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INDIA - ICRISAT DAY

(November 15, 2000)

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RESEARCH PARTNERSHIP

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On March 28 1972 the Consultative Group on International Agricultural Research (GCIAR) and the Republic of India signed the Memorandum of Understanding for the establishment of the International Crop Research Institute for Semi-Arid Tropics (ICRISAT) at Hyderabad (India) This historic event, the first ever expression of global concern for one billion unfortunates inhabiting the world's harshest environment, marked the beginning of India's partnership with ICRISAT Recognizing that an end to the problems of this ecology lies in enhanced and assured farm productivity the institute placed its research thrust on (i) improvement of major food grain crops of the semi-arid tropics and (ii) conservation and sustainable use of natural resources-soil water and genetic diversity Given the nature of the ecology what had been accomplished by the institute during the first 20 years of its existence is by no means a small achievement Aside productive varieties and crop production packages, truly its achievement is in the building of a strong infrastructure valuable data base on the biophysical and socio-economic variables and development of a large technical manpower without which achievement of its promised goal of better quality of life would remain a dream only In its massive effort and successful achievements, the role of NARS in general and India in particular has been considerable and the present exercise is to highlight the partnership role of India in the various activities of the institute

Global Repository of Genetic Resources of Mandate Crops: Collection, Evaluation & Sharing

Germplasm strength being the feedstock for progressive crop improvement, the very first activity of the institute was to collect and evaluate the germplasm of the mandate crops viz sorghum, pearlmillet, pigeonpea, chickpea and groundnut Incidentally the transfer of quite sizeable germplasm of sorghum and other millets maintained by India was catalytic to this activity The Indian component included indigenous collection made under the PL 480 Scheme and exotic collection in its possession then Subsequently conducted collection surveys in collaboration with the National Bureau of Plant Genetic Resources (NBPGR) and the concerned crop institutes greatly enriched the global

*Presented at the INDIA-ICRISAT DAY on November 15, 2000 at ICRISAT Hyderabad collection in size and diversity The relative contribution of India in the total collection as of today is 18% with pigeonpea accounting for the highest (26%) (Table 1)

Table 1: Relative contribution of India to the global germplasm collection

Crop	Total No. of accessions in the Genebank		No.of Indian accessions*	Percentage contribution
	1991	2000		
Sorghum	33,108	88,116	14,602	16 5
Pearlmillet	22,110	42,066	7,189	17 0
Minor millets	7,144	18,279	3,460	18 9
Pigeonpea	11,910	29,010	7,488	25 8
Chickpea	16,443	42,614	5,988	14 0
Groundnut	12,841	31,331	6,060	19 3
Total	**1,03,556**	**2,51,416**	**44,787**	

* Donated (32272)+ Jointly collected (12515)

The collection constituted as international screening nurseries were subjected to systematic evaluation for traits of economic value jointly with the NARS India's role in this activity, especially screening for biotic and abiotic stresses, had been sizeable by way of providing hot spot facilities and technical manpower for screening In the case of sorghum, for instance, Hisar (Haryana) and Warangal (Andhra Pradesh) proved excellent locations for stemborer screening, while Pantnagar (UP) for Anthracnose and foliar diseases, Dharwar (Karnataka) for midge and rust and Ananthapur (Andhra Pradesh) for drought Similarly for chickpea Pantnagar, Ludhiana (Punjab), Kanpur (U P) and Junagadh (Gujarat) were effective hot spots respectively against Botrytis grey mold, Ascochyta blight, Fusarium wilt and stunt The screening over the years had led to the identification of a wide choice of donor sources against major biotic and abiotic stresses (Tables 2-4)

Table 2: Potential donor sources for biotic and abiotic stresses in sorghum

Resistance	Donor source
Biotic	
Shootfly	IS Nos 1034, 1071, 1096, 2205, 2123, 18551
Stemborer	IS Nos 1044, 1119, 2123, 5448, 5470, 2205,
Midge	DJ 6514, IS 18700
Grainmold	IS Nos 4006, 5959, 13267, 23599, 25017
Anthracnose	IS 18484
Striga	N 13, 555
Abiotic	
Drought	DJ 1195, IS 1037

