Report on Socio-Economic Impact Assessment of Improved Samba Mahsuri (ISM)

National Institute of Agricultural Extension Management (MANAGE)

Rajendranagar, Hyderabad-30 (TS)

Citation: Reddy A Amarender (2018) Report on Socio-Economic Impact Assessment of Improved Samba Mahsuri (ISM), National Institute of Agricultural Extension Management (MANAGE), Rajendranagar, Hyderabad – 500030, Telangana State, India. 68 pp.

Report on Socio-Economic Impact Assessment of Improved Samba Mahsuri (ISM)

**A Study Report by the National Institute of Agricultural Extension Management (MANAGE)
for CSIR-Centre for Cellular and Molecular Biology (CCMB), Hyderabad**

**National Institute of Agricultural Extension Management (MANAGE)
Rajendranagar, Hyderabad-30 (TS)**

सीसीएमबी CSIR CCMB

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Dr. Rakesh K. Mishra
Director

Foreword

Rice is one of the most important crops in our country and is crucial for our food security. It is my pleasure to present this socio-economic impact assessment of Improved Samba Mahsuri (ISM) rice jointly developed by CSIR-Centre for Cellular & Molecular Biology (CSIR-CCMB) and ICAR-Indian Institute of Rice Research (ICAR-IIRR). I am very proud that the two organizations took up the challenge of eliminating bacterial blight disease that can cause yield losses between 25-50% to the crop and worked together to deliver a variety that is resistant to this, otherwise, unmanageable disease. This variety not only has bacterial blight resistance, higher yield and fine quality but it also has low glycemic index which makes it beneficial to diabetic people. Furthermore, this is one of the fine rice variety popular across the country, be it in South India or the northern part of the country. Currently, ISM developed by CSIR-CCMB and ICAR-IIRR is grown in 8 states, as indicated in this report.

This success story highlights the use of a biotechnology tool like marker-assisted selection in rice breeding and demonstrates that highly valuable products can be obtained using combination of modern and traditional approaches. This provides an example where difficult problems can be addressed and solutions can be delivered to the stakeholders within a reasonable time span when organizations with complementary expertise join hands. The coordinated and collaborative activity of two big organizations, viz., Council of Scientific and Industrial Research (CSIR) on the one hand and Indian Council of Agricultural Research (ICAR) on the other, led by their laboratories, viz., CSIR-CCMB and ICAR-IIRR, demonstrates how two public organizations can work together for a greater cause. I think this should serve as an example for many other organizations to come together to solve some of our national problems that need to be addressed.

I would also like to thank the National Institute of Agricultural Extension Management (MANAGE) who carried out this extensive study and presented this exhaustive report appropriately highlighting the impact of ISM rice variety. I am also thankful to the CSIR for consistently supporting this project right from the beginning all the way up to the popularization of this variety and continuing to do so to achieve the desired impact of this work by delivering it to the farmers.

We look forward to many such projects in the future as well.

[Rakesh Mishra]

Preface

Rice is an important food crop all over the world. India is a major producer of rice accounting for 42.50 million ha and production of 110 million MT accounting for 28.33 percent of area and 22.13 percent of production.

The major problems faced in cultivation of rice are low yield and lack of improved varieties resistant to pests and diseases. One of the major problems in rice cultivation is its susceptibility to Bacterial Leaf Blight (BLB). Hence, researchers made efforts to develop improved varieties to overcome the problem of BLB and developed resistant varieties of rice accordingly.

However, the diffusion of these varieties slowed down in the recent years, resulting in stagnation of yields. Samba Mahsuri is one such variety which has got fine grain quality and is preferred among large section of consumers. However, this variety is susceptible to BLB. Keeping this in view, CSIR-Centre for Cellular and Molecular Biology (CCMB) in collaboration with Indian Institute of Rice Research (IIRR), developed Improved Samba Mahsuri which is resistant to BLB.

Cultivation of ISM variety was popularized by National Seeds Corporation (NSC) and State Seed Corporations (SSCs). This variety is cultivated in many states across the country. As a result, over a period of time area under ISM increased substantially due to its resistance to BLB. Due to its resistance to BLB, use of pesticides reduced leading to lower cost of cultivation and hence became popular among the farming community in the country. However, in few of the states in India, there is a scope to increase area under ISM variety.

In order to know the impact of ISM, CSIR-Centre for Cellular and Molecular Biology (CCMB) requested MANAGE to conduct a study to know the impact of ISM on socio-economic condition of the farmers. I appreciate the efforts of Dr. Amarendra Reddy, Director (Monitoring & Evaluation) and Principal Investigator and his team in conducting the study.

I hope, findings of the study will go a long way in popularizing cultivation of Samba Mahsuri and help the farming community in realising higher yields and thus leading to higher incomes. Hence, it is recommended that efforts should be made to popularize this variety across the States.

A handwritten signature in blue ink, likely belonging to V. Usha Rani, IAS.

(V. Usha Rani, IAS)

Director General

Acknowledgements

The study on "Socio-Economic Impact Assessment of Improved Samba Mahsuri (ISM)" was carried out at the National Institute of Agricultural Extension Management (MANAGE), Rajendranagar, Hyderabad, and was sponsored by the CSIR-Centre for Cellular and Molecular Biology (CCMB) Habsiguda, Hyderabad.

In carrying out this study, we have benefited immensely from the guidance of various scholars and officials from different government departments. At the outset, we would like to thank Smt. V Usha Rani, IAS, Director General of our institute as well as Dr. Rakesh K Mishra, Director, CSIR-CCMB and Dr. Ramesh V Sonti, Chief Scientist, CSIR-CCMB, for their constant encouragement and support throughout the study. Special thanks to Dr. Muthuraman, Dr. Sundaram and Dr. Subha Rao from ICAR-IIRR. We also thank Dr. M. R. Vishnupriya and Dr. Hitendra Kumar Patel from CSIR - CCMB.

We are grateful to Directors, Joint Directors and other officials from state departments of agriculture for their cooperation during the field survey as well as for their help in conducting Focus Group interactions and sharing their valuable suggestions. We thank Dr. Ratna Reddy, LNRMI, Hyderabad; Dr. Padma Raju, ex Vice Chancellor, PJTSAU, Rajendranagar; Dr. C.P. Chandrashekar, former Dean, PJTSAU, for their guidance and active involvement.

We thank our colleagues at MANAGE for their constant support and encouragement in carrying out the study.

We are also thankful to the field supervisors and surveyors for carrying out the field surveys and Focus Group interactions in different states and districts selected for the study across India. The study would not have reached this stage without the cooperation of cluster group leaders, who provided all the data required for the study without any hesitation and expectations. We thank each one of them for their invaluable support.

