Tracking the impact of wilt resistant medium duration pigeonpeas in the semi-arid tropics of India

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ABSTRACT

The paper presents results from tracking the spread and impact of a cultivar, the wilt resistant medium duration pigeonpea ICP 8863 (Maruthi), in the highly variable semi-arid tropics environment of India. It calculates the welfare gains from research where the target environment is characterized by various adoption regimes. Analysis is enhanced by the use of two categories of adoption. Complementary information from various sources -- including seed sector sales, estimates by subject matter specialists from the Department of Agriculture and Extension network, farm level reconnaisance and formal surveys -- are used to form a composite picture of adoption and impact. The results show that, 6 years after release, the wilt resistant variety has covered almost 60% of the wilt endemic areas where the material was released. Rates of adoption vary depending on access to improved varieties through the seed sector and on formal release by the states. The returns to investment in pigeonpea wilt resistant research are substantial.

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Fusarium wilt caused by *Fusarium udum* Butler is one of the most widespread and destructive diseases of pigeonpea [*Cajanus cajan* (L.) Millsp.] in Asia and Africa. An international survey of pigeonpea diseases covering Asia, Africa and the Americas, carried out from 1975 to 1980, revealed that the disease was prevalent in almost all the pigeonpea-growing areas. Monitoring surveys in eleven major producing states of India indicated high incidence in the states of Maharashtra (22.6%), Bihar (18.3%) and Uttar Pradesh (15.4%) (Kannaiyan et al, 1984). The same series of surveys extended in Africa found that wilt was the only major disease of pigeonpea in Malawi, Tanzania and Kenya. Pathology research results suggested that wilt-affected areas of pigeonpeas suffer a 50 percent yield reduction. (J.G. Ryan, 1981). Production losses from wilt on pigeonpeas in 1977-78 were estimated to reach 97,000 tons in India and 14,000 tons in Kenya, Malawi and Tanzania. The economic value of production losses due to this disease was reported to be $US 36.4 million annually in India and $US 5.2 million annually in the three eastern African countries.

The findings of the survey were an important basis by ICRISAT in setting a high research priority for Fusarium wilt of pigeonpea. Investigations were primarily aimed at identifying resistant lines, multilocation screening of pigeonpea for fusarium wilt resistance and developing resistant cultivars. It was viewed that resistant cultivars will offer farmers a cost-effective method for controlling the disease. Cultural practices, such as crop rotation and mixed- or inter-cropping, were also noted to help reduce the incidence of the disease.

The paper presents results from tracking the spread and impact of a cultivar, the wilt resistant medium duration pigeonpea ICP 8863 (Maruthi), in the highly variable semi-arid tropics environment of India.

1. Background

Availability of stable and broad-based resistance source is essential for breeding resistant cultivars. At the time when the international survey of pigeonpea diseases was completed, sources of resistance to wilt have been identified at ICRISAT Center. Of more than 11 000 entries screened in the wilt-sick plots at ICRISAT Center, 33 showed resistance to wilt (Nene and Kannaiyan, 1982). Seeds of these resistant lines were maintained and made available upon request by ICRISAT. At about the same time, a few lines and cultivars tolerant or resistant to wilt have also been reported at other research stations in India including PUSA, Kanpur and Badnapur (Swaminathan et al, 1979).

ICP 8863 was developed by selection from ICP 7626 (P-15-3-3), a landrace from northern India. The original collection was sown in a wilt-sick plot at ICRISAT Center, Patancheru, during the 1977/78 cropping season. Seeds collected from the resistant plants were resown in the wilt-sick plot for further purification. Henceforth, the variety was tested in wilt-sick plots at 13 locations in India (ICRISAT Plant Material Description no. 44, 1993).

Multilocation screening of pigeonpea for fusarium wilt was carried out in India during the period 1978 to 1983 to identify genotypes with broad-based resistance. The collaborative effort called the ICAR/ICRISAT Uniform Trial for Pigeonpea Wilt Resistance (IIUTPWR) was among several institutions including ICRISAT (Patancheru, Andhra Pradesh), Marathwada Agricultural University (Badnapur, Maharashtra), Rajendra Agricultural University (Dholi, Bihar), Agricultural Research Station, University of Agricultural Sciences (Gulbarga, Karnataka), C.S. Azad University of Agriculture and Technology (Kanpur, Uttar Pradesh), J.N. Krishi Viswa Vidyalaya (Jabalpur, Madhya Pradesh), Pulses and Oilseeds Research Station (Berhampore, West Bengal), Agricultural College (Ranchi, Bihar) and Division of Mycology and Plant Pathology (IARI, New Delhi). The trial was coordinated by ICRISAT and carried out by the pathologists of the Indian Council of Agricultural Research (ICAR) and ICRISAT.

Sixty one pigeonpea germplasm and breeding lines were evaluated at 15 wilt-endemic locations. Genotypes showing less than 20% wilted plants in all seasons of testing at a particular location were considered to be resistant. Fifty-one of these genotypes were those that have been found wilt-resistant in wilt-sick plots at ICRISAT Center; ten genotypes were contributed by Marathwada Agricultural University. Most of the genotypes tested included germplasm accessions obtained from the Genetic Resources Unit of ICRISAT. All have non-determinate flowering pattern and are either medium or long duration types. All, except ICP 9168 - which is from Kenya, originated from India.

The significant findings of the multilocation trial are as follows:

a) five pigeonpea lines (ICP 4769, 8863, 9168, 10958, 11299) and two cultivars (C11 and BDN1) were found to be resistant to wilt across a wide range of locations and seasons indicating stable and broad-based resistance;

b) the multilocation screening work has for the first time helped to identify wilt-resistant true-breeding lines and cultivars that hold their resistance across wilt-endemic locations and across time:

   i. the genotypes listed in a) above were subsequently included as long-term resistant checks in IIUTPWR and were found resistant in the subsequent years;

   ii. few cultivars such as C11 (ICP 7118), BDN 1 (ICP 7182), NPWR 15 (ICP 8859) and KWR 1, listed earlier as tolerant/resistant at some locations in India (Swaminathan et al, 1970) were found to segregate for wilt resistance when evaluated in wilt-sick plots in ICRISAT Center;

   iii. ICP 8863 was found to have durable resistance to wilt, having held its resistance since 1977. This particular line also has shown good yield potential.

By the time multilocation trials were underway in the early 80's for checking stability of resistance to fusarium wilt, farmers in northern Karnataka, particularly in Gulbarga and Bidar area, started to detect growing incidence of wilt. Substantial production loss due to the disease prodded farmers to seek for wilt resistant materials from the Agricultural Research Station in Gulbarga. Scientists from this station searched for wilt-resistant lines from ICRISAT, the main source of disease resistant lines for pigeonpea.

The first set of multilocation trials which have been underway at that time showed advance results which indicated the strong potential of ICP 8863. It is the only available pigeonpea variety that combines a high level of resistance to wilt and a high degree of purity with broad-based resistance. It is marginally earlier maturing than the popular medium-duration cultivars which were grown in peninsular India. Its yield advantage in wilt-sick plots in multilocational trials was so apparent that it was selected by the scientists from Karnataka. On-station and on-farm adaptive trials for ICP 8863 were conducted in earnest at the Agricultural Research Station, University of Agricultural Sciences, Gulbarga, Karnataka. Several large scale demonstrations were subsequently conducted through the university and front line demonstrations on farmers' fields. The release of ICP 8863 was facilitated by scientists and research managers in the NARS and the Department of Agriculture to provide solution to growing production losses due to fusarium wilt in Gulbarga. ICP 8863 was released in the state of Karnataka in 1986 under the name Maruthi.

2. Research Evaluation Framework and Discussion of Parameter Estimates

2.1 Framework

A "simple non-traded goods" research evaluation framework based on the economic surplus model is chosen to estimate welfare gains from research. Adoption regimes were defined to reflect a) a favorable environment with a good seed sector support and extension network; and b) a constrained adoption environment where seed availability is an important bottleneck. The existence of different adoption regimes makes it necessary to estimate the impacts in these regions separately.