Table 3: Potential donor sources for biotic stresses in pigeonpea

Resistance	No. of donors identified	Donor source
Fusarium wilt	24	ICP Nos. 4769, 7118 8859 8862 8863, 9120, 9168 10958 12731, 12748 ICPL 88008, 88847 G 9648 AWR 74/15 Banda Palera DWR 251, 370
Sterility mosaic	30	ICP Nos 6997, 7035 7197 7234 8094, 8362, 10976, 10979, 10983 11049 11146, 11206, 11231, 11297, ICPL 335, 342, 366 83024 PI 397430, PR 5149, BSMR 1 BSMR 2
Phytophthora blight	5	KPBR 80-2-1 KPBR 80-2-2 ICP Nos 8130, 9252, 10958
Wilt + Sterility mosaic	9	ICP Nos 4769 7035, 8860 8862, 10171 11297, PR 5149, BWR 159 PI 397430
SM+ Phytophtora blight	3	ICP 8103, KPBR 80-2-2 KPR 80-2

Table 4: Potential donor sources for biotic and abiotic stresses in chickpea

Resistance	Donor source
Abiotic	
Drought	ICC 4958, Phule G5, Katila, Phule G 85-1-1 Annigeri, K 850
Low temperature	ICCV 88503, ICCV 88506, GNG 160
Biotic	
Ascochyta blight	E 100 Y (M), E 100Y, PBG 1, H75-35, Gaurav
Fusarium	WR 315 Aurodhi, CPS 1, WR 375, JG 315, JG 1265, K 315, K350, GW6

Improved disease/pest screening techniques: Rapid and reliable techniques for mass screening of germplasm and breeding populations against traits of interest, especially biotic and abiotic stresses are important for effective selection in desired direction. Jointly with the national centres the institute has come out with refined and much more efficient techniques for adoption by breeders in India and elsewhere (Table 5)

Table 5: Improved disease/insect pest screening techniques of ICRISAT adopted in India

Technique	Pest	Crop
• Mass rearing	Stemborer	Sorghum
• Infestor/infector row	Shootfly	Sorghum
	Sterility mosaic	Sorghum
	Downy mildew	Pearl millet
• Artificial infestation/inoculation	Stemborer	Sorghum
	Grain mold, Smut	Sorghum
	Downy mildew	Pearl millet
• Hot spots/sick plots	Stemborer, Midge	Sorghum
	Wilt, Phytophthora	Pigeonpea
	Wilt	Chickpea
• Sprinkler screening /early planting	Grain mold	Sorghum

Genetic Enhancement of Crops for Higher Productivity and Stability

The period of first 20 years witnessed two major policy directions on the issue of sharing the products of breeding research with NARS Initially the philosophy of Dr R W Cummings that the institute role be confined to generating and not naming the material was the guiding principle and accordingly population breeding received priority under the stewardship of Dr Dogget Later the emphasis was shifted to 'sharing by finished products' possibly guided by the notion that the strategy would bring more visibility to the institute Subsequent conviction that unfinished material would provide wider base for the NARS to tailor many times more strains appropriate to their diverse needs ensuring thereby their role as well in the varietal development, the policy on the stage of technology sharing has been reverted to the original one The change enabled the institute to generate and evaluate through testing networks large volumes of breeding material in association with Indian crop breeding centres culminating in the evolution of several varieties/hybrids besides development of diverse parental lines, heterotic gene pools and improved sources of resistance to biotic/abiotic stresses

The breeding thrust although was in keeping with the global need and priority invariably such priorities proved more relevant to India which accounts for --------% of the semi arid area and largest area for all the mandate crops The research thrust varied with the crop as briefly indicated below

Sorghum	___	Earliness, diversification of male sterility, resistance to shootfly, midge and grain mold
Pearlmillet	___	Earliness resistance to downy mildew and drought earliness
Pigeonpea	___	Earliness, resistance to Helicoverpa and sterility mosaic
Chickpea	___	Tolerance to drought and low temperature, resistance to *Helicoverpa* wilt and Ascochyta blight
Groundnut	___	Resistance to foliar diseases and termites

The breeding accomplishments during the period under report are cropwise detailed as under