A Amarender Reddy
Principal Investigator

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Abbreviations

AICRIP	: All India Coordinated Rice Improvement Program
BLB	: Bacterial Leaf Blight
CCMB	: Centre for Cellular and Molecular Biology
CSISA	: Cereal Systems Initiative for South Asia
FS	: False Smut
FTF	: Feed the Future
IIRR	: Indian Institute of Rice Research
IRR	: Internal Rate of return
ISM	: Improved Samba Mahsuri
KVK	: Krishi Vigyan Kendra
NFSM	: National Food Security Mission
NGO	: Non-Governmental Organization
NSC	: National seed Corporation
PJTSAU	: Professor Jayashankar Telangana State Agricultural University
PMFBY	: Prime Minister Fasal Bhima Yojana
SAU	: State Agriculture University
SDA	: State Department of Agriculture
ShB	: Sheath Blight
SHG	: Self Help Group
ShR	: Sheath Rot
SM	: Samba Mahsuri
StR	: Stem Rot
STRASA	: Stress-Tolerant Rice for Africa and South Asia

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Executive Summary

The diffusion of improved varieties slowed down in the recent years, resulting in stagnation of yields. This study aimed at evaluating the development, diffusion and impact of improved rice variety with an overall objective to understand the varietal diffusion process and recommend policies for speedier diffusion, especially varieties developed by public sector institutions. Samba Mahsuri (SM) is a rice variety that has a fine grain quality and good cooking quality and taste, and thus it is widely accepted by consumers across many states. It is quite popular among farmers, millers and consumers given its varietal attributes. However, it is susceptible to many pests and diseases, especially Bacterial Leaf Blight (BLB). BLB is a common disease with loss ranging between 10 to 30% depending on the climate and local weather conditions. Appropriate chemicals for controlling the disease are not available. Keeping this in view, CSIR-Centre for Cellular and Molecular Biology (CCMB), in collaboration with Indian Institute of Rice Research (IIRR), developed the Improved Samba Mahsuri (ISM) rice variety which was resistant to BLB by using the gene marker technology (marker-assisted selection). After successful lab tests, field trials started in 2005-2006 in multi-location settings. With success in field trials, ISM was commercially released in the year 2008 in several states, mainly in undivided AP and Karnataka, by the name Improved Samba Mahsuri (ISM). It was also licensed to SRI BIO-Tech to be marketed during kharif 2011-12 with a commercial name of SRI BIO 226; subsequently they discontinued it as it was not their core business. Since 2012, CSIR-CCMB and ICAR-IIRR have implemented a project called BLIGHT OUT under the CSIR-800 scheme for the popularisation of ISM. In 2016, CSIR requested for an impact assessment study on the ISM rice variety. CSIR-CCMB then approached National Institute of Agricultural Extension Management (MANAGE), requesting them to take up the impact study.

Terms of Reference for the Impact Study

CSIR wanted to know farmers' feedback about the performance of the variety and the total area (cumulative) under Improved Samba Mahsuri (ISM) since 2011 as well as the total value of the produce in farmers' hands and future scope for further spread of the variety. MANAGE undertook the impact assessment study with a focus to add further value to the endeavour of CSIR. Among many others, the critical aspect of the study can be summarised as follows:

1. Comparative assessment of Improved Samba Mahsuri (ISM) vis-a-vis Samba Mahsuri (SM) by collecting data from 2,240 farmers, who shifted to ISM from Samba Mahsuri, Swarna and other varieties, through a pre-tested questionnaire. The data was collected by trained field surveyors using specially designed software (survey solutions) through tablets. The socio-economic and micro-level impacts were studied at farmers' level for understanding the relative advantages offered by ISM.

2. Village-level information on the basic socio-economic indicators and the extent of varietal adoption was also collected using Focus Group Discussions (FGD). The diffusion and adoption of ISM in the context of existing agro-climatic and socio-economic conditions are covered under this head.
3. Cluster-level interactions were carried out with agricultural officers, KVKs, seed companies, local seed dealers and research institutes who were involved in the sale, diffusion and popularisation of the ISM rice variety. While analysing the way ISM was popularised in the last few years, some suggestions have been provided for further strengthening future endeavours.

Methodology

Given that ISM was specifically targeted for endemic areas, affected by BLB, the study adopted purposive sampling technique while selecting states and districts, blocks and mandals. The study was conducted in Kurnool and East Godavari districts of Andhra Pradesh. Below the Mandal/block level, selection of villages and farmers were done on a random basis.

Secondary data was collected from various publicly available documents and primary data was collected from farmers of the selected states (mainly Andhra Pradesh, Telangana, Karnataka and Chhattisgarh) during the crop year 2016-17. The study team interviewed about 2,240 farmers by canvassing pre-tested individual farmer questionnaires and village questionnaires separately. Some seed producers and suppliers, agricultural department officers, National Seed Corporation (NSC) representatives and rice breeders were also contacted for their expert opinions.

Note: In each village, Focus Group Discussions (FGDs) were conducted with about 40 farmers, totalling 2,240 farmers.

Key Findings

Area under ISM

This was calculated based on interactions with agricultural officers, KVKs, SAUs, officials of SRI-BIO Tech and Indian Institute of Rice Research (IIRR) and cross-checked with the field-level data on varietal adoption and preferences. Based on these various interactions and field studies, we found that the variety was cultivated in the states of AP, Bihar, Chhattisgarh, Karnataka, Tamil Nadu, Maharashtra and Telangana.

No organisation or agency, including the government have documented the variety-wise area in paddy. In the absence of documentary evidence and sources of data, estimating the actual area under the ISM variety in such a huge area and from multiple sources of seed supply is a difficult exercise. One can only make approximate estimations. We collated information from multiple sources and cross-checked it with field visits and arrived at an estimate that 1.3 lakh hectare area was under ISM between 2011 to 2016. We have not taken into consideration varietal spread based on breeder seed indent, which came from the states of Uttar Pradesh, West Bengal and Orissa. At the moment, our preliminary estimates of 1.3 lakh hectares may be considered as an approximate estimation of the area under ISM. The trend in area under ISM is shown in the following figure:

From the figure, it can be seen that there was a peak in the adoption of ISM in the years 2011 and 2012, as it was marketed by a private company called SRI-BIO Tech during these years; subsequently, there was a dip in the area under ISM after they stopped marketing of ISM. This points towards the importance of having an institutional method of seed delivery for the popularisation of ISM. Subsequently, post 2014, the area under ISM increased primarily because it performed very well in the district of East Godavari after cyclone Hudhud and increased indent through local- and district-level agricultural officers for mitigating losses due to BLB. The seed supplied in East Godavari is primarily from National Seed Corporation (NSC) and AP SEEDS. One difficulty we have noticed in the field-level survey is that the seeds that have been supplied in East Godavari through these two sources had a lot of impurities and caused a lot of disquiet. However, the seed supplied under the CSIR-800 scheme has been of high quality and has demonstrated to farmers the true worth of the variety as well as built trust among them about the variety's BLB resistance. As such there is a tremendous demand for ISM seed in BLB epidemic areas, especially the East Godavari and Nandyal areas of the Kurnool district of Andhra Pradesh.

Value of produce in farmer's hand

The total cumulative production of ISM paddy from 2011 to 2016 was 7 lakh tonnes based on farmers' feedback with average yield of 5.7 tonnes per hectare. Estimated value of total produce was Rs. 1,249 crore (based on 2016 prices). The trait value is Rs. 240 crore, and it represents the value that farmers obtained by cultivating ISM instead of SM. This represents the estimated reduction in loss that was prevented due to the adoption of ISM owing to its BLB-resistant trait.

Farmers' feedback

In the kharif season, farmers mostly grow Samba Mahsuri-type paddy varieties. Farmers believe that pests and diseases are the major constraints in increasing and stabilising the paddy yields in the Samba Mahsuri variety. During the years 2014 and 2015, there was a severe infection of bacterial leaf blight, especially in Godavari district. In some villages, farmers reported up to 70% yield loss due to BLB in Hudhud-cyclone-affected areas in the year 2014. The ISM variety was

resistant to BLB even under these conditions of severe disease epidemic. BLB mostly occurs in areas with high frequency of floods and cyclones and places that are close to forest areas and where there is excessive use of fertilisers such as urea. However, BLB is not a serious problem in Telangana State.