2.2 Research lag

The description of the research process for fusarium wilt research in section 1 indicates that the released variety ICP 8863 is a product of joint R&D efforts by ICRISAT and the Indian NARS. Firstly, the original collection of this material was a selection from P-15-3-3 obtained from Badnapur, Maharashtra. It was identified and kept as part of the germplasm lines of ICRISAT. Further purification was undertaken and multi-location screening was undertaken under the ICAR/ICRISAT Uniform Trial for Pigeonpea Wilt Resistance (IIUTPWR), a cooperation between ICRISAT and several institutions in the NARS. Its release was facilitated by scientists in Karnataka to address the increasing incidence of wilt in the region. A total of 9 years of applied and adaptive research with ICRISAT/NARS joint effort involved selection, multi-location screening and further purification before the cultivar was released in 1986. Four years are further added to the research lag to consider seed multiplication and front-line demonstrations by Karnataka NARS from 1986 to 1989. From the point of view of scientists at the Gulbarga Agricultural Research Station who initiated the release of the cultivar, the ready availability from ICRISAT of the material essentially shortened their R&D lag by 50% (personal communication, 1994). This estimate was given in the context of their experience with ICP 8863.

2.3 Adoption

2.3.1 Tracking the spread of ICP 8863

After almost two decades since the research started on fusarium wilt - from problem identification to product development and dissemination, it is of prime interest to determine the extent of utilization and impact of the product in its target regions.

A systematic tracking approach was developed as the pigeonpea crop is generally grown in the highly variable semi-arid tropics environment where adoption may be expected to be non-uniform. Complementary information from several sources are pieced together to form a composite picture of the spread of ICP 8863. They include seed sector sales, area estimates by subject matter specialists appointed by the Department of Agriculture and Extension network, farm level reconnaisance and formal surveys.

Target areas for adoption study are identified from analysis of available district level data: trends in area, production and yield, growth rates within and across time and regions. Table 1 contains basic information including production and hectarage in the wilt endemic areas covered by the study. Northern Karnataka, considered the pigeonpea granary of India, covers about 301,000 hectares of pigeonpea with production levels of 118,000 metric tons. The total area planted to pigeonpea in the border districts of Andhra Pradesh and Maharashtra is 226,000 hectares with production levels of 66,000 metric tons. In Maharashtra, the total area covered is 700,000 hectares with production levels of about 493,000 metric tons. All above figures are based on 1988-1990 averages. The grand total is about 1.27 million hectares and 677,000 metric tons. This represents an increase from 1.012 million hectares and 567,000 metric tons based on 1985-87 averages.

District level data derived from the International Survey of Pigeonpea Diseases further provided benchmark information indicating the prevalence of fusarium wilt in the regions. Maps classifying districts where pigeonpea is an important crop and where wilt is endemic are shown in Figures 1 and 2.

2.3.2 Complementary sources of adoption data

Seed production and distribution data from both public and private seed companies offer useful guide in directing us where cultivars were accepted and utilized. As soon as ICP 8863 was released, seeds were made available in 1986. The Karnataka State Seeds Corporation (KSSC) supports 14.7% of annual total demand for ICP 8863 seeds (KSSC, personal communication). This is based on the norm that farmers usually purchase and replace the seeds once in three years. Seeds produced by KSSC are allocated to various districts and blocks according to

demand. Seed procurement price by the company is Rs 13.75/kg and certified seeds are sold at Rs 16/kg. (1993-94 prices).

Eighty five percent of seed demand relies on multiplication and distribution of seeds through farmers who have learned the seed production technology and who have found it profitable.

KSSC reports the sale of Maruthi seeds to have increased significantly from 49 t in 1990 to 140 t in 1994. Maruthi's share in KSSC's total sale of all pigeonpea varieites increased from 32% in 1990 to 47% in 1994. It now covers the large pigeonpea tracts of several districts in Karnataka, including, Gulbarga, Bidar, Bijapur and Raichur. Based on the data given in the Table 2 (and Figure 3), a conservative estimate of the area grown to this variety in these districts (using farmers' average seed rate of 10 kg ha^{-1}) is approximately 95 238 ha.

Another important source of adoption data may be accessed through reconnaisance surveys. Discussions with NARS scientists, extension personnel, as well as subject matter specialists and village assistants of the Department of Agriculture oftentimes reveal invaluable directions for ground-truthing adoption levels. For example, reports by subject matter specialists of the various Principal Agriculture Offices of the Ministry of Agriculture in state of Karnataka indicate that about 116 120 ha area was sown under Maruthi in the eight major pigeonpea-growing districts of Karnataka. Figure 4 provides a comparison of the data obtained from subject matter specialists and those obtained from on-farm surveys.

2.3.3 Technology adoption and impact surveys

District level secondary data on area, production and yield are important basis in the choice of survey locations. The proportion of gross cropped area and growth rates in area and yield are also useful in guiding district, block and village selection.

Block (taluka, mandal) level data may be obtained from the Department of Agriculture offices established in each district. Village level data are obtained from Assistant Directors of each block. A brief summary of the sampling scheme used for this study is as follows: the top two pigeonpea producing districts in top producing blocks are selected for a random selection of sample villages. A random sample of 10 farmers is selected from a sampling frame drawn of pigeonpea growing farmers in the village.

Survey modules were developed to include the following aspects for inquiry: basic farmholding information, land use/cropping system, adoption, input/output information, and post-harvest information and seed utilization.

2.4 Cost Structure

Table 3 contains a cost analysis for pigeonpea ICP 8863 based on the cost data generated from the on-farm surveys. It contains input use and factor prices for ICP 8863 and the best cultivar used by farmers before ICP 8863 was available. Output information are also presented.

2.5 Research Cost

Research costs on wilt resistant research in ICRISAT and the collaborating institutions in the NARS are estimated based on the yearly budget presented in Table 4 (a,b).

Historical records of budgets disaggregated by research projects conducted during the early years of ICRISAT are very difficult to retrieve, if at all these are available in the archives of its Finance Division of ICRISAT. Thus, for the purposes of this study, actual expenditures for Fusarium wilt research was estimated with the guidance of scientists who were actually members of the ICRISAT Fusarium wilt research team during the period of its implementation and administrative officers in charge of budget. The breakdown of research cost were made on the basis of salaries of the research team members and proportions of scientists' time allocated to Fusarium wilt research. Operating cost were estimated based on total Legumes Pathology program operating cost apportioned among three major research activities (i.e Pigeonpea Fusarium Wilt, Pigeonpea Sterility Mosaic and Chickpea Wilt Complex) implemented by the program at the time. Similar imputations were made for the NARS counterpart funds. Two budget scenarios are used. The lower budget scenario is presented to show the variations in the recall that was made; this also affords an opportunity to simulate the effect of marginal budget reductions on the net benefit estimates.

3. Results and Discussion

3.1 Adoption and Impact surveys

The objective of this exercise is to confirm the large-scale adoption of ICP 8863 among farmers in the wilt-endemic areas of Karnataka, Maharashtra and Andhra Pradesh and to obtain on-farm information on the impact of ICP 8863 vis-a-vis the variety that was used by farmers before the improved variety was released.

On-farm surveys covering three adoption regimes were conducted. The first covered the wilt endemic regions of northern Karnataka, including the districts of Gulbarga, Bidar, and parts of Bijapur and Raichur. This area represents a favorable adoption environment where the state seed agency strongly supports seed production of released and recommended varieties. This area is also characterized by a good extension network from the State Ministry of Agriculture.
The second set of on-farm surveys explored the boundary districts of states bordering northern Karnataka. This includes 6 boundary districts of the state of Andhra Pradesh and 2 districts of

southern part of Maharashtra. This area was covered to answer questions regarding the spread of varieties across states where the seed is not released but where access to reliable sources of seeds is possible. Interaction with local agricultural officials and seed dealers and farmers in Karnataka State near the norrthern borders led us to information regarding the increasing demand of ICP 8863, more popularly known as "Maruthi", in the neighboring districts of the states of Andhra Pradesh and Maharashtra.

The third set of on-farm surveys included villages in wilt endemic areas of the major pigeonpea producing state of Maharashtra. It is noted that ICP 8863 is not released in this state and this prevents the state seed corporation from undertaking seed production and multiplication. Since information about ICP 8863's durable resistance to wilt has reached farmers in the area, its demand has been growing especially in the wilt endemic areas of the eastern part of the state. Presently, farmers essentially depend on a number of progressive seed producing farmers who have however experienced limited access to seeds from the neighboring state of Karnataka. As demand grew in recent years, seed dealers in the area sought and were able to obtain limited certified seeds from the Karnataka State Seeds Corporation. One agency - Mahesh Seeds - began ICP 8863 seed production in 1990 and claims to be able to supply only about .01% of total demand in the districts of Yeotmal, Akola and Amvarati; seeds of Maruthi are sold to farmers at a rate double the existing market price.