Sorghum Knowledge on the potential of *Zera-Zera* germplasm gained from the experience of India, identification of potential donor sources against key pests like stemborer midge and shootfly and diverse sources of cytoplasmic male sterility led to the release of four varieties and one hybrid directly by ICRISAT and an equal number by the public and private sector institutions by using ICRISAT-bred material (Tables 6 and 7) Significantly the very first hybrid of the institute ICSH 153 (CSH 11) was based on India-developed *cms* line 296 A Majority of the hybrids under extensive cultivation today however, are based on ICRISAT bred *cms* lines such as 81A and 841A Especially, private sector-bred hybrids like PKH 400, PSH 8340, MLSH 36, PJH 55, PJH 58, JKSH 2, JKSH 27 etc, identified in 1990 are based on the ICRISAT bred male sterile lines Equal number of exotic germplasm identified as promising in India have been released between 1990 and 1992 (Table 8)

Table 6: Varieties and hybrids of sorghum released by ICRISAT in India (1972-1992)

Genotype	Pedigree	Year of release	Special features
Variety			
E 1966 (NTJ 2)	IS 30488	1980	*Zera-Zera* landrace
ICSV 1 (CSV II)	SC 108-3/CSx4	1984	----
ICSV 112 (CSV 13)	[(IS 126220/555/IS 1342C/22(96) E35-1]	1987	----
ICSV 145	555/GPR 148	1988	Striga resistant
Hybrid			
ICSH 153 (CSH 11)	296A/MR 750	1986	*CMS* Indian source

Table 7: List of varieties and hybrids of sorghum developed by India using ICRISAT developed material

Genotype	Pedigree	Year of release	Special features
Variety*			
ICSV 197	IS3443/DJ 6514	1986	Midge R
NTJ 2	IS 30468	1990	Zera Zera landrace
Hybrid**			
ICSH 110	296A/MR 836	1988	Indian cms source

** Private sector bred hybrids (PKH 400, PSH 8340, MLSH 36, PJH 55, PJH 58, JKSH 22, JKSH 27) and public sector-bred hybrid CSH 14 identified respectively in 1990 and 1985 were released in 1993

* ICSV 745 identified in 1989 was released in 1993

Table 8: ICRISAT identified exotic sorghum germplasm released as varieties in India

Acc. No.	Country of origin	Release name	Year of release
IS 30468	Ethiopia	NJ 2122	1990
IS 3924	Nigeria	Swarna	1991
IS 35412	Sudan	CS 3541	1992
IS 3687/IS 1151	USA/India	148/168	1992
IS 3922/ IS 1151	Nigeria/India	604	1992
IS 3922/ IS 1151	Nigeria/India	302	1992
IS 2954/IS 18432	USA/India	370	1992
IS 2950/IS 1054	USA/India	R 16	1992

The flow of ICRISAT-bred material involving Indian germplasm to other countries has been equally impressive (Table 9) It is a good example to show how research partnership with NARS enables ICRISAT to help identify what are best to one member country from others

Table 9: ICRISAT-bred varieties and hybrids of sorghum released outside India involving Indian germplasm.

Variety/Hybrid	Country	Year of release	Indian germplasm involved
Mekamish	Ethiopia	1979	CS 3541
ICSV 2	Zambia	1983	CSV 4
ICSV 1	Malawi	1985	CSV 4
ICSV 12	Zimbabwe	1985	555
ICSV 12	Mexico	1989	555
ICSV 12	Nicaragua	1990	555
SRN 39	Sudan	1991	GPR 148
M 90353	Sudan	1992	GPR 148 & CS 3541
M 62641	Mexico	1989	CS 3541
M 90812	Mexico	1991	GPR 165
M 91057	Mexico	1991	GPR 148
M 62650	Honduras	1985	CS 3541
M 90975	Guatemala	1985	GPR 168

Pearl millet Among the two millets, ICRISAT's contribution was maximum in pearlmillet In all 8 varieties and 3 hybrids have been released directly by ICRISAT, while 4 varieties (ICMV 1, ICMV 4 ICTP 8203, ICMV 155) and 8 hybrids by SAU's and ICAR institutes using ICRISAT-bred material (Tables 10 11, 12) Two most significant breeding achievements in this crop have been insulation of majority of the varieties and hybrids with high level of resistance to downy mildew and development of diverse male sterile lines and restorers all combining high level of resistance to downy mildew (Table 13)