Severely BLB-affected areas

In severely endemic areas such as Kurnool and East Godavari, farmers opine that the ISM variety performed better than the Samba Mahsuri variety. In some of the villages, there was 100% replacement of Samba Mahsuri with ISM, mainly due to seed supply from National Seed Corporation (NSC) and State Seed Development Corporation (APSSDC). Farmers got pure seed from KVKs and research stations, and they are highly satisfied with the varietal performance, especially with regard to resistance to Bacterial Leaf Blight. However, farmers feel that the seed supplied through NSC and APSEEDS had a lot of impurities and farmers complained that tillers from the same hill matured in different time periods with different grain quality. With impurities and unsynchronised flowering and maturity, farmers were not able to harvest crop in time and millers deducted the purchase price. Hence, there is a need for a strategy in maintaining purity of ISM seed production and distribution channels to build trust among farmers in popularising the ISM variety. Often, farmers are not aware of the availability of disease- and pest-resistant varieties, including ISM. In some epidemic areas, farmers and agricultural officers were not aware of the ISM variety and its traits, and farmers incurred huge losses. Due to lack of a continuous supply of ISM seed from reliable sources, its adoption has not picked up. There is also a need to popularise the fact that this variety is resistant to BLB and ensure that the seeds are available with local seed dealers in selected epidemic areas not only in East Godavari and Kurnool districts, but also in Uttar Pradesh, West Bengal and Orissa, where isolated epidemic areas were identified.

Not severely BLB affected areas

In non-endemic areas such as Nalgonda, Warangal and other Telangana districts, the occurrence of BLB is rare and loss due to BLB was just about 5% in the affected areas. In these districts, the performance of ISM was on par with Samba Mahsuri. But given the historical preference for the Samba Mahsuri paddy variety by farmers and millers, farmers still prefer the Samba Mahsuri variety in these districts. In Telangana districts, various private companies are aggressively marketing Samba Mahsuri type paddy varieties under different brand names, with attractive packaging, branding and marketing strategies.

A more important change that has occurred in farmers' seed purchase behaviour during the past decade is that farmer-to-farmer exchange and own seed use drastically reduced even though paddy is a self-pollinated crop mostly dominated by varieties. Farmers are not averse to purchasing new seed every year, as seed rate ranges between 15 and 25 kg/acre and cost may not be higher than Rs.700 per acre. Under this scenario, there was a need for promoting seed production and distribution by multiple agencies such as progressive-farmer-turned-small-seed-producers, small or medium local seed companies and dealers as well as through large private companies.

Other benefits of ISM cultivation

The ISM variety matures 10 days before SM, which is advantageous as it saves input cost and saves from untimely rains. Many farmers have expressed that it was more resistant to lodging than SM

and Swarna rice varieties. This contributed to the increased popularity of ISM in the Godavari and other districts where water logging has been observed. An additional benefit that was observed in the Nandhyal area of Andhra Pradesh is that this variety is also tolerant to the bacterial leaf streak disease, for which there are very few reported sources of tolerance in the rice varieties.

Shortfall

A few farmers who were supplied seeds of NSC and APSSDC indicated that the grain filling is not complete in this variety and that the variety does not exhibit uniform flowering. This could be due to the contamination noticed in the seeds supplied by the two public sector companies. Another shortfall in ISM and Samba Mahsuri is the incomplete panicle exertion, particularly if the varieties are planted late. It is suggested that the developers of the technology ensure supply of genetically pure, breeder's seed to public sector organisations such as NSC and APSSDC so that they can supply pure seeds to farmers. Researchers also need to keep this in mind in developing future varieties with better panicle exertion.

Potential areas under ISM

As of now, the variety is primarily being cultivated in the East Godavari and Kurnool districts of Andhra Pradesh and adjoining areas of Karnataka. There is a potential for this variety spreading to areas of Chhattisgarh, UP, Bihar, Tamil Nadu and areas where Samba Mahsuri is cultivated and BLB is a serious constraint.

Recommendations

Overall, the Improved Sambha Mahsuri (ISM) variety is very suitable for areas in which Samba Mahsuri (SM) is cultivated and Bacterial Leaf Blight (BLB) is a constraint. There is a significant unmet demand from farmers for seeds. Varietal adoption by farmers was mostly driven by timely supply of seeds in adequate quantities from reliable sources. We recommend that there should be strong institutionalised supply of seeds. It should be noted that in 2011 and 2012, there was a significant area under ISM, and this is to be attributed directly to the marketing of this variety by SRI-BIO Tech. Efforts should be made to involve such seed companies in the sale of this variety. National Seeds Corporation has come forward to distribute ISM seeds, but there have been issues regarding the quality of seed (admixture with other varieties), especially in the East Godavari district of Andhra Pradesh. In contrast, there have been very few complaints of seed purity from the Nandhyal area, where primarily small private players have been involved in seed production and distribution.

It would be good if additional private players could be brought into the business of production and distribution of ISM. With regard to the CSIR-800 project, we recommend that the focus should be on areas where BLB is the problem; the seed should be distributed in a cluster-wise manner. More focus should be given to vertical expansion of the variety in identified epidemic areas rather than horizontal expansion into areas that are not seriously affected by the disease. This can be done through continuous supply of seed year after year in epidemic areas where losses due to BLB are more than 10% so that the farmers feel that there are significant benefits due to adoption of BLB-resistant ISM.

Chapter 1

INTRODUCTION

1.1. Rice Production Scenario

Globally, rice is planted in about 150 million ha, and 497 million tonnes of rice is produced annually (FAO, 2014). Of this, Asia accounts for 90% of the production and consumption of rice. India has the world's largest area under rice cultivation at 42.5 million ha, and is the second largest producer with 110.15 million tonnes in 2016-17, next only to China. Rice is the second most important food crop of the world, feeding over one half of the population, providing 20-80% of the dietary energy in the average daily intake of people in Asia.

India contributes 21 percent to the global rice production. About 31 million tonnes of rice is traded in the international market and the leading rice exporting countries are Thailand, Vietnam, USA, India and Pakistan. However, in 2012, India surpassed Thailand to become the first rice-exporting country, with export of more than 10 million tonnes for the first time in recent years. Rice export contributes to nearly 25% of the total agricultural exports from the country.

In 2011–12, rice accounted for 22.3% of the total gross cropped area (195.2 million ha) and constituted 25.8% of the total crops, of which small farmers produced more than 60% (Birthal *et al.*, 2011). In the past 50 years, India's rice production (paddy equivalent) has nearly doubled from 58 million tonnes in the late 1960s to more than 110.15 million tonnes in the past few years. This is largely due to the introduction of high-yielding varieties as part of the Green Revolution technology package. Increased availability of rice led to a rise in per capita annual consumption from 70 kg in the early 1970s to more than 83 kg in 2014.

In India, rice provides around 31% (about 70% in the traditional rice-growing tropical southern and eastern parts) of the dietary energy in the average daily intake of people. Rice in India is cultivated in diverse ecologies with varied productivities. Rice ecologies broadly comprise irrigated, rainfed low land, rainfed upland and flood-prone/deep water environments accounting for 45.3, 30.6, 17.2 and 6.9% of the rice area respectively. Relatively risk-free irrigated ecology with a productivity of 3.11 t/ha contributes 84 million tonnes (67.3%) to the country's rice production as against the rainfed lowland, upland and deep water ecologies with yields of 1.56, 0.8 and 1.0 t/ha, respectively, contributing 28.6 (22.9%), 8.2 (6.6%) and 4.1 (3.3%) million tonnes.

The major share of rice is cultivated during the Kharif season. A relatively small share of rice is grown in the rabi/summer season with assured irrigation. Indian rice production is largely under irrigated conditions (60%), and the remaining 40% is rainfed. This crop plays a vital role in our national food security and is the means of livelihood for millions of rural households. The rice area and production trend over the years is depicted in Fig 1:

Fig 1: Area and production trends of paddy in India over the years

Source : AICRIP

The area under rice crop during the 1950s was 35 million hectares, which reached 44 million hectares by the 1990s, but recently, there was slight decline to 42 million hectares. However, total production increased more than three times during the same period from 33 million tonnes to 102 million tonnes (Table.1). The yield increased by three times from 947 kg/ha to 2,373 kg/ha. The area under irrigation also increased from 37% to 57% during the same period (Table -1). The coefficient of variation was lower in the case of the area under rice, while it was higher in the case of yield. This indicates that abiotic and biotic stress management is important in order to reduce volatility in yield.