The results of the three sets of surveys are summarized in Table 5. Information on the rates of adoption and ceiling level of adoption over 7 years after the release in 1986 is presented. Important observations are noted. First, the rate of adoption of ICP 8863 picked up in Karnataka, growing from 5% in 1987 to 55% in 1991, peaking at almost 60% in 1992-1993. It is expected that the ceiling level of adoption will hold at these values, taking into account information that the formal seed sector has the capability of meeting 15% of the total seed demand of ICP 8863. Much of the demand will continue to be met by a more constrained distribution of seeds among farmers and informal seed channels.

Second, the adoption trends obtained from the districts bordering northern Karnataka are interesting. While wilt is experienced every year by farmers in this area and losses ranging from 10% to 30% yield reduction have been reported, it took almost two years of lag before adoption of the first wilt resistant variety took place. As flow of information about the durable resistance to wilt of "Maruthi" reached farmers, adoption picked up fast and access to certified seeds was possible from the neighboring district of Gulbarga which is the main seed production center in the state of Karnataka. Presently, "Maruthi" is very popular among farmers in these adjoining districts of Andhra Pradesh although the variety is not released in this state. On-farm survey results reveal that adoption has reached 100% in certain villages near the district center.

Third, a constrained adoption scenario is clearly demonstrated by the on-farm survey results conducted in eastern Maharashtra. Farmers in this area report that wilt has been a yearly occurence; wilt incidence has been recorded to be as high as 68.8% in some districts (Kannaiyan et. al., 1984; Nene et.al., 1989). However, farmers do not have ready access to the wilt resistant variety through the formal seed sector. As explained earlier, the Maharashtra State Seeds

Corporation is unable to sell "Maruthi" in Maharashtra as it is not released in this state and farmers are severely constrained by the limited informal seed channels that have slowly evolved. The survey results reflect the consequences: a two years adoption lag is observed with a slow rate of adoption reaching less than 18% after 7 years. It is expected that farmer-to-farmer seed distribution will remain a major source for widespread adoption of the variety in this important pigeonpea producing area of Maharashtra unless release of this wilt resistant variety is facilitated in this state.

3.2 Assessment of benefits from technology adoption

This section presents quantitative indicators showing the benefits from the use of wilt resistant variety ICP 8863. Results are analyzed to draw important lessons for research and extension policy and future research priorities.

Tables 6 and 7 contains data summarized from previous sections representing basic information needed in conducting a benefit assessment. Net present value of the stream of benefits from the research effort on fusarium wilt is obtained with consideration of the following information:

a. production levels in the target area: the wilt endemic region;
b. cost structures based on on-farm survey
c. varying extent of adoption in different adoption regimes; adoption rates and ceiling level of adoption differentiated by region may also be related to the extent of disease incidence;

d. possible input price variation across regions;
e. research cost;

The internal rate of return of the research investment is also presented.

The base case analysis takes parameter estimates based on on-farm survey results where input/output and cost information is obtained for production of wilt resistant pigeonpea variety ICP 8863 and a wilt susceptible local variety used by farmers in the study areas.

Estimates of yield gain of ICP 8863 over the best cultivar obtained from the on-farm surveys is considerable. The percentage gain is 50% for the grain output, 45% for the fodder by-product and 27% for stalk.

The cost analysis in Table 3 based on data observed on farm indicates a unit cost reduction of 3820 Rupees (US$123) per ton with the use of the improved variety ICP 8863. This is equivalent to a percentage unit cost reduction of 42%. The cost structures obtained from the on-farm surveys indicate that the major differences in input use are in seed rate and fertilizer application. Farmers using the local variety are observed to use higher seed rate for two reasons: the seed of the

improved variety has a price premium and losses due to wilt have to be compensated for. The same farmers tend to use more farm yard manure.

The utilization of the wilt resistance variety has proved to expand production levels due to yield gains which translate to reduction in the farmers' cost structure.

Given the research cost presented in Table 4 (a,b), the base price of Rupees 5468 (US$177) per ton, a discount rate of 8% and a supply elasticity of 0.2 and demand elasticity of 0.5, the net present value of benefits from fusarium wilt research is approximately US$75 million. This represents an internal rate of return of 73%. These results represent the benefits accruing to all the regions covered in the study. The net present value of benefits accruing to the primary target area of northern Kanataka alone is US$23.6 million.

The following list summarizes the benefits perceived by farmers from the use of the wilt resistant ICP 8863, based on on-farm surveys:

	Efficiency
1.	Disease resistance (wilt)
2.	Earlier duration (160 days)
3.	Suitability for kharif as well as rabi crops
4.	Suitability for sole as well as intercrop
5.	Efficiency in input use
	i. good response to irrigation
	ii. plant height ideal for plant protection operations

Follow-up monitoring in the regions covered by the study provide further information on the impact of wilt resistant ICP 8863 (e.g. T.N. Raju, Tour report on multilocation pigeonpea disease nurseries, 1993 Dec). Wilt incidence in the farmers' fields were found to be low in Gulbarga area and farmers primarily attribute this improvement to the widespread cultivation of wilt resistant variety Maruthi (ICP 8863) in the area.

A major observation in this study is the existence of various adoption regimes due to the varying seed sector support and extension conditions. The potential benefit of lifting the above adoption constraints, e.g. via facilitation of release of improved varieties, is significant, estimated to be in the order of US$116 million.

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Table 1a. Pigeonpea area ('000 ha) in three adoption regions: (a) N. Karnataka; (b) Border districts of Andhra Pradesh and Maharashtra; and (c) Maharashtra and Madhya Pradesh, 1980-90.

	Years											
State	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average 1988-199
N. Karnataka	198.0	218.1	140.7	232.1	240.3	243.6	259.2	279.6	298.1	302.0	302.4	301
Border dist of AP+Mah	168.5	171.3	167.3	172.2	170.8	170.9	166.2	185.1	213.1	231.3	232.9	226
Mah+MP (WO Osmanabad)	500.2	505.7	522.2	537.2	572.2	577.1	576.0	579.3	657.8	699.4	743.6	700
Total	866.8	895.0	830.2	941.6	983.3	991.6	1001.3	1044.0	1168.9	1232.7	1278.9	1227

Table 1b. Pigeonpea production ('000 t) in three adoption regions: (a) N. Karnataka; (b) Border districts of Andhra Pradesh and Maharashtra; and (c) Maharashtra and Madhya Pradesh, 1980-90.

	Years											
State	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Average 1988-199
N. Karnataka	55.2	112.0	67.4	88.4	127.3	123.6	110.3	141.4	111.1	127.2	115.5	118
Border dist of AP+Mah	46.7	60.3	52.7	76.0	70.8	57.9	33.2	75.8	49.3	100.9	47.3	66
Mah+MP (WO Osmanabad)	285.6	342.5	349.2	381.9	391.6	393.3	333.7	431.3	528.5	587.3	363.1	493
Total	387.5	514.8	469.2	546.3	589.7	574.8	477.1	648.4	688.9	815.4	525.9	677

Table 2.

Pigeonpea seed sales by Karnataka State Seeds Corporation.

				Year			
	1988	1989	1990	1991	1992	1993	1994
Variety							
ICPL87				3.4	11.7	17.6	10
HY3C	14.3	18.5	25.2	11	12.4	2.1	20
GS1	53.4	52.6	46.9		32.6	21	30
TTB7		13.9	9.9	38.4	35.8	36	40
PT221	23.9	30.7	21.3	51.9	28.1	21.6	60
MARUTHI	12.6	16.2	49	98.8	82.5	79.4	140

COST ANALYSIS FOR ICP 8863 RESEARCH

Table 3 Cost Analysis of Research Impacts for ICP 8863 (MARUTHI) in Production System 7, India.