Table 10: ICRISAT-bred pearlmillet varieties released in India (1972-1992)

Variety	Pedigree	Year of release	Special features	Adaptation
WC-C75	7 full sib WCC - 1975	1982	High GY + FY DMR	MS TN AP MP KA HA RAJ
ICMS 7703 (MP 15)	Synthetically bred by crossing lines from 7 crosses	1985	High GY + FY DMR	TN
ICTP 8203 (MP 124)	Five S_2 progenies from early maturing Iniad landraces from Togo	1988	Early DMR	---
PCB 138	ICPT 8203 selection	1989	---	---
ICMV 155 (MP155)	59 mass selected S1 plants from New Elite Composite Cycle 4 bulk	1991	High GY +FY, DMR	---
RAJ 171	8 S_2 progenics Intervarietal Composite Cycle 5	1992	---	--
ICMV 82132	S5, progenics of SRC	1989	---	---
ICMV 88908	Mass selected (BSEc/ ICMV 87901)	1990	---	---

Table 11: ICRISAT- bred pearlmillet hybrids released in India (1972-1992)

Hybrid	Pedigree	Year of release	Special features	Adaptation
ICMH 451 (MH 174)	81A/ICMP 451	1986	High GY+ FY DMR good grain quality	MS AP HA RAJ GUJ
ICM 501 (MH 180)	834 A/ICMP 501	1986	DMR Large seeded	Not adopted
ICMH 424 (MH 143)	841A/ ICMP 423	1988	High GY+ FY DMR	Not adopted

Table 12: India-bred hybrid of pearlmillet involving ICRISAT-bred parental lines

Hybrid	Bred by	ICRISAT parental lines used	Year of release	Special features	Adaptation
Pusa 23	IARI, Delhi	841 A	1987	High GY+FY, DMR	MS, AP, GUJ, HA
HHB 50	HAU, Hisar	81 A	1988	DMR, Early	HA
HHB 60	HAU, Hisar	81 A	1988	Early	HA
HHB 67	HAU, Hisar	843 A	1990	Early	HA Raj
GHB 181	GAU Jamnagar	81A	1989	---	GUJ
RHB 58	RAU, Jaipur	81 A	1990	---	RAj
MLBH 104	Mahendra	Pollinator	1991	Early, large seed	MS
RHB 30	RAU	843 A	1991	Early, DMR	---

Table 13: ICRISAT - bred CMS and R-lines of high combining ability with downy mildew resistance in pearl millet

CMS/B	Restorer
81 A/81 B	ICMP 312
834 A/834 B	ICMP 423
841 A/841 B	ICMP 451
842 A/842 B	ICMP 356
843 A/843 B	ICMP 501
5141 A/5141 B	
88004 A/88004 B	

Pigeonpea Breeding for resistance to major pests and diseases (*Helicoverpa*, sterility mosaic), and development of early maturing varieties of varied plant types for crop intensification/diversification and exploring the prospects of hybrid breeding were the thrust areas since beginning Major achievements included high yielding varieties and a hybrid of early and medium maturity combining resistance to one of more pests and diseases, identification of location-specific sources of resistance to major diseases and insect pests, development of genetic male sterility-based hybrids and identification of stable sources of cytoplasmic male sterility

In all four varieties two each of short and medium maturity were released between 1985 and 1990 (Table 14). Three of the India-bred cultures have been released in other countries as well. They included ICP 7035 released as 'Komica' in Fiji, ICP 61543 in Myanmar and four different selections from ICP 11605 as Hunt, Quantum and Quest in Australia and as Megha in Indonesia.