Table 1: Changes in area, production, yield and area under irrigation

Period	Mean				CV (%)			
	Area (Million ha)	Production (Million Tonnes)	Yield (Kg./ ha)	Area Under Irrigation (%)	Area (Million ha)	Production (Million T)	Yield (Kg./ ha)	Area Under Irrigation (%)
1958-1967	35	33	947	37	3.8	12.0	9.6	1.8
1968--1977	38	42	1103	38	2.4	7.6	5.5	1.3
1978-1987	40	55	1348	42	2.4	11.9	10.1	3.0
1988-1997	42	74	1761	48	3.0	9.8	7.3	4.9
1998-2007	44	87	1983	53	3.1	7.5	6.0	3.9
2008-2017	42	102	2373	57	5.2	6.3	7.6	1.2

Fig.2: Distribution of certified/quality seeds (lakh quintal)

Source : AICRIP

Although the paddy area was stagnant from 2001 to 2016, the distribution of certified and quality seeds significantly increased from 25 lakh quintal to 72 lakh quintal during the same period (Fig. 2). An important reason for increased productivity levels in the last decade is the increased use of certified or truthful seed. Over the years, share of private companies in the total seed distributed through formal channels has increased. Now, their share stands at 50% of the total formal seed distributed in India (Fig. 3). Any effort to involve the private sector in seed production and distribution would directly contribute to varietal adoption.

Fig. 3: Share of public and private seed in paddy

Source: AICRIP

The top 10 states in terms of area and production of paddy are depicted in Fig 4. Uttar Pradesh tops the list, followed by West Bengal, Odisha, Chhattisgarh and Punjab. Andhra Pradesh holds the 9th rank in terms of both area and production. The figure also indicates that the yield levels are higher in Punjab, Andhra Pradesh, Tamil Nadu, West Bengal and Uttar Pradesh, while they're lower in Odisha, Chhattisgarh, Assam and Madhya Pradesh.

Fig. 4: Top 10 states in terms of area and production

Source: AICRIP

At the current rate of population growth, rice production should increase from 110 million tonnes in 2016-17 to about 125 million tonnes by 2020 (Kumar *et al.*, 2009).

Breeder Seed Production (BSP) tripled from 2,006 quintals to 7,757 quintals in the last 10 years, and the varieties under BSP went up from 81 varieties in 2000 to 217 in 2014 (Fig. 5). It should be noted that after 2006, the number of varieties increased significantly. The production of Truthfully Labelled Seed (TLS) of popular varieties such as Samba Mahsuri (BPT 5204), MTU-1010, Swarna increased tremendously. This enormous increase in seed production (breeder, certified and truthful) would certainly have an impact on the seed replacement rate, productivity and farmers' incomes.

Fig 5: Breeder Seed Production

Source: AICRIP

More than 430 rice varieties and hybrids were released and notified in India from 1996-2012 for cultivation in different agro-ecological regions of different states (status paper on rice). However, only the top 10 varieties occupy more than 80% of the paddy area in India. The remaining varieties are not popular or are limited to a few niche areas. Over the years, the number of varieties released increased. Between 1966 and 1975, only 72 varieties released, whereas that number increased to 328 between 2006 and 2014 (Fig. 6).

Fig 6: Decade-wise nominations tested and varieties released through AICRIP

Source: AICRIP

Table 2: Rice varieties and hybrids released as central and state releases (1965 – 2014)

Total No. of Varieties	Varieties	Hybrids	Total
Central Variety Release Committee (CVRC)	129	44	173
State Variety Release Committee (SVRC)	883	28	911
Total	1012	72	1084

Source:AICRIP

Modern varietal change is an important tool with significant potential contributions to agricultural development. Unlike some other types of agricultural technology, modern varietal change is not limited by agro-ecology, nor does it require major capital investments by potential adopters. A list of some important varieties released in southern India, especially Telangana and Andhra Pradesh, over the years is provided in Table 3.

Field observations show that a majority of farmers continue to use Samba Mahsuri, Swarna and MTU-1010 even though a number of improved varieties were released in the last decade. A lack of dynamism in varietal change in paddy represents a wasted opportunity that could potentially be huge, exacting a heavy toll on farmers' profitability and consumer preferences alike. Expenditure on staple crops such as paddy and wheat was about 50% of the income of poor consumers and farmers. The uptake of improved varieties can directly lead to positive consequences for food

security. Development of varieties with attributes such as high crop productivity and increased pest and disease tolerance reduces the cost of production, as well as prices and leads to a stable supply for consumption by hundreds of millions of poor rural and urban households in India.

Table 3: Important rice varieties released for AP/Telangana

Name	Parentage	Year of Release
Hamsa	HR 12 / T (N)1	1968
Tellahamsa (RNR 10754)	HR 12 / T (N)1	1971
Rajendra (RNR 12392)	IJ 52 / T(N)1	1976
Mahsuri	T65/Mayang Ebos 80 / Mayang Ebos 80	1972
Samba Mahsuri (BPT-5204)	GEB 24 x T (N)-1) x Mahsuri	1986
Swarna (MTU-7029)		1987
Saleema (RNR 29692)	GEB 24/Sigadis/IR8/RNR 8102	1987
Satya (RNR 1446)	T. Hamsa/Rasi	1987
Chandan (RNR 74802)	Sona/Manoharasali	1989
Sagar Samba (RNR 52147)	IR 8/Siam 29/IR 8/Ptb 21	1993
Rajavadlu (RNR 99377)	Rajendra / IR 30	1993
Early Samba (RNR M7)	Mutant of Samba Mahsuri	1999
Sumati (RNR 18833)	Chandan / Pak basmati	2002
Improved Samba Mahsuri (RP BIO 226)	Samba Mahsuri*3 x SS1113	2008
Taramati (RNR-23064)	Tellahamsa / BPT-5204	2009
Sugandha Samba (RNR-2465)	RNR M7 / RNR-19994	2010
Krishna (RNR 2458)	Chandan/ BPT 5204	2012
Shobhini (RNR 2354)	RNR M7 / RNR-19994	2014
RNR 15048 (Telangana Sona)	MTU 1010/ JGL 3855	2015
Bathukamma		2016
NLR 8		2016

Source: AICRIP

Without the adoption of agricultural technologies, there is no impact (Adato and Meinzen-Dick, 2007). Past research suggests that if new materials do not replace their earlier generation counterparts, returns to genetic improvement stagnate. Indeed, the area planted to a new technology is the most important determinant in the size of economic benefits (Walker and Crissman, 1996; Morris *et al.*, 2003). Globally, credible databases that document the diffusion and impact of well-identified improved varieties are rare.

1.2. The context

Millions of poor, small farmers grow rice in Asia and Africa under diverse conditions. These include areas affected by drought, submergence, salinity, problematic soils, insects, diseases and other pests. Farmers often have to contend with various adverse factors simultaneously. Research organisations need to focus on developing new improved rice varieties that are tolerant of stresses

(such as high temperature, drought, submergence and various pests and diseases) as well as have higher grain yield with the desirable grain quality in order to meet the growing demand with the least instability in production. Similarly, rice varieties that are genetically resistant to various pests and diseases need to be developed and popularised in order to reduce the dependence on pesticides, reduce the risk and cost of production and for human health and environmental reasons. Clearly, a steady stream of improved technologies is needed to tackle these persistent and evolving problems.

Diseases and insect pests lead to serious constraints on rice yield, particularly in tropical countries. The disease scenario in India since 1945 is shown in Fig 7. In order to appreciate the origin and the significance of varieties such as ISM, we need to understand that the distribution of rice diseases in different regions across the world is governed primarily by temperature, humidity, plant density and other environmental factors. The introduction and widespread cultivation of dwarf and high nitrogen responsive rice varieties helped only for a brief period, as the susceptibility of these varieties to diseases was a more probable danger than the advantage that could be derived from them. The intensity of the spread of varieties over the years is shown in Figure 7.