Output/Cost Item	Unit	Best Cultivar Used Before ICP 8863			ICP 8863 (Maruthi)		
		Unit Price (Rs)	Quantity	Cost (Rs)	Unit Price (Rs)	Quantity	Cost (Rs)
STATE : KARNATAKA							
COST INFORMATION per hectare per year							
VARIABLE COSTS :							
Male Labor							
. Land Preparation	Days	20.00	7.00	140.00		8.00	160.00
. FYM application	Days	20.00	2.47	49.40		0.64	12.80
. Planting	Days	30.00	1.85	55.50		1.25	37.50
. Weeding	Days	20.00	0.82	16.40		-	-
. Fertilizer	Days	20.00	0.41	8.20		-	-
. Interculture	Days	20.00	4.00	80.00		5.40	108.00
. Irrigation	Days	20.00	1.24	24.80		3.00	60.00
. Spraying	Days	25.00	6.00	150.00		7.00	175.00
. Harvesting	Days	25.00	5.35	133.75		7.00	175.00
. Threshing	Days	25.00	6.18	154.50		3.82	95.50
Female Labor							
. Land Preparation	Days	12.00	6.00	72.00		8.00	96.00
. FYM application	Days	12.00	3.29	39.48		0.55	6.60
. Planting	Days	13.50	2.00	27.00		3.35	45.23
. Weeding	Days	13.50	17.00	229.50		17.40	234.90
. Fertilizer	Days	12.00	1.44	17.28		2.71	32.52
. Interculture	Days	-	-	-		-	-
. Irrigation	Days	-	-	-		-	-
. Spraying	Days	-	-	-		-	-
. Harvesting	Days	13.50	3.29	44.42		1.10	14.85
. Threshing	Days	13.50	12.30	166.05		11.25	151.88
Bullock Labor							
Land Preparation	Days	50.00	6.00	300.00		6.00	300.00
. FYM application	Days	50.00	3.00	150.00		0.46	23.00
Planting	Days	65.00	1.65	107.25		1.18	76.70
. Fertilizer	Days	-	-	-		-	-
. Interculture	Days	50.00	2.00	100.00		4.00	200.00
. Spraying	Days	50.00	-	-		0.46	23.00
. Harvesting	Days	60.00	-	-		-	-
. Threshing	Days	60.00	0.82	49.20		1.14	68.40
Seeds	Kgs.	15.00	12.35	185.25	18.00	9.50	171.00
Farm Yard Manure	Qtl.	15.00	52.69	790.35		8.23	123.45
Fertilizer							
. Urea	Kgs	2.70	-	-		36.36	98.17
. DAP	Kgs	6.50	70.00	455.00		53.06	344.89
. SSP	Kgs	3.00	-	-		3.43	10.29
. 20:20:0	Kgs	5.40	-	-		30.87	166.70
. 15:15:15	Kgs	5.20	20.58	107.02		-	-
Chemicals (pesticide)	Lts.	240.00	1.65	396.00		1.70	408.00
Equipment							
. Land Preparation	Days	800.00	-	-		0.07	56.00
. Irrigation	Days	16.00	1.03	16.48		2.15	34.40
Miscellaneous				203.24			175.49
TOTAL VARIABLE COSTS				4268.06			3685.26

Table 3. Cost Analysis of Research Impacts for ICP 8863 (MARUTHI) in Production System 7, India.

Output/Cost Item	Unit	Best Cultivar Used Before ICP 8863			ICP 8863 (Maruthi)		
STATE : KARNATAKA		Unit Price (Rs)	Quantity	Cost (Rs)	Unit Price (Rs)	Quantity	Cost (Rs)
FIXED COSTS							
. Owned land : tax				60.00			60.00
. Land rent				1200.00			1200.00
. Depreciation & interest on Capital				810.00			810.00
Total Fixed Costs				2070.00			2070.00
TOTAL COST				6338.06			5755.26
Output per hectare per year							
. Grain	Kgs	5.47	700.00	3829	4.97	1099.61	5465.06
. By-product	Qtl	120.00	5	600	120	7.25	870.00
. Stalk	Qtl	20.00	15	300	20	19	380.00
Total value of output	Rs			4729			6715.0617
Percentage Change							680.72
. Grain							42.73
. By-product							45.00
. Stalk							26.67
UNIT COST ASSESSMENT							
Unit Variable cost	Rs/ton			6097.23			3351.42
Unit Fixed Cost	Rs/ton			2957.14			1882.49
Unit Total Cost	Rs/ton			9054.37			5233.91
UNIT COST REDUCTION							
Unit Variable Cost Reduction	Rs/ton						2745.81
Unit Fixed Cost Reduction	Rs/ton						1074.66
Unit Total Cost Reduction	Rs/ton						3820.47
Percentage Unit Cost Reduction							42.19

Table 4a. Breakdown of research cost for fusarium wilt research in ICRISAT and the NARS.

Year	ICRISAT	NARS
1975-76	-	$ 845 Selection from landrace
1977	$ 5,070	$ 845 Original collection sown in wilt-sick plot at ICRISAT
1978-80	$42,250	$ 845 Further purification
1981-83	$42,250	$ 845 Multi-location screening for Fusarium wilt resistance
1984-85	-	$1267.5 On-station and on-farm adaptive trials
1986-89		$2535 Seed multiplication and extension after release

Basis: Research Team Member for Fusarium Wilt Research	Full Cost	Proportion of time in Project	Budget Allocation
1 Principal Scientist	$80,000	18%	$14400
1 National Scientist	$ 8,000	100%	$ 8000
1 Research Associate	$ 2,400	100%	$ 2400
1 Field Assistant	$ 1,200	100%	$ 1200
3 Regular Work Force	$ 1,250	100%	$ 1250
Operating Expenses			$15,000
Total ICRISAT			$42,250
NARS On-station trials			$ 845.00
On-farm demonstrations			$1267.50
Seed Multiplication/Extension			$2535.00

Table 4b. Breakdown of research cost for fusarium wilt research in ICRISAT and the NARS (low range funding scenario).

Year	ICRISAT	NARS	
1975-76	-	$ 662	Selection from landrace
1977	$ 3,309	$ 662	Original collection sown in wilt-sick plot at ICRISAT
1978-80	$33,091	$ 662	Further purification
1981-83	$33,091	$ 662	Multi-location screening for Fusarium wilt resistance
1984-85	-	$ 993	On-station and on-farm adaptive trials
1986-89		$1985	Seed multiplication and extension after release

Basis: Research Team Member for Fusarium Wilt Research	Full Cost	Proportion of time in Project	Budget Allocation
1 Principal Scientist	$80,000	9%	$ 7241
1 National Scientist	$ 8,000	75%	$ 6000
1 Research Associate	$ 2,400	100%	$ 2400
1 Field Assistant	$ 1,200	100%	$ 1200
3 Regular Work Force	$ 1,250	100%	$ 1250
Operating Expenses			$15,000
Total ICRISAT			$33,091
NARS On-station trials			$ 662.00
On-farm demonstrations			$ 993.00
Seed Multiplication/Extension			$1985.46

Table 5 Adoption of ICP 8863 (Maruti) pigeonpea in Karnataka, Maharashtra and Andhra Pradesh.

Year	Karnataka	Karnataka Borders		Maharashtra
		Rangareddy (Andhra Pradesh)	Osmanabad (Maharashtra)	
1987	4.81	0.00	0.00	0.00
1988	8.82	0.00	12.85	0.00
1989	8.57	3.48	24.29	2.20
1990	17.97	10.16	18.57	2.02
1991	55.09	34.27	36.62	3.99
1992	59.43	48.90	40.59	13.15
1993	58.94	51.77	58.71	17.71

ECONOMIC ASSESSMENT OF WILT RESISTANT MEDIUM DURATION PIGEONPEAS ICP 8863 IN THE SEMI-ARID TROPICS OF INDIA

Collaborating Institutions :

International Crops Institute for the Semi-arid Tropics
Indian Council for Agricultural Research

Tables of Information :

DAT	Background Data
COST	Cost Analysis
BCA	Summary Data for Benefit Assessment
BCB	Detail of Benefits and Research Costs
SUM	Summary of Results

Table 6. Background Information. Wilt Endemic Regions in Central and Peninsular India (ICRISAT IAC Production System 7)

Year	Total Area ('000 ha)		Karnataka Total Production ('000 Met Ton)		Price (Rupees / Metric To	AP and Mah. borders Total Production ('000 Met Ton)		Price (Rupees / Metric To	Mah. and MP Total Production ('000 Met Ton)		Price (Rupees / Metric Ton)
1970	732.48		74.21			45.8			237.43		
1971	649.19		50.48			29.675			223.62		
1972	640.373		20.76			23.545			192.453		
1973	758.724		50.325			42.375			281.385		
1974	746.983		80.13			43.08			310.37		
1975	795.733		131.015			54.62			327.503		
1976	751.571		78.395			37.545			216.617		
1977	769.196		116.845			38.05			259.057		
1978	807.412		115.715			51.9			297.169		
1979	799.303		137.35			57.355			320.576		
1980	866.76		55.25			46.655			285.57		
1981	895.05		112.00			60.305			342.47		
1982	830.17		67.38			52.69			349.16		
1983	941.55		88.42			76.01			381.85		
1984	983.28		127.34			70.795			391.61		
1985	991.56		123.57			57.92			393.28		
1986	1001.31		110.30		4605	33.15		4332.24	333.68		5150.1
1987	1044.00	1071418	141.40	120935	6450	75.75	52716.67	6328.76	431.25	431157	6019.8
1988	1168.95		111.11		5350	49.25		5877.22	528.54		5316.4
1989	1232.692		127.245			100.905			587.27		
1990	1278.929		115.4605			47.295			363.148		