Table 14: Varieties of pigeonpea developed by ICRISAT and India based on ICRISAT material

	Release name	Year of release	Special features
ICPV 1 (ICP 8863)	Maruthi	1985	Med. duration, R to wilt
ICPV 87 (ICP 11543)	Pragathi	1986	Short duration, suitable for multiple cropping
ICPV 151 (ICP 11605)	Jagrithi	1989	Short duration, suitable for multiple cropping
ICPV 332 (ICP 14770)	Abhaya	1989	Med. duration, pod borer resistant

As regards hybrid breeding, ICRISAT developed world's first pigeonpea hybrid ICPH 8 (*ms* Prabhat DT x ICPL 161). The short duration hybrid evolved using genetic male sterility system is higher yielding and widely adapted. This accomplishment proved a forerunner to subsequently released hybrids such as CPH 953 (*ms* Co5/ICPL 57109) and KE 1 (*ms* Prabhat/T21) and catalyst to development of several GMS lines in good agronomic backgrounds for use by various centres in India (Table 15). It was this effort that ultimately led to the identification in the nineties, sources of cytoplasmic male sterility under the ongoing India-ICRISAT collaborative program since 1989 on 'Development of cytoplasmic-nuclear male sterility system in pigeonpea'.

Table 15: Genetic male sterile pigeonpea parents developed at ICRISAT for use by Indian centres

GMS line	User centres
ms Prabhat DT	IARI, PAU, HAU, GAU, PKV, RAU
ms Prabhat NDT	DPR, IARI, TNAU, RAU
ms 3783	DPR, GAU, RAU, NDUAT
IMS 1	DPR, IARI, PAU, HAU, GAU, TNAU, PKV
QMS 1	PAU, HAU, GAU, TNAU, PKV
QMS 9	TNAU, PKV
ms T21	HAU, GAU, TNAU, RAU
ms ICPL 87091	GAU
ms C 11	GAU

An achievement of great significance relevant to resistance breeding is the development of region-specific improved donor sources against all major pests and diseases (Table 16). Many valuable improved sources have been identified for use at regional and national levels. Two collaborative programs viz. multilocation evaluation of pigeonpea for disease resistance between 1979 and 1995 and identification of strains of SM pathogen/biotypes of vector and inheritance of disease resistance from 1989 to 1995 have enabled jointly to identify many valuable donor sources. The base so developed would greatly help develop multiple resistant varieties and hybrids with ease in the coming year

Table 16: Region-specific improved sources of resistance to major insect pests and diseases in pigeonpea

Centre	Disease/pest	Res. lines/accessions
Dholi	Sterility mosaic	ICP 7035 ICP 8862 ICP 10976
Rahuri	Fusarium wilt	ICPL 89044 ICP 8094 ICPL 86005
		ICPL 88023 ICPL 88025
	Wilt Ster mosaic	ICPL 88046, ICPL 88047 ICPL 87119
Lam	Sterility mosaic	ICPL 87119
	Helicoverpa	ICPL 332
	Wilt	ICPL 8859
	Wilt Ster mosaic	ICPL 87119 KP 8860
AICPIP adopted	Wilt	ICP 8869 Maruthi
sources for	Sterility mosaic	ICPL 87119, ICPL 15 Rampur
national level	Wilt, Sterility mosaic	ICPL 83027, 83024, 87119, 85047
crossing program	Podfly	ICPL 11964 10531
	Helicoverpa	ICPL 332 (Abhaya)

Chickpea Development of high yielding varieties combining resistance/tolerance to the major yield constraining factors viz , drought, low temperature, pod borer and wilt was the major objective of chickpea breeding program During the period under report nine varieties either bred by ICRISAT or by India using ICRISAT material were released in India (Table 17) Significantly most of them are resistant to wilt

Table 17: ICRISAT-bred varieties of chickpea in India

Variety	Pedigree	Year of release	Special features	Adaptation
ICCV 1	H 208/T3	1983	---	UP
ICCV 2	[K850/GW5/7)P458 (L550/Gumuchi]	1989	Wilt resistant, Kaluli type	AP, MS, GUJ
ICCV 3 (Swetha)	[K850/GW5/7)P458 (L550/Gumuchi]	1989	Wilt resistant Kabuli type	AP
ICCV 5	CPS 1/ C 104	1989	---	
ICCV 6	C 550 / L 2	1990	Wilt resistant	MP UP
ICCV 88202	PRRI / ICCC 1	----	---	GUJ
ICCC 37 (Kranti)	P 481 / (JG 62/81630)	1989	Wilt resistant	AP, MS
ICCC 42	(K 850/GW 5/7)/ (H 208/Annigeri)	---	---	MP, MS