Various biotic stress outbreaks of Bacterial Leaf Blight started affecting rice production at a macro level and productivity at a farmer level. An occurrence of Bacterial Leaf Blight (BLB) started in India by 1975 in isolated places, and then it spread to Andhra Pradesh, Chhattisgarh, Uttar Pradesh, West Bengal, Bihar and Odisha. It was more prevalent in the *kharif* season. It is especially rampant in areas where Samba Mahsuri was grown.

Fig 7: Disease scenario in rice

Source: AICRIP

(ShB- Sheath Blight; FS- False Smut; ShR- Sheath Rot; StR- Stem Rot)

Improved technologies for increased rice productivity and reducing losses from pests and diseases are critical for achieving food security and reducing poverty. In the quest for increasing rice production, farmers have resorted to intensive methods of rice cultivation involving high-yielding

susceptible cultivars with reduced genetic variability, higher plant population per unit area, high doses of nitrogenous fertilisers and staggered sowing and planting, which intensified the severity of Bacterial Leaf Blight in rice in most Asian countries.

Bacterial blight is essentially a disease that spreads in the monsoon season. The intensity of the disease is heavily influenced by rainfall, cloudy, drizzling and stormy weather and high nitrogen fertilisers. Hence, it predominantly occurs in the Kharif (rainy) season.

Table 4: Control of Bacterial Leaf Blight through chemicals and adoption of tolerant varieties

Chemical control	Tolerant varieties/breeding lines
2,4-D ethyl ester 1 ml/l followed by Streptocycline 200 mg/l + Copper oxychloride 2.5g/l; Spraying twice with 250 ppm of Agrimycin-100; 2,4-D ethyl ester 3 days before inoculation followed by Streptocycline + COC	Ajaya ADT 39, CR 837, HKR 95-128, HKR 95-131, Improved Pusa Basmati-1, Improved Samba Mahsuri, IRBB 58, IRBB 59, IRBB 60, IR 64, OR 2329-22, PAU 1061-19-22, PR 110, PR 111, PR 114, PR 118, PR 120, Pant Dhan 10, Pant Dhan 11, Saket 4, Sita, PR 4141 Bhudeb, Khitish, Sabita, ADT 39, ADT 36 and Co 43

Source: All India Coordinated Rice Improvement Project Reports

The disease is prevalent in moderate to severe form in almost all of the rice growing areas during the monsoon season. There is a lack of availability of appropriate chemicals for controlling the disease. Chemical control and tolerant varieties to BLB recommended by AICRIP are shown in Table 4. It has been observed that chemical control is costly as well as environmentally unsafe, and it requires scarce labour to spray. Also, the chemicals are not effective. On the other hand, tolerant varieties identified were not performing as expected. To develop a resistant variety, CSIR-CCMB and ICAR-IIRR jointly put in effort and developed Improved Samba Mahsuri (ISM), a BLB-resistant derivative of Samba Mahsuri using marker-assisted selection. The improved rice variety ISM (also known as RP BIO-226) was released by Ministry of Agriculture, Govt. of India, in 2008.

1.3. Development of Improved Samba Mahsuri (ISM)

Samba Mahsuri (SM) is a rice variety developed through the use of marker-assisted selection. Samba Mahsuri or Sona Mahsuri or BPT 5204 is a medium-slender grain rice variety grown largely in the states of Andhra Pradesh, Telangana, Karnataka and Chhattisgarh. In Telugu, Samba Mahsuri rice is also called Bangaru Theegalu (meaning golden vines). It is popular for its unmatched grain quality among non-basmati rice. It is lightweight and considered to be of premium quality and fetches about 20-30% higher prices than common rice. It is also exported to USA, Canada, Europe, Australia, Singapore, Malaysia and Middle East countries such as Saudi Arabia, UAE and Qatar etc. Samba Mahsuri derived from the cross {(GEB 24 x T (N)-1) + Mahsuri} was developed at Rice Research Unit, Agricultural College, Bapatla under, the aegis of Andhra Pradesh Agricultural University (renamed Acharya NG Ranga Agricultural University). The duration (Seed to Seed) of Samba Mahsuri is 145-150 days, with an average yield of about 2 t/ac and 4 weeks dormancy. It can be grown in varied soil and rainfall situations, but severe winter situations should be avoided.

It is ideal for preparing dishes such as sweet pongal, biryani, fried rice and for daily cooking. There is another variety by the official name 'Sona Mahsuri' i.e. BPT 3291 in AP. It is not as popular as BPT 5204 because of its bold type and hence fetches lesser price in the market. In 2007-08, the area

covered by BPT 3291 was 2.75 lakh acres, which is about 10% compared to 25.68 lakh acres of BPT 5204. The area shares of these two varieties were similar even in 2016-17.

In AP, Samba Mahsuri is mainly cultivated in Kurnool, East Godavari, West Godavari, Krishna and Nellore. In Telangana, it is grown in Mahabubnagar, Nizamabad, Warangal and Nalgonda districts. To a smaller extent, it is grown in all other districts of AP and Telangana due to its premium price and ready market availability. In Karnataka, it is mainly cultivated in Raichur, Koppal and Bellary districts. Best quality Samba Mahsuri rice can be found in the regions of Kurnool, Warangal, Nellore and Godavari districts of Andhra Pradesh, followed by Sindhanur region of Raichur district of Karnataka as well as Karur, Tiruchi and Thanjavur areas of Tamil Nadu. In recent years, brown rice (semi-processed paddy) has become popular as it helps in reducing obesity, diabetes, heart disease, high cholesterol etc. The brown Samba Mahsuri rice is preferred by urban consumers due to its taste and cooking quality over brown rice of other varieties. Samba Mahsuri (SM) is susceptible to the serious Bacterial Leaf Blight disease, which is caused by the bacterial pathogen *Xanthomonas oryzae* pv. *oryzae* (Xoo); the disease can result in yield losses of up to 30 to 50 percent. As effective chemicals that can control yield loss due to BLB were not available, the development of a host plant (resistant) variety of rice was proposed. Keeping this in view, CSIR-Centre for Cellular and Molecular Biology (CSIR-CCMB), in collaboration with ICAR-Indian Institute of Rice Research (ICAR-IIRR), developed the Improved Samba Mahsuri (ISM) rice variety, which was resistant to BLB using the gene marker technology (marker-assisted selection). It possesses three major BLB resistance genes, *Xa21*, *xa13* and *xa5*, and shows a high level of resistance to bacterial blight. Subsequently, hundreds of bacterial blight pathogen isolates collected from different locations of India have been tested on either ISM or on another line developed by International Rice Research Institute, which also carries *Xa21*, *xa13* and *xa5*. The three gene pyramid lines are resistant to all of these isolates, indicating that the combination of *Xa21*, *xa13* and *xa5* is quite effective in controlling bacterial leaf blight (Mishra *et al* 2013 –*PLoS ONE*. 8 (11). e81996).

ISM has also been registered with the Protection of Plant Varieties and Farmers Rights Authority (PPV and FRA), Government of India. It has excellent qualities, including a fine grain type with good cooking quality as well as taste, and hence it is highly preferred by consumers across many states. If there is an incidence of BLB, Improved Samba Mahsuri gives 15-30% more yield than any other bacterial-blight-susceptible variety. Improved Samba Mahsuri can be cultivated in areas with assured irrigation, where fine grained rice varieties are preferred and widely grown.