Sources : Indian Agricultural Statistics,
Agricultural Situation in India

Table 7.
Summary Data for Benefit Assessment

Base Level of production	120935	Metric Tonnes
Yield Change due to desease	42.73	percent
Base Price Level	5468	Rs/ton
Supply Elasticity	0.2	
Demand Elasticity	0.5	

Benefit Assessment		
Discount Rate	0.08	
IRR Guess	0.08	

Intermediate Data:		
Total Unit Cost Reduction	3820.466	Rs/ton
Slope of Supply Curve	4.423015	
Slope of Demand Curve	11.05754	
Exchange Rate	30.9	

Table 8. Analysis For ICP 8863 (Maruthi) Research. Karnataka

Year	Net Benefits (SUS)	Research Costs (SUS) Total	ICRISAT	ICAR/ Other Institutions	Research Gains (SUS) Total	Adoption Level	Annual Gains	Gains to Consumers	(%)	Gains to Producers	(%)
Present Value	74,994,509	181782	171,075	10,707	23,743,395			6,783,827		16,959,568	
Total	371451319	278428	257,725	20,703	105,023,144			30,006,612		75,016,531	
1975	(845)	845	0	845							
1976	(845)	845	0	845	0						
1977	(5,070)	5,070	4,225	845	0						
1978	(43,095)	43,095	42,250	845	0						
1979	(43,095)	43,095	42,250	845	0						
1980	(43,095)	43,095	42,250	845	0	0					
1981	(43,518)	43,518	42,250	1,268	0	0					
1982	(43,518)	43,518	42,250	1,268	0	0	0				
1983	(43,518)	43,518	42,250	1,268	0	0	0				
1984	(1,268)	1,268	0	1,268	0	0	0				
1985	(1,268)	1,268	0	1,268							
1986	782,391	2,535	0	2535	784,926	0.05	15,698,527	224,265	28.57	560,662	71.43
1987	1,410,332	2,535	0	2535	1,412,867	0 09	15,698,527	403,676	28.57	1,009,191	71.43
1988	2,709,339	2,535	0	2535	1,412,867	0.09	15,698,527	403,676	28.57	1,009,191	71.43
1989	4,630,689	2,535	0	2535	2,825,735	0.18	15,698,527	807,353	28.57	2,018,382	71.43
1990	13,266,132	0			8,634,190	0 55	15,698,527	2,466,911	28.57	6,167,278	71.43
1991	19,848,563	0			9,262,131	0.59	15,698,527	2,646,323	28.57	6,615,808	71.43
1992	22,769,198	0			9,262,131	0 59	15,698,527	2,646,323	28.57	6,615,808	71.43
1993	26,709,982	0			9,419,116	0.6	15,698,527	2,691,176	28.57	6,727,940	71.43
1994	33,196,494	0			9,419,116	0.6	15,698,527	2,691,176	28.57	6,727,940	71.43
1995	37,520,836	0			9,419,116	0.6	15,698,527	2,691,176	28.57	6,727,940	71.43
1996	39,438,623	0			8,634,190	0 55	15,698,527	2,466,911	28.57	6,167,278	71.43
1997	30,806,733	0			6,279,411	0 4	15,698,527	1,794,117	28.57	4,485,293	71.43
1998	23,105,049	0			4,709,558	0 3	15,698,527	1,345,588	28.57	3,363,970	71.43
1999	23,105,049	0			4,709,558	0 3	15,698,527	1,345,588	28.57	3,363,970	71.43
2000	23,105,049	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43
2001	23,105,049	0			4,709,558	0 3	15,698,527	1,345,588	28.57	3,363,970	71.43
2002	23,105,049	0			4,709,558	0 3	15,698,527	1,345,588	28.57	3,363,970	71.43
2003	23,105,049	0			4,709,558	0 3	15,698,527	1,345,588	28.57	3,363,970	71.43
2004	23,105,049	0			4,709,558	0 3	15,698,527	1,345,588	28.57	3,363,970	71.43
2005	23,105,049	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43

IRR = 0.725885

Table 8. Analysis Mah and MP

Year	Research Gains (SUS) Total	Adoption Level	Annual Gains	Gains to Consume	(%)	Gains to Producer	(%)
Present Value	42,498,221			12,142,349		30,355,872	
Total	224,865,761			64,247,360		160,618,401	
1975							
1976	0						
1977	0						
1978	0						
1979	0						
1980	0	0					
1981	0	0					
1982	0	0	0				
1983	0	0	0				
1984	0	0	0				
1985							
1986	0	0	54,054,270	0		0	
1987	0	0	54,054,270	0		0	
1988	1,081,085	0.02	54,054,270	308,882	28.57	772,204	71.43
1989	1,081,085	0.02	54,054,270	308,882	28.57	772,204	71.43
1990	2,162,171	0.04	54,054,270	617,763	28.57	1,544,408	71.43
1991	7,027,055	0.13	54,054,270	2,007,730	28.57	5,019,325	71.43
1992	9,729,769	0.18	54,054,270	2,779,934	28.57	6,949,835	71.43
1993	13,513,567	0.25	54,054,270	3,861,019	28.57	9,652,548	71.43
1994	20,000,080	0.37	54,054,270	5,714,308	28.57	14,285,771	71.43
1995	24,324,421	0.45	54,054,270	6,949,835	28.57	17,374,587	71.43
1996	27,027,135	0.5	54,054,270	7,722,039	28.57	19,305,096	71.43
1997	21,621,708	0.4	54,054,270	6,177,631	28.57	15,444,077	71.43
1998	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43
1999	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43
2000	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43
2001	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43
2002	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43
2003	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43
2004	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43
2005	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43

Table 8. Analysis AP and Mah borders

Year	Research Gains (SUS) Total	Adoption Level	Annual Gains	Gains to Consume	(%)	Gains to Producer	(%)
Present Value	8,934,675			2,552,764		6,381,911	
Total	41,840,842			11,954,526		29,886,316	
1975							
1976	0						
1977	0						
1978	0						
1979	0						
1980	0	0					
1981	0	0					
1982	0	0	0				
1983	0	0	0				
1984	0	0	0				
1985							
1986	0	0	7,264,035	0		0	
1987	0	0	7,264,035	0		0	
1988	217,921	0.03	7,264,035	62,263	28 57	155,658	71.43
1989	726,404	0.1	7,264,035	207,544	28.57	518,860	71.43
1990	2,469,772	0.34	7,264,035	705,649	28.57	1,764,123	71.43
1991	3,559,377	0 49	7,264,035	1,016,965	28 57	2,542,412	71.43
1992	3,777,298	0.52	7,264,035	1,079,228	28.57	2,698,070	71.43
1993	3,777,298	0.52	7,264,035	1,079,228	28 57	2,698,070	71.43
1994	3,777,298	0.52	7,264,035	1,079,228	28 57	2,698,070	71 43
1995	3,777,298	0 52	7,264,035	1,079,228	28.57	2,698,070	71.43
1996	3,777,298	0.52	7,264,035	1,079,228	28 57	2,698,070	71.43
1997	2,905,614	0 4	7,264,035	830,175	28 57	2,075,439	71.43
1998	2,179,211	0.3	7,264,035	622,632	28.57	1,556,579	71.43
1999	2,179,211	0 3	7,264,035	622,632	28.57	1,556,579	71 43
2000	2,179,211	0 3	7,264,035	622,632	28 57	1,556,579	71.43
2001	2,179,211	0 3	7,264,035	622,632	28 57	1,556,579	71.43
2002	2,179,211	0.3	7,264,035	622,632	28 57	1,556,579	71 43
2003	2,179,211	0 3	7,264,035	622,632	28 57	1,556,579	71.43
2004	2,179,211	0 3	7,264,035	622,632	28 57	1,556,579	71.43
2005	2,179,211	0 3	7,264,035	622,632	28 57	1,556,579	71.43