Table 18: Chickpea varieties released in India using the germplasm of ICRISAT

Variety	ICRISAT material used	Year of release	Adaptation
Jyothi	IC 4923	1978	AP
ICCV 4	ICCV 1	1983	GUJ
RSG 44	TG 62/F496	1984	----
GNG 149	L 550/L2	1985	----
Anupam	F 378/F 404	1988	----
Kranti	ICCC 37 (ICCL 80074)	1989	AP, MS
Swetha	ICCV 2 (ICCL 82001)	1989	AP
ICCV 6	ICCV 6	1990	MP, UP
Bharathi	ICCV 10	1992	

Three of the India-bred varieties viz , ICC 552, IC 4951, IC 6098 have been released as Yezin 1 and ICC 4951 in Myanmar and as Radha in Nepal respectively

In respect of resistance breeding, besides those identified as region-specific donor sources against major pests and diseases, ICCV 2, ICCV 37 and ICCV 10 against wilt, ILC 3279, ILC 195 and ILC 182 against *Aschochyta* blight and ICCVT against *Helicoverpa* have been identified by AICPIP as strong sources for use at national level

Groundnut Breeding research at the institute began in 1979 Major breeding emphasis was for higher yielding varieties combining high level of resistance to foliar diseases The research efforts initially led to the evolution of eight varieties (Table 19) and later large volumes of breeding lines, using which India could develop 11 varieties subsequently (Table 20)

Table 19: ICRISAT-bred varieties of groundnut in India

Variety	Pedigree	Year of release	Special features	Area of adaptation
ICGS 11	Natural hybrid derivative from Kadiri 3	1986	----	AP TN KA MS MP
ICGS 44	Natural hybrid derivative from Kadiri 3	1988	----	AP TN KA MS MP
ICGS 76	TMV 10/Chico	1989	R to rust & late leaf spot	MS
ICGS 37	Natural hybrid derivative from Kadiri 3	1990	----	MS GUJ
ICGS 1	Natural hybrid derivative from Kadiri 3	1990	Tol to bud necrosis	...
ICCV 10	Ah 65/NCAc 17090	1990	R to leaf spot	Peninsular India (AP KA TN)
ICGV 86	X14-4-8-19B/P1259747	1991	R to leaf spot	Peninsular India (AP KA TN)

Table 20: Groundnut varieties developed by India using ICRISAT-bred parent material (1972-1992)

Variety	ICRISAT Parent material	Year of release	Bred selected by	Salient features	Areas of adaptation
Spring G'nut 84	ICGS 1	1984	PAU	Tol to Bud necrosis	AP TN
Konkan Gaurav	ICGS 1	1990	KKV	Tol. to Bud necrosis	MS
VRI-1	TMV 7/FB 7-2	1986	TNAU	High shelling % fresh seed domancy	TN
ALR-1	FESR Sel	1987	TNAU	R to rust and leaf spot	TN
Girnar 1	X 14-4-B 19 BVNC Acc 17090	1989	NRCG	Multiple R to foliar diseases & Jassids Tol to drought	GUJ
RG 141	Kadiri NCAC 2821	1989	RAU Raj	High yield	RAJ

Several of the improved breeding lines are sources of resistance to major pests and diseases For instance, ICGV 87157 ICGV 87160, ICGV 86590 ICGS 7292, ICGS 9294 and ICGS10920 against foliar diseases and ICG 2271 and ICGV 86031 against termites and leaf miner respectively have been found effective sources

Apart from applied breeding research basic investigations on various aspects of breeding/selection had been carried out in partnership with Indian centres Among them study to understand the mechanism of tolerance/resistance to stresses and their genetics. development of breeding-selection strategies, especially to overcome the defects in otherwise heterotic parents. treating family as a unit of selection, when resistance is the criterion of selection development and use of 'resistance index' for breeding for quantitatively inherited resistance as in the case of shootfly stem borer etc., are important