It is widely popular among farmers, millers and consumers as its grain quality and other attributes are similar to the Samba Mahsuri rice variety. After successful lab and field tests at ICAR-IIRR, multi-location tests were conducted in 2005-2006. With success in field trials under the All India Coordinated Rice Improvement project in 2005 and 2006, ISM was commercially released for cultivation in the year 2008 by the Central Varietal Release Committee of Ministry of Agriculture, Govt. of India, in several states, including undivided AP, Tamil Nadu, Chattisgarh, Odisha and Karnataka under the name of Improved Samba Mahsuri (ISM). The performance of ISM (also known as RPBio-226) in the Raichur district during kharif 2016 under the Bhoo-samrudhi program of ICRISAT reported a yield of 9.2 t/ha. It was also licensed to M/s Srii Biotech Pvt. Ltd., Hyderabad, to market during kharif 2011-12 with a commercial name of SRI BIO 226 and M/s Metahelix Life Sciences Pvt. Ltd., Bengaluru, in the year 2015. Since 2012, CSIR-CCMB and ICAR-IIRR have implemented a project called BLIGHT OUT under the CSIR-800 scheme for the popularisation of

ISM, wherein a total of 10,000 farmers were given seeds of ISM (10 kg to each farmer) free of cost to facilitate fast diffusion of the variety.

On account of such experiences, Improved Samba Mahsuri has been cultivated in approximately 1,30,000 hectares to date, mostly in Andhra Pradesh and to some extent in Telangana, Karnataka, Tamil Nadu, Chhattisgarh, Maharashtra and Bihar. The total turnover for farmers is approximately Rs.1,200 to 1,300 crore with trait value of Rs. 230 to 250 crore. The trait value is the benefit from the adoption of ISM in terms of reducing losses due to its attribute of resistance to BLB (in terms of 2016-17 prices) over the last 10 years. In 2016, CSIR wanted to undertake an impact assessment study on the ISM rice variety. CSIR-CCMB approached National Institute of Agricultural Extension Management (MANAGE) and requested them to take up the study in the year 2017.

1.4 Scope of Study

CSIR wanted to know the feedback of farmers regarding the performance of the variety and the total area (cumulative) under ISM since 2011. They also wanted to learn about the total value of the produce in farmers' hands and the future scope for further spread of the variety. MANAGE has undertaken the impact assessment study with a focus to add further value to the endeavour of CSIR. Among many others, the critical aspects of the study could be summarised as follows:

1. Comparative assessment of Improved Samba Mahsuri (ISM) *vis a vis* Samba Mahsuri (SM) by canvassing a pre-tested questionnaire among 1,000 farmers who have shifted to ISM from Samba Mahsuri, Swarna and other varieties. The data was collected by trained field surveyors using specially designed software (survey solutions) through tablets. The socio-economic and micro-level impacts were studied at farmers' level for the relative advantages offered by ISM.
2. Village-level information on the basic socio-economic indicators and the extent of varietal adoption was also collected using focus group discussions. The diffusion and adoption of ISM in the context of existing agro climatic and socio-economic conditions are covered under this head.
3. Cluster-level interactions with agricultural officers, KVKs, seed companies, local seed dealers and research institutes that were involved in the sale, diffusion and popularisation of the ISM rice variety. While analysing the way ISM was popularised in last few years, some suggestions are provided for further strengthening the future endeavours.

Chapter 2

REVIEW OF LITERATURE

As new technologies are increasingly being adopted by farmers, the need to understand the process of adoption and identify adoption constraints increases too. Simple regression analyses are often used to identify the determinants of adoption.

2.1. Varietal diffusion and adoption process

Mottram (2004) studied the impact of new upland rice varieties in eastern India from client-oriented breeding. Evidence from village surveys indicated that the introduction of two new upland rice varieties (Ashoka 228 and Ashoka 200F) led to the adoption rate being high and increasing every year. A village-level survey was conducted in seven villages in each of the selected seven districts of Odisha, Jharkhand and West Bengal, and it was found that formal seed distribution through GVT (Gramin Vikas Trust) and farmer-to-farmer seed distribution played an important role. After doing a preference ranking among different rice varieties, it was found that Ashoka varieties got the highest score because of high yield, drought resistance, less cooking time, straw quality, disease resistance and high market price.

Studies in Nigeria (Saka *et al.* 2005) on Adoption of Improved Rice Varieties among Small-Holder Farmers showed that farmers responded appreciably to intervention programmes that promoted the cultivation of improved rice varieties with an adoption rate of 67%. The empirical results also indicated that the choice of adoption of improved rice varieties was jointly influenced by the size of rice farms, yield and the frequency of extension.

Marites and Hossain (2015) studied Adoption of Modern Varieties and Rice Varietal Diversity on Household Farms in Bangladesh and found that farmers who acquired seed from informal sources—i.e. from their own farms or neighbouring farmers—are more likely to adopt MVs. This is because there is neither a formal seed market nor a formal seed distribution system that farmers rely on to acquire seeds. In addition, if modern and traditional seeds are available to farmers in the market, they will likely reduce their use of seeds from their own harvest, thereby avoiding not only lower yields but also genetic erosion. Empirical evidence suggests that the adoption of MVs lowers varietal diversity at the farm level.

Morris *et al.* (2001) examined the adoption of improved maize production technologies developed through the Ghana Grains Development Project (GGDP) by Ghanaian farmers. During 1997, more than half of the sample farmers (54%) planted MVs on at least one of their maize fields, and a similar proportion (53%) implemented the plant configuration recommendations. Adoption rates varied by agro-ecological zone, with the lowest adoption of all three technologies in the forest zone. Adoption rates were higher among male farmers than among female farmers, except in the case of fertilisers, in which no significant difference was found. The data generated through this CRI/CIMMYT survey provided factors that could influence the adoption process. These were: (1) characteristics of the technology; (2) characteristics of the farming environment into which the technology is introduced; and (3) characteristics of the farmer making the adoption decision. The survey revealed that adoption of GGDP-generated maize technologies had been extensive.

Diversity, spatial distribution and the process of adoption of improved rice varieties in Bangladesh were examined by Hossain and Jaim (2012), who found that extension officials are the dominant source of first information regarding a new variety, but the extension contact is biased in favour of large farmers. For small and marginal farmers, enterprising farmers are the major source of information about an improved variety. A new variety spreads quickly once farmers are convinced about its good traits that are also of their liking. It takes about three years to diffuse a variety to its potential area in a village after its introduction. The area covered, however, does not go beyond half to two-thirds of the total area.

Behura *et al.* (2012) found in their study on diversity, spatial distribution and the process of adoption of improved rice varieties in the Odisha state of India that the role of radio, television, seed companies and NGOs in disseminating first-time information about modern varieties was negligible. The survey revealed that for modern varieties, farmers used their own seeds in about 88% of the cases, whereas only about 8% of the farmers bought seeds from government seed sale centres. On average, it took 4–5 years for full adoption of most of the popular modern varieties in Odisha. However, by the fourth year, most of the popular modern varieties were fully adopted. The survey also identified the extinction of a considerable number of both traditional and modern varieties. Low yield was the main reason for rejecting traditional varieties, whereas for modern varieties, pest susceptibility and relatively low yield were the two dominant reasons.

In the report on diversity, spatial distribution and the process of adoption of improved rice varieties in Jharkhand, Lakra *et al.* (2012) identified 71 varieties of rice grown in medium lands during the wet season. The study revealed seven types of hybrid rice. Among these hybrids, Pioneer was the most popular and covered 43% of the hybrid area. 14 improved varieties were grown for medium lands, and IR36 was the most popular variety, covering the highest area (28%), followed by Lalat (23%). High yield was the most important trait in selecting a rice variety, which was reported by more than 70% of the respondents. About half (47%) of the farmers reported that they used their own harvested seeds for the next season. 30% of the farmers bought seeds from traders. Seed traders were the main source of improved varieties. A majority of the respondents reported that they obtained information about popular improved varieties from other farmers. About 72% of the farmers reported that it took two years for full adoption of IR36. On the other hand, it took three years or a little more for full adoption of Swarna, Lalat, IR64 and Sita.