Table 8. Analysis For ICP 8863 (Maruthi) Research. Karnataka

Year	Net Benefits ($US)	Research Costs ($US) Total	ICRISAT	ICAR/ Other Institutions	Research Gains ($US) Total	Adoption Level	Annual Gains	Gains to Consumers	(%)	Gains to Producers	(%)
Present Value	23,561,613	181782	171,075	10,707	23,743,395			6,783,827		16,959,568	
Total	104744716	278428	257,725	20,703	105,023,144			30,006,612		75,016,531	
1975	(845)	845	0	845							
1976	(845)	845	0	845	0						
1977	(5,070)	5,070	4,225	845	0						
1978	(43,095)	43,095	42,250	845	0						
1979	(43,095)	43,095	42,250	845	0						
1980	(43,095)	43,095	42,250	845	0	0					
1981	(43,518)	43,518	42,250	1,268	0	0					
1982	(43,518)	43,518	42,250	1,268	0	0	0				
1983	(43,518)	43,518	42,250	1,268	0	0	0				
1984	(1,268)	1,268	0	1,268	0	0	0				
1985	(1,268)	1,268	0	1,268							
1986	782,391	2,535	0	2535	784,926	0.05	15,698,527	224,265	28.57	560,662	71.43
1987	1,410,332	2,535	0	2535	1,412,867	0.09	15,698,527	403,676	28.57	1,009,191	71.43
1988	1,410,332	2,535	0	2535	1,412,867	0.09	15,698,527	403,676	28.57	1,009,191	71.43
1989	2,823,200	2,535	0	2535	2,825,735	0.18	15,698,527	807,353	28.57	2,018,382	71.43
1990	8,634,190	0			8,634,190	0.55	15,698,527	2,466,911	28.57	6,167,278	71.43
1991	9,262,131	0			9,262,131	0.59	15,698,527	2,646,323	28.57	6,615,808	71.43
1992	9,262,131	0			9,262,131	0.59	15,698,527	2,646,323	28.57	6,615,808	71.43
1993	9,419,116	0			9,419,116	0.6	15,698,527	2,691,176	28.57	6,727,940	71.43
1994	9,419,116	0			9,419,116	0.6	15,698,527	2,691,176	28.57	6,727,940	71.43
1995	9,419,116	0			9,419,116	0.6	15,698,527	2,691,176	28.57	6,727,940	71.43
1996	8,634,190	0			8,634,190	0.55	15,698,527	2,466,911	28.57	6,167,278	71.43
[illegible]	6,279,411	0			6,279,411	0.4	15,698,527	1,794,117	28.57	4,485,293	71.43
[illegible]	4,709,558	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43
[illegible]	4,709,558	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43
[illegible]	4,709,558	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43
[illegible]	4,709,558	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43
[illegible]	4,709,558	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43
2003	4,709,558	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43
2004	[illegible]709,558	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43
2005	4,709,558	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43

IRR = 0.637656

Table 8. Analysis For ICP 8863 (Maruthi) Research. Kamataka

Year	Net Benefits (SUS)	Research Costs (SUS) Total	ICRISAT	ICAR/ Other Institutions	Research Gains (SUS) Total	Adoption Level	Annual Gains	Gains to Consumers	(%)	Gains to Producers	(%)
Present Value	116,303,100	181782	171,075	10,707	23,743,395			6,783,827		16,959,568	
Total	514964174	278428	257,725	20,703	105,023,144			30,006,612		75,016,531	
1975	(845)	845	0	845							
1976	(845)	845	0	845	0						
1977	(5,070)	5,070	4,225	845	0						
1978	(43,095)	43,095	42,250	845	0						
1979	(43,095)	43,095	42,250	845	0						
1980	(43,095)	43,095	42,250	845	0	0					
1981	(43,518)	43,518	42,250	1,268	0	0					
1982	(43,518)	43,518	42,250	1,268	0	0	0				
1983	(43,518)	43,518	42,250	1,268	0	0	0				
1984	(1,268)	1,268	0	1,268	0	0	0				
1985	(1,268)	1,268	0	1,268							
1986	3,848,307	2,535	0	2535	784,926	0.05	15,698,527	224,265	28.57	560,662	71.43
1987	6,928,980	2,535	0	2535	1,412,867	0.09	15,698,527	403,676	28.57	1,009,191	71.43
1988	6,928,980	2,535	0	2535	1,412,867	0.09	15,698,527	403,676	28.57	1,009,191	71.43
1989	13,860,495	2,535	0	2535	2,825,735	0.18	15,698,527	807,353	28.57	2,018,382	71.43
1990	42,359,257	0			8,634,190	0.55	15,698,527	2,466,911	28.57	6,167,278	71.43
1991	45,439,930	0			9,262,131	0.59	15,698,527	2,646,323	28.57	6,615,808	71.43
1992	45,439,930	0			9,262,131	0.59	15,698,527	2,646,323	28.57	6,615,808	71.43
1993	46,210,099	0			9,419,116	0.6	15,698,527	2,691,176	28.57	6,727,940	71.43
1994	46,210,099	0			9,419,116	0.6	15,698,527	2,691,176	28.57	6,727,940	71.43
1995	46,210,099	0			9,419,116	0.6	15,698,527	2,691,176	28.57	6,727,940	71.43
1996	42,359,257	0			8,634,190	0.55	15,698,527	2,466,911	28.57	6,167,278	71.43
1997	30,806,733	0			6,279,411	0.4	15,698,527	1,794,117	28.57	4,485,293	71.43
1998	23,105,049	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43
1999	23,105,049	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43
2000	23,105,049	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43
2001	23,105,049	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43
2002	23,105,049	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43
2003	23,105,049	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43
2004	23,105,049	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43
2005	23,105,049	0			4,709,558	0.3	15,698,527	1,345,588	28.57	3,363,970	71.43

IRR = 0.913165

Table 8. Analysis AP and Mah borders

Year	Research Gains (SUS) Total	Adoption Level	Annual Gains	Gains to Consum	(%)	Gains to Producer	(%)
Present Value	10,986,563			3,139,018		7,847,545	
Total	48.596,395			13,884,684		34,711,711	
1975							
1976	0						
1977	0						
1978	0						
1979	0						
1980	0	0					
1981	0	0					
1982	0	0	0				
1983	0	0	0				
1984	0	0	0				
1985							
1986	363,202	0.05	7,264,035	103,772		259,430	
1987	653,763	0.09	7,264,035	186,789		466,974	
1988	653,763	0.09	7,264,035	186,789	28.57	466,974	71.43
1989	1,307,526	0.18	7,264,035	373,579	28.57	933,947	71.43
1990	3,995,219	0.55	7,264,035	1,141,491	28.57	2,853,728	71.43
1991	4,285,781	0 59	7,264,035	1,224,509	28.57	3,061,272	71.43
1992	4,285,781	0.59	7,264,035	1,224,509	28.57	3,061,272	71.43
1993	4,358,421	0 6	7,264 035	1,245,263	28 57	3,113,158	71.43
1994	4,358,421	0 6	7,264,035	1,245,263	28 57	3,113,158	71.43
1995	4,358,421	0 6	7,264,035	1,245,263	28 57	3,113,158	71.43
1996	3,995,219	0 55	7,264 035	1,141,491	28 57	2,853,728	71.43
1997	2,905,614	0 4	7,264,035	830,175	28 57	2,075,439	71 43
1998	2,179,211	0.3	7,264.035	622,632	28 57	1,556,579	71.43
1999	2,179,211	0 3	7,264.035	622,632	28 57	1,556,579	71 43
2000	2,179,211	0 3	7,264.035	622,632	28 57	1,556,579	71 43
2001	2,179,211	0 3	7,264,035	622,632	28 57	1,556,579	71.43
2002	2,179.211	0.3	7,264,035	622,632	28.57	1,556,579	71.43
2003	2,179,211	0.3	7,264.035	622,632	28.57	1,556,579	71 43
2004	2,179,211	0.3	7,264,035	622,632	28 57	1,556,579	71.43
2005	2,179,211	0.3	7,264,035	622,632	28 57	1,556,579	71.43