Impact of varietal technology Trend of area increase under given varieties/hybrids, amount of breeder seed produced and supplied over the years, production/productivity advance of the crop from the base year and level of crop losses due to major stresses are some of the indicators to assess the impact of varietal technology In the case of pearlmillet among the recommended varieties and hybrids ICPT 8203 and MLBH (based on ICRISAT R-line) registered as high as 40 and 23% of the total area under the crop during 1993-1994 in Maharashtra WC-C75 once most popular variety occupying very large area was replaced by ICPT 8203 (Table 21) Sizeable production and supply of breeder seed of both hybrids and varieties during the corresponding period confirmed the growing popularity of varieties/hybrids as compared to local and old improved ones (Table 22) High level of resistance to the dreaded disease downy mildew and high grain and fodder yields are attributable to their growing popularity among farmers

Table 21: Adoption of improved ICRISAT pealmillet varieties in Maharashtra

Variety/Hybrid	% of total pearlmillet area				
	1990	1991	1992	1993	1994
ICPT 8203	26 4	37 1	40 3	35 5	33.5
WC-C75	7 6	4 7	4 4	0.5	1.2
ICMH 451	1 5	2.7	2 6	1.2	1.6
MLBH 104	5.1	8 5	13.9	23.0	22.8

Table 22: Breeder seed supply of parental lines of hybrids and open-pollinated cultivars of pearlmillet (1991-1995)

Genotype	Kg seed		Total
	Public	Private	
Hybrid parents (6A, 6B & 4R lines)	2016	2769	4785
Open pollinated cultivars (6)	1008	1383	2391

Max. seed supply:

A lines --- 81A, 841A, 843A
R lines --- ICMP 451 ICMR 356
Cultivars --- ICPT 8023 WC-C75 ICMV 155

In the case of pigeonpea the early maturing variety ICPL 87 found natural spread in western Maharashtra and northern Karnataka with districts Dhule and Ahmednagar accounting for 98 and 90% of the area under the crop while Jalgaon Sholapur Aurangabad and Beed between 40 and 50% (Table 23) Varieties of its maturity and plant type facilitating crop intensification by intercropping and multiple cropping are bound to become popular in such ecologically handicapped regions

Table 23: Adoption of pigeonpea variety ICPL 87 in western Maharashtra and Northern Karnataka

District	% area	
	1990	1994
Dhule	<5	98
Jalgaon	45	49
Ahamednagar	40	89
Sholapur	<2	40
Aurangabad	14	40
Beed	9	40
Gulbarga	<2	>15
Bidar	<2	>12

Percentage area under the improved chickpea varieties viz . ICCV 1 ICCV 2. and ICCV 37 in the states of A P Gujarat, M P and Maharashtra showed steady increase between 1992 and 1995 Their coverage was in the range of 10-20% (Table 24) One of the key factors for their growing adoption was high level of resistance to the killer disease wilt besides high yields

Table 24: Adoption of improved chickpea varieties released during 1983-1989

State	% Area planted in			
	1992	1993	1994	1995
Andhra Pradesh				
ICCV 2	4	7	7	17
ICCV 37	4	6	6	9
Annigere	74	66	70	58
Local	17	16	15	15
Gujarat*				
ICCV 1	21	21	25	25
Dahod yellow	79	79	75	70
Madhya Pradesh				
ICCV 2				13
Russian				48
Local				18
Maharashtra				
ICCV 2	2 5	3	6	9
ICCC 37	12	14	18	18
Chaffa	49	44	38	39
Local	12	12	11	9

ICCV 1 - Mod resistant to pod borer   ICCV 2 - Kabuli resistant to F Wilt;
ICCV 37 - Resistant to wilt,   * - Based on one district

Natural Resource Management

Research activities relating to resource base management have been largely through partnership with CRIDA The collaboration structured on the basis of complimentarily helped understand and address the various agroecological limitations constraining the farm productivity in the representative SAT environments The major research programs undertaken during 1972-1992 and salient findings therefrom are as under