2.2. Determinants of varietal diffusion

Khondoker Mottaleb *et al.* (2015) used econometric models to determine factors influencing hybrid rice adoption in Bangladesh. Multinomial logit model, the seemingly unrelated regression estimation and the Lagrange Multiplier Test are used to estimate the factors influencing the adoption of improved varieties. Results indicated that land characteristics, better loan facilities and infrastructure favoured the adoption of hybrid seeds and MVs. It was concluded that in addition to government efforts, the socio-economic characteristics of the farmers should also be paid attention to.

Behra *et al.* (2012), in their work on diversity, spatial distribution and the process of adoption of improved rice varieties in Odisha investigated varietal diversification of rice. They used Stratified Random Sampling. According to the study, it was seen that during the wet season, most of the varieties used were traditional varieties (TVs), whereas in the dry season, most of the varieties were modern varieties (MVs). The distribution is different according to the different agro-ecological conditions. Variety Swarna is popular in the wet season and Lalat is popular in the dry season.

Reasons for preferring a variety are high yield, good taste of cooked rice, lodging resistance, shorter duration etc. Other farmers are a major source of information, and their own harvest is a major seed source. It takes four years for full adoption. Reasons to reject TVs are low yield and for MVs are pest susceptibility and relatively low yield. Yield can be increased and stabilised by focusing on environmental stress. The study suggested that more efforts should be made towards bio-fortification of existing popular varieties such as Samba Mahsuri, which will enrich grains through micro-nutrients and vitamins.

Diversity, spatial distribution and the process of adoption of improved rice varieties in West Bengal by Bagchi *et al* (2012) revealed that TVs are used in areas with high salinity and inundation and MVs are used in irrigated areas. Reasons for preferring a variety are high yield, good taste of cooked rice, lodging resistance, shorter duration etc. Other farmers are a major source of information, and their own harvest is a major source of seed. It takes 5 years for full adoption. Reasons to reject TVs are low yield, longer maturity period and for MVs are relatively longer maturity period, relatively less yield, lodging problems and less milling recovery. Yield can be increased by focusing on disseminating varieties that are tolerant to environmental stress, expansion of irrigation and pure line selection of TVs.

Joshi and Bauer (2006), in their study on Farmers' Choice of the Modern Rice Varieties in the Rainfed Ecosystem of Nepal, showed that key variables affecting farmers' demand for variety are both production and consumption attributes valued by the households and farm and farmer characteristics, which are easy threshing ability, milling, usage of grains for preparing special products, early maturity of the variety, less irrigation requirement, sources of seed, education and the experience of the farmers.

Raju *et al.* (2015), in their report on Factors Affecting Adoption of Improved Rice Varieties among Rural Farm Households in Central Nepal, found that education, extension services and access to seed play significant roles in varietal adoption decisions. Additionally, farm and field characteristic variables, such as farm size, endowment of favourable land type (e.g. lowlands) and animal power (e.g. oxen) were the key factors influencing the probability of adopting improved rice varieties. The results showed that technology-specific variables (e.g. yield potential and acceptability) were significant for explaining adoption behaviour, implying that it is important to take farmers' preferences for varietal characteristics into consideration in the design of a research and development program.

2.3. Varietal diffusion of risk-reducing improved varieties (insect resistant, flood resistant)

Ahmed *et al.* (2012) examined the adoption of stress-tolerant rice varieties in Bangladesh using data collected through two distinct household surveys. They analysed the modern rice technology promoted in USAID's Feed the Future (FTF) project in the south and southwest regions of Bangladesh. The study found that the adoption of the set of modern stress-tolerant paddy varieties promoted by the Cereal Systems Initiative for South Asia (CSISA) project has been very low. Authors argued that plausible explanation for the relatively low adoption of the stress-tolerant rice varieties could be that small and marginal farmers are risk-averse, with less education and lack of complementary technologies.

Khondoker *et al* (2012), in "Ex-Ante Impact Assessment of a Drought Tolerant Rice Variety in the Presence of Climate Change", suggested that the economic benefits of a new drought-tolerant rice variety will more than outweigh the cost of developing this new variety, especially in the light

of global climate change. In addition, results from partial equilibrium market models suggested that production, consumption and rice exports in South Asia would be higher with the drought-tolerant variety.

Gauchan *et al* (2012) studied the patterns of adoption of improved rice varieties and farm-level impacts on stress-prone rainfed areas of Nepal and reported that farmers adopted modern varieties on a major part of their rice farm, covering about 71% in Tanahun, 84% in Siraha and 98% in Banke. Yields of MVs are significantly superior to the yields of TVs at all the sites. Yield effects, however, vary by site. The yield effects of MVs are stronger at Tanahun and Banke sites than in Siraha. Newer generation MVs account for about 40% of the total MV area at the study sites. The dominant newer generation MVs are Radha-4 in Banke and Tanahun and Radha-11 (Meghdoot) in Siraha. The yield of newer generation rice varieties is not superior to that of old generation MVs despite their better adaptability to rainfed conditions (e.g., Radha-4 and Radha-11). However, new MVs are relatively better performing in lowland fields in moisture-stressed rainfed conditions.

Deka and Gauchan (2012), in their paper on "Patterns of Adoption of Improved Rice Varieties and Farm-level Impacts in Stress-prone Rainfed areas of Assam" found that farmers adopted modern varieties on a major portion of their rice farms. Only a handful of MV rice dominates the rice area at the study sites. The dominant MVs are Ranjit, Mahsuri, Bahadur, Luit and Pankaj. Swarna was also grown by some farmers in a small proportion of the area. Newer generation MVs account for about 55% of the total MV area at these sites. The major newer generation MVs are Ranjit (released in 1992), Bahadur (released in 1994) and Luit (released in 1997). MVs out-yield TVs on all land types and across the sites. However, the yield of newer generation rice varieties is not significantly superior to that of old MVs despite some of their preferred traits of tolerance of diseases, pests and submergence (e.g., Jalashree, Jalakunwari). High yield, high market price, and good taste (eating quality) are the most preferred traits for the cultivation of MVs.

Bagchi and Emerick (2012) examined patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas of West Bengal, India. MV adoption is very high at the survey sites. Most lands, regardless of type and season, grow MVs. During the boro season, the total rice area of the sample households is planted to MVs, while 7% to 10% of the rice area is planted to TVs during the aman season. The major rice varieties at the submergence site (Nadia) are Ranjit (new) and Swarna (old) during aman and Nayanmoni, Sankar and Satabdi (new MVs) during the boro season. At the drought-prone site (Purulia), old-generation MVs such as Lalat and Swarna are the major aman rice varieties. The varietal attributes desired by sample farmers include high yield, good taste and good quality of grains. Overall, the yield of MVs (3.07 t/ha) is higher than that of traditional varieties (2.70 t/ha) during the aman season. The yield of MV rice is higher at submergence sites (3.85 t/ha) than at drought sites (2.92 t/ha) during the aman season.

2.4. Impacts of varietal diffusion

To track the distribution of Swarna-Sub1 in South Asia, a large-scale household survey of about 9,000 households was conducted in 2014 (Yamano *et al.*, 2015; Malabayabas *et al.*, 2015). According to the survey, the total area under stress-tolerant rice varieties was estimated to be 0.6 million ha (or 3% of the total rice area), with 1.4 million farmers in 2013 in Bangladesh and four states in eastern India.

Wang *et al.* (2012) studied patterns of varietal adoption and economics of rice production in Asia and showed that the impact of improved stress-tolerant varieties was likely to be higher in Cambodia, given the lower average yield and the dominance of rainfed production systems.