Table 8. Analysis Mah and MP

Year	Research Gains (SUS) Total	Adoption Level	Annual Gains	Gains to Consum	(%)	Gains to Producer	(%)
Present Value	81,754,924			23,358,550		58,396,374	
Total	361,623,063			103,320,875		258,302,188	
1975							
1976	0						
1977	0						
1978	0						
1979	0						
1980	0	0					
1981	0	0					
1982	0	0	0				
1983	0	0	0				
1984	0	0	0				
1985							
1986	2,702,713	0.05	54,054,270	772,204		1,930,510	
1987	4,864,884	0.09	54,054,270	1,389,967		3,474,917	
1988	4,864,884	0.09	54,054,270	1,389,967	28.57	3,474,917	71.43
1989	9,729,769	0.18	54,054,270	2,779,934	28.57	6,949,835	71.43
1990	29,729,848	0.55	54,054,270	8,494,242	28.57	21,235,606	71.43
1991	31,892,019	0.59	54,054,270	9,112,005	28.57	22,780,014	71.43
1992	31,892,019	0.59	54,054,270	9,112,005	28.57	22,780,014	71.43
1993	32,432,562	0.6	54,054,270	9,266,446	28.57	23,166,116	71.43
1994	32,432,562	0.6	54,054,270	9,266,446	28.57	23,166,116	71.43
1995	32,432,562	0.6	54,054,270	9,266,446	28.57	23,166,116	71.43
1996	29,729,848	0.55	54,054,270	8,494,242	28.57	21,235,606	71.43
1997	21,621,708	0.4	54,054,270	6,177,631	28.57	15,444,077	71.43
1998	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43
1999	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43
2000	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43
2001	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43
2002	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43
2003	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43
2004	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43
2005	16,216,281	0.3	54,054,270	4,633,223	28.57	11,583,058	71.43

Figure 1.

Pigeonpea in India

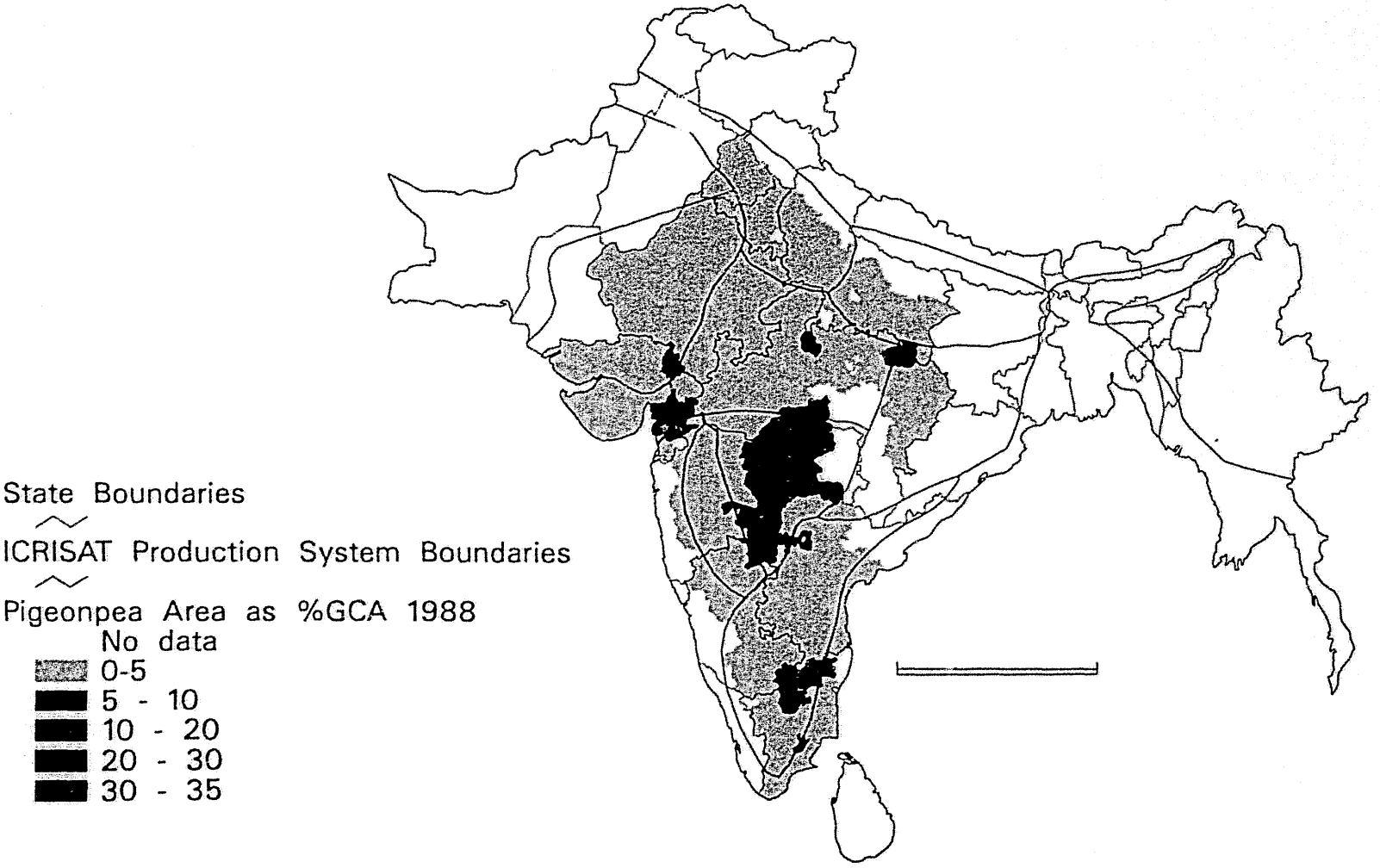


Figure 2.

Percent of Pigeonpea wilt 1975-76

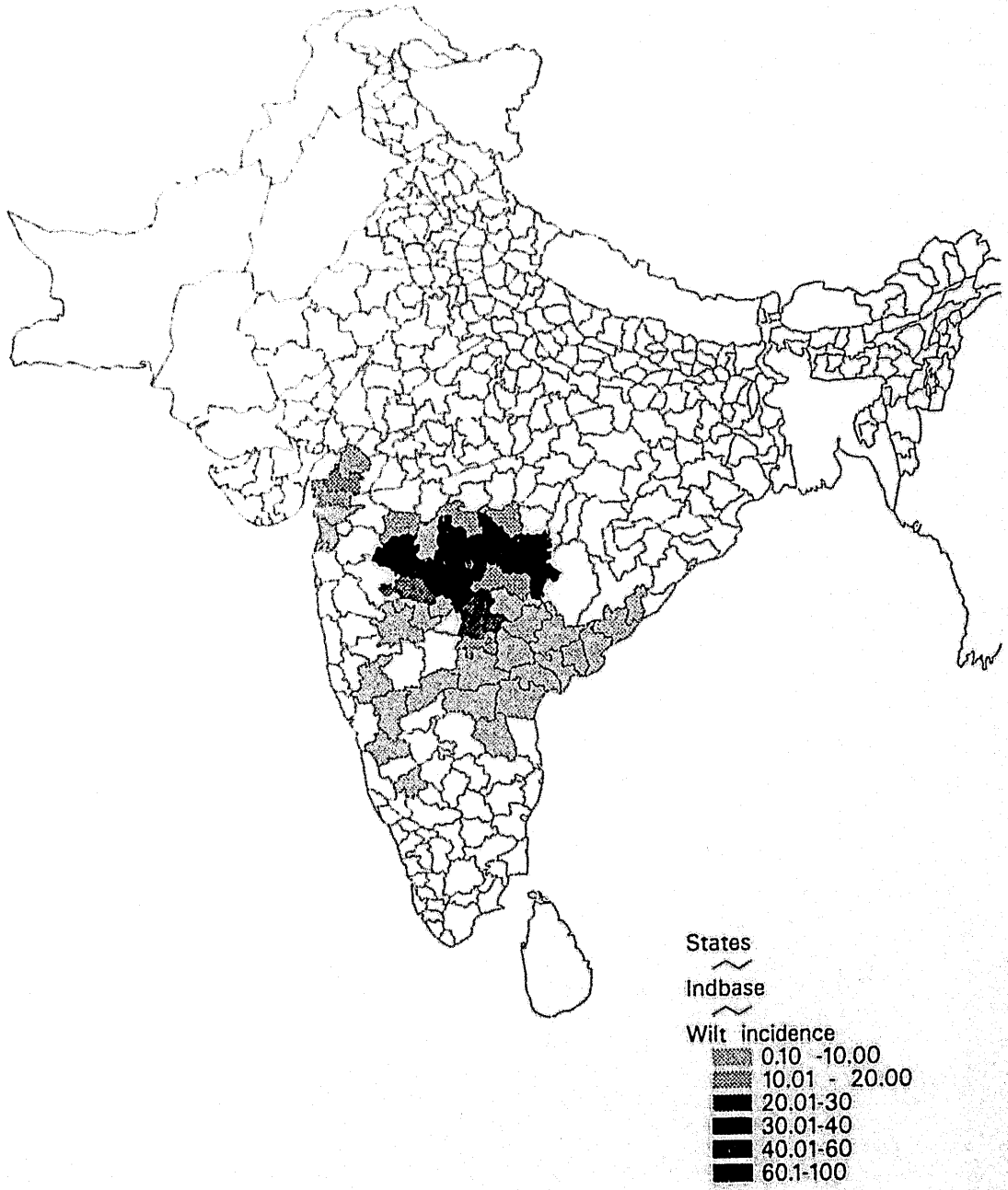


Figure 3.