Watershed approach for enhanced productivity on a sustainable basis: Long dry spells followed by heavy rains leading to avoidable soil and water losses and hence crop uncertainty are characteristic to SAT Years of experimentation of 'Broad bed & Furrow system', a watershed approach coupled with a package of crop production practices exclusively designed and developed by the institute helped to identify it as an effective strategy for enhancing farm productivity on a sustainable basis. It enables farmers to take two crops (3.2 t/ha of sorghum or maize + 1 3 t/ha of pigeonpea or chickpea) in otherwise monocropped by overcoming waterlogging in the rainy season and conserving soil moisture for a post-rainy season crop Extensive study reveals the practice to bring down the loss of run off water from 220 mm to 110 mm/ha and soil losses by six times from 6 6 t to 1 1 t/ha Although it is not widely practiced largely on account of socio economic reasons its long term effect on sustainability can not be under estimated (Table 25)

Table 25: Adoption intensity of components of vertisol technology

	A.P		Karnataka	M.P	Maharashtra	
Technology	Taddenpally (Medak)	Sultanpur (Medak)	Farhatabad (Gulbarga)	Begumganj (Raisen)	Kanzara (Akola)	Shirapur (Sholapur)
Broad bed & Furrow	—	-	-	-		-
Summer cultivation	—		-	++	++	
Double cropping	+	+	+	+++	+++	++
Dry seeding	—			+	++	
Fertilizer use	+	+	++	+++	+++	++
Seed + Fert placement	—		+++	+++	+++	++
Plant protection	—	-	+++	+++	++	+
Use of CDP	—	-	+++	—	—	—

CDP = controlled droplet application of pesticides

Crop intensification by intercropping Successful development of very early and less bushy pigeonpea varieties facilitated study of their suitability for varied farms of intercropping and multiple cropping Comparative study of erect and less bushy perennial varieties in intercropping with greengram in alfisols for over 10 years (1982-1992) showed the latter to give higher grain and biomass yields while the former to increase greengram yield

Nitrogen management and biological nitrogen fixation The study was undertaken between 1985 and 1989 with the objective of capitalizing biological N fixation by introducing legumes in crop rotation Comparison of sorghum + pipeonpea and greengram + sorghum as against the sole crops of sorghum revealed positive N balance (97 kg/ha) in the inter cropping sorghum with green gram as compared to sole sorghum resulting in a net negative balance of 111 kg'N /ha after three years

Behaviour of phosphorus in vertisol With the idea of understanding the use level of applied P in black soils and accordingly deciding P application need studies were undertaken at five AICRPDA centres The findings revealed P adsorption capacity of the vertisols to vary widely Of 80% adsorbed of the applied P only 50-60% are released for plant use The findings proved valuable in planning need based P application strategy for the vertisols

Alley Cropping Study of Leucaena-based alley-cropping brought out the undesirability of the system for SAT ecology as it introduce competition for moisture between tree and crop components resulting in severe reduction in crop yields

Among the ongoing collaborative projects 'Sustaining production of soybean-based system through integrated soil-water-nutrient management in landscape watersheds' has helped to succesfully characterize natural resource bases and identify the key constraints to increased sustainable cropping in Adasha (Kothapally, AP), Ringnodia (M P) and Milli (Laletora, M.P) watersheds.

Human Resource Development

Recognizing that lack of adequate technical manpower well acquainted with the problems of SAT is one of the major limitations impeding the envisaged pace of progress, ICRISAT gave priority attention to human resource development through short and long term training programs Indian institutes/universities and resource persons had played significant role in the training activity of ICRISAT right from it inception Simultaneously as many as 357 Indian scientists and technician had been trained during 1970-1990 (Table 26)

Table 26: Number of Indian scientists and technicians trained at ICRISAT during 1972-1990

Category	Trainees/scholars
Apprentice	47
In-service trainees	111
Research scholars	91
Post-doctoral fellows	29
Research fellows	79
Total	357

Conclusion

Given the harshness of the ecology what had been accomplished during the first twenty years is by any standard is impressive and laudable What to be achieved however, are many and much more challenging They are vital for enhancement of farm productivity on a sustainable basis - the key to the promised prosperity in the long neglected ecology Unless and until the problems that continue to defy solution through the currently available technologies are solved the mandated 'goal' can never be achieved Change in our mindset to blend the rapidly unfolding frontier technologies with more focussed applied research is what is needed to make the desired progress