Among the households, the impact was higher for those that have a higher share of rice income in their total income. Similarly, a higher poverty impact is likely to be generated if the dissemination strategy targets those households that derive most of their income from rice production.

To measure the farm-level impacts of STRASA varieties, a randomised control trial was conducted and the results are summarised in Dar *et al.* (2013), indicating that the average yield of Swarna-Sub1 was 45% higher than that of Swarna, one of the parental varieties, under submergence for 10 days. They found no difference in the yields of the two varieties under normal conditions.

Yadavendra *et al.* (2007), in a study on the impact of new maize and rice varieties on the livelihoods of poor farmers in marginal agricultural areas of western India, reported that the important traits of early maturity, high grain yield and high grain quality in all the three rice varieties (Ashoka 200F, Ashoka 228 and Kalinga III) were important traits that were preferred by farmers. However, all three were inferior for fodder production. The new varieties gave benefits beyond doubt.

Hossain *et al.* (2006), in a study on adoption and productivity impact of modern rice varieties in Bangladesh, showed that Bangladeshi farmers have been replacing MVs with new generation MVs, particularly if the new generation MVs were of shorter maturity and the yield was higher compared to the existing ones. A production function analysis confirmed higher productive efficiency in the first and second generation MVs, but the increase was small compared to the initial shift from TV to MV. The productive efficiency was higher for the MVs of Indian origin, but the difference was not statistically significant for the MV produced in Bangladesh. The important findings also showed that MV2, MV3 and MV-Indian were more or less equally productive but were more productive than TV and MV1 and clearly highlighted the important contribution that the National Rice Research Institution, BRRI, made toward improving rice yields in Bangladesh.

A study on determinants of adoption and productivity of improved rice varieties in southwestern Nigeria by Saka and Lawal (2009) employed adoption index, logit model and stochastic frontier model to assess the adoption status, its determinants and impact on farmers' productivity respectively. The results showed that farmers responded appreciably to intervention programmes that promoted the use of improved rice varieties with an adoption rate of 68.7%, which resulted in an estimated proportional production increase of 19.4%. The mean yield of improved rice varieties (1.6 t/ha) was significantly higher than the yield of the local varieties (1.154 t/ha) with a yield advantage of 38.7%. In addition, rice yield for adopters of improved rice varieties (1.90 t/ha) was significantly higher than that of non-adopters (1.07 t/ha).

Wiredu *et al.* (2010), in "Impact of improved varieties on the yield of rice producing households in Ghana", perceived that the rate of adoption varied by location. The rate of adoption of improved rice varieties was estimated at about 46%. Adoption had a positive impact on farmers' rice yields. Experience, gender (male) and expectations about the yield and performance of improved technologies had a positive effect on yield. Proper targeting of beneficiaries of interventions and effective training in good agricultural practices were expected to increase adoption rates and improve the level of performance.

Economic Impact Assessment of Technology: Ogunsumi *et al.* (2007) studied a case of improved soybean varieties in southwest Nigeria for the period from 1975 to 1999 using the agronomic data on the yield of the nationally coordinated soybean research from two major zones, namely southwest and the middle belt. The study assessed the economic returns due to improved soybean varieties. The result of the internal rate of returns of 38 percent was observed from the streams of net returns from research that produced soybean varieties in Nigeria between the years 1975 and

1999. The pay-off to soybean research investment was attractive during the period: well above the average interest rate of 15 percent during the period. There was a justification for the investment on soybean variety research.

Saka and Lawal (2009) studied determinants of adoption and productivity of improved rice varieties in southwestern Nigeria. The results showed that farmers responded appreciably to intervention programs that promote the use of improved rice varieties with an adoption rate of 68.7%, which resulted in an estimated proportional production increase of 19.4%. The mean yield of improved rice varieties (1.601 t/ha) was significantly higher than the yield of the local varieties (1.154 t/ha), with a yield advantage of 38.7%. In addition, rice yield for adopters of improved varieties (1.90 t/ha) was significantly higher than that of non-adopters (1.07 t/ha).

In China and India, two of the world's largest rice producers, Fan *et al.* (2005) found that because of IRRI's research on Modern Varieties (MVs), more than 6.8 million Chinese people moved out of poverty from 1981 to 1999 and 14 million Indian people moved out of poverty from 1991 to 1999. However, the bulk of the poverty reduction in India and China occurred because of early-generation MVs. Although this raises questions about the recent contributions of rice research, no study has quantified the contributions of international rice research to varietal improvement and economic impacts.

Chapter 3

METHODOLOGY

This comprehensive impact assessment study has a detailed adoption analysis and on-farm survey to fully understand the various dimensions of impacts and generate the best possible data. The study has been designed to understand and measure the adoption, diffusion and impact of ISM on improved cultivars in the state of Andhra Pradesh through a representative primary survey. Quantification of farm-level welfare benefits experienced by paddy growing farmers is determined by examining various scenarios of technology adoption, namely replacement of old improved cultivars with the adoption of new improved cultivars. Overall, the study aims to understand the preference for ISM variety over Samba Mahsuri.

3.1. Sampling and data collection

The development of an appropriate and robust sampling strategy is a critically important step in ensuring a truly representative sample for the study. A given technology is likely to be adopted in areas where it is agro-climatically most suitable and in the areas where the variety is supposed to be targeted. This aspect needs to be taken care of in survey sampling, or else the findings of the study will be a “self-selection” bias. There were several rounds of discussions with crop improvement scientists, sampling experts and CSIR-CCMB and ICAR-IIRR team members to evolve the right sampling procedure to assess the extent of the area under ISM and its impact. District level Time series data of area, production and yield were obtained from Village Dynamic Studies in South Asia (VDSA) and relevant Government of India and state of Andhra Pradesh offices/sites.

State (sub-national) and district data were collected for examining the spatial distribution of paddy area, production and yield across the country and to identify BLB endemic areas. More detailed sub-district (*mandal*)-level data was used to select villages for the field survey and to estimate the extent of ISM variety and benefits due to adoption. Given that the ISM was specifically targeted to endemic areas of BLB-affected areas, the study adopted purposive sampling while selecting states and districts and also to some extent blocks and mandals. But selection of villages and farmers below the mandal/block level was done on a random basis (Table 5).

Table 5: District-wise total samples and percentage

State name	District	Sample Size	% to the Total Sample
Andhra Pradesh	East Godavari	308	48.97
	Kurnool	206	32.75
	Krishna	25	3.97
Telangana	Karimnagar	32	5.09
	Nizamabad	27	4.29
	Warangal	16	2.54
	Nalgonda	15	2.38
Grand Total		629	100.00

3.1.1 Survey Instrument

The aim was to keep the household survey instrument simple and make all questions relevant to the varietal adoption of paddy farmers. Refer to Appendix, which presents the final household and village questionnaires used in the survey. The survey instruments were developed, pre-tested and refined through several interactions with the group of rice experts and sample farmers. The modules were refined after incorporating the feedback from farmers and considering the quality of information provided by them.

3.1.2 Approach of data collection

- 1) **Focus group meetings and workshops:** In addition to the structured questionnaires for the farmers and village representatives, the study team also conducted focus group discussions at various stages of the survey, with district-level agricultural officers, millers, agricultural research station scientists to understand the dynamics in the varietal diffusion. Important observations were drawn from the participants of the focus group meetings relating to preferred varietal traits such as higher yield, short duration, drought resistance, lodging resistance, endemic pest and diseases, grain cooking quality, milling quality, tolerance to biotic and abiotic stresses etc.
- 2) **Workshops and brainstorming sessions:** The study team conducted a national workshop and invited eminent scientists, economists and agricultural officers to understand varietal diffusion among paddy farmers. The strategies adopted in the past to popularise varieties such as Samba Mahsuri, MTU-1010 and Swarna by well-known research institutions and breeders were discussed.

3.2. Data consolidation