicles as requested by the Transport Unit and GGMK key was used 118 times to open the locks for various staff.

Milk Collection

Security personnel are taking delivery of the milk in 204 canteen area on behalf of PSD as per their requirements and milk was collected by security on 77 days.

Fire Fighting

One fire incident occurred due to burst out and normal wear and tear at Bldg. 200 A/C plant room. In the incident, the cable joint caught fire and the fire was extinguished completely by the security personnel with fire tender and fire beater without causing any damage.

General shift supervisor is given the task to check the serviceability of fire alarm system, hydrant points, etc.

Checking of Internationally Recruited Staff (IRS) houses

During this quarter three surprise checks were carried out in IRS houses.

ISRC

Security took over the responsibilities of guarding the ISRC premises situated at Road No.1, Banjara Hills effective 01 Sep.

Visitors

A total of 4052 people visited the Institute, of which 2471 were official and 1581 were personal visitors.

Field Medical Unit

During the quarter 3702 patients received treatment from the Field Medical Unit (FMU) as follows :

Regular staff (IRS/NRS)	- 2072
RWF	- 1072
Trainees	- 214
TFL/visitors	- 344
Total	- 3702

Types of Ailments Treated at FMU

Type of ailment	No. of cases
Injuries on duty	54
Old injuries + follow-up cases	1026
Flu/fever	180
Cold and URTI	783
Ear problems	30
Eye problems (FB/Conjunctivitis)	97
Diarrhoea/Dysentery	140
Abdominal problems	139
Bites/stings (scorpion, dog, insect etc.)	15
Dental problems	15
Miscellaneous conditions	1221
Hypertension[1]	2

1. Newly detected on routine examination.

Total no. of acute cases treated under observation : 12

Comprehensive Medical Check-up

Age group	Regular staff	RWF
44-50 years	59	3
Beyond 50 years	27	20
Newly detected cases		
Hypertension	1	-
Diabetes Mellitus	4	-

Periodical Screening for Occupational Health

Type of staff	No. of staff
RWF from FESP (Cholinesterase)	38
Staff from Food Services (Jul)	52
D/GAs with Chronic ailments (Aug)	10

Medical Check-up for Other Staff

Type of activity	No. of staff
Pre-employment medical check-up	2
RTA driving licenses and renewals	105
Health insurance for overseas travel	8

Pathological Laboratory Services

Type of path lab tests conducted	No. of tests
Haematology tests	234
Biochemical analysis (blood glucose, S Cholesterol, LFT etc.)	217
Stool analysis	195
Urine analysis	204
Urine for glucose	506

First-aid Tour Kits

Issued first-aid tour kits on 56 occasions to different programs undertaking official travel by road.

Ambulance Utilization

Total no of occasions used	:	14
No. of occasions used on charge basis	:	9