Pigeonpea seed sales by Karnataka State Seeds Corporation, 1988-94.

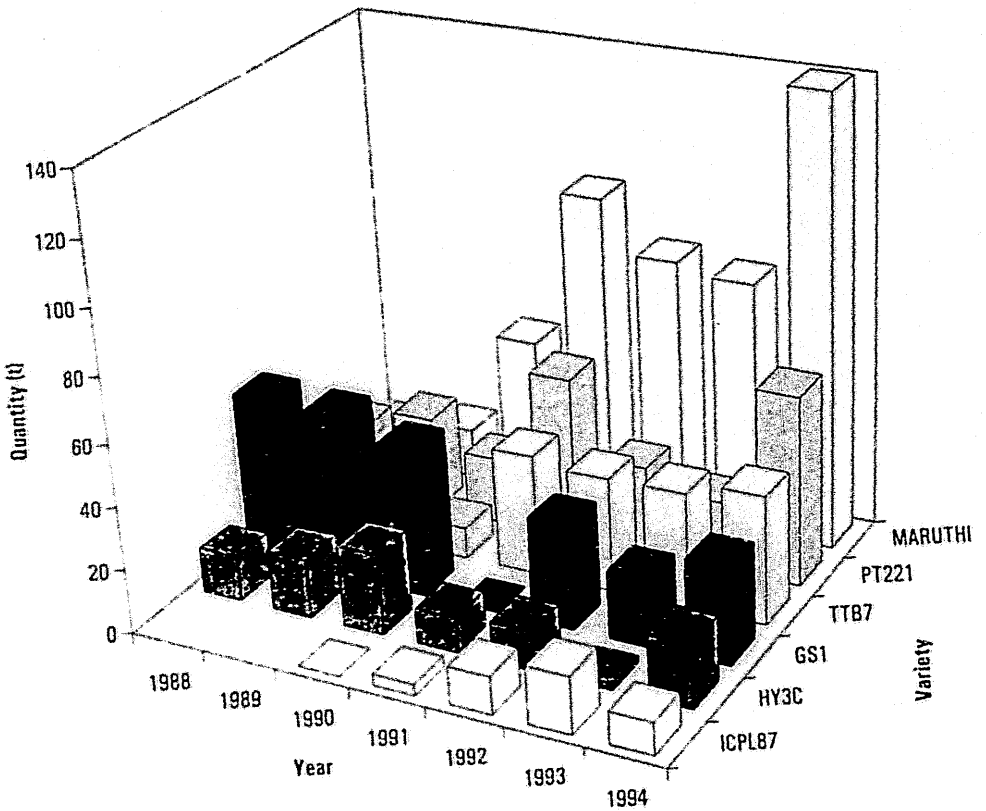
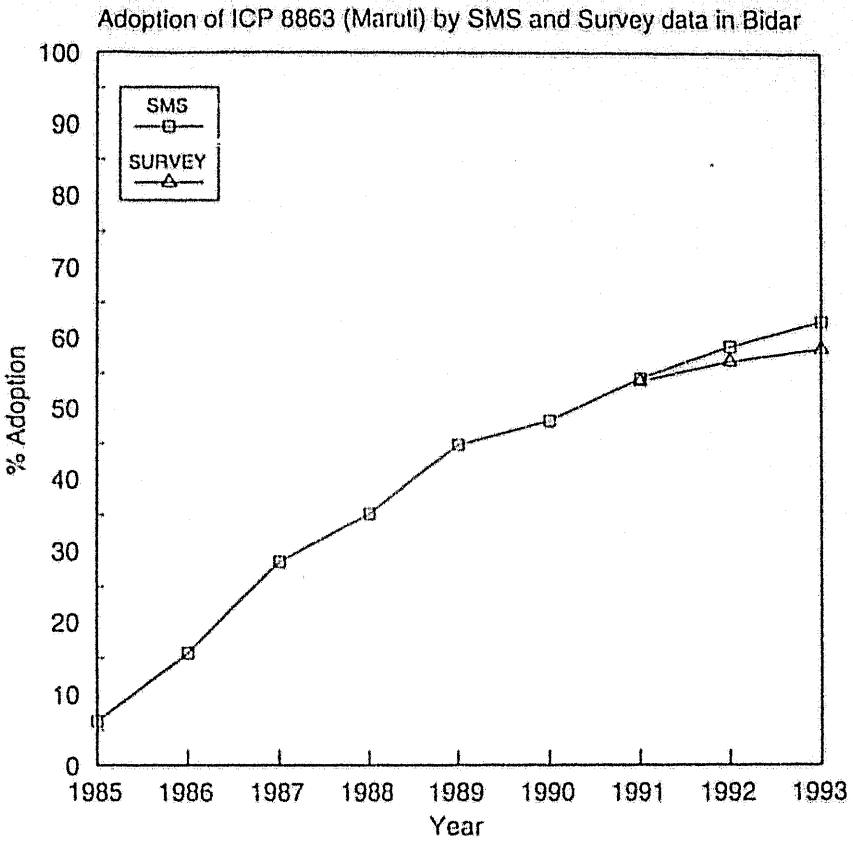
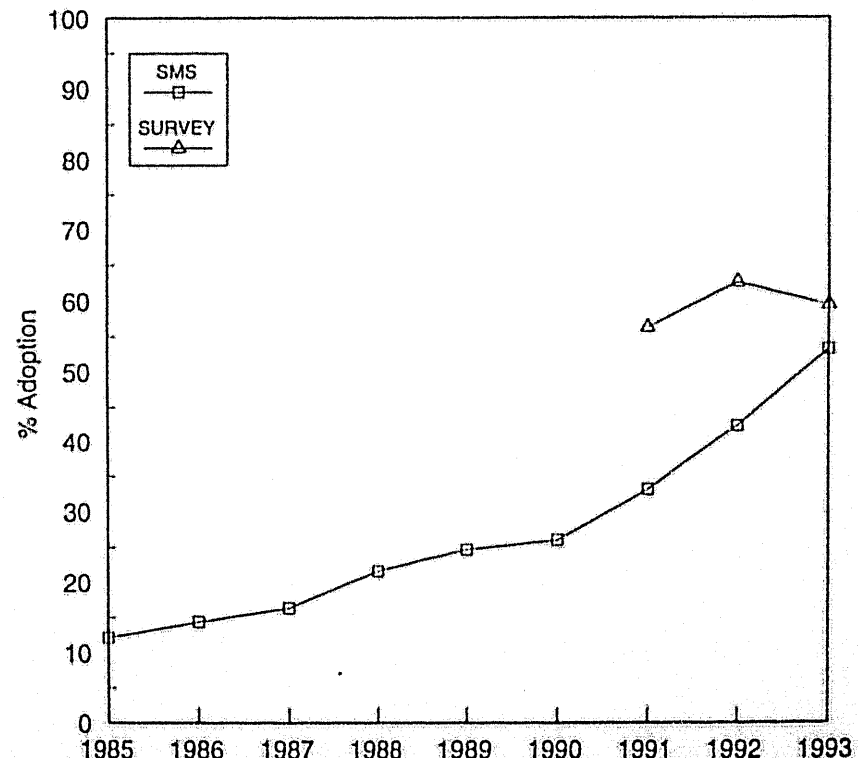


Figure 4.

(a)


Adoption of ICP 8863 (Maruti) by SMS and Survey data in Bidar
SMS
SURVEY
% Adoption
Year
0
10
20
30
40
50
60
70
80
90
100
1985
1986
1987
1988
1989
1990
1991
1992
1993

(b)


Adoption of ICP 8863 (Maruti) by SMS and Survey data in Gulbarga
SMS
SURVEY
% Adoption
0
10
20
30
40
50
60
70
80
90
100
1985
1986
1987
1988
1989
1990
1991
1992
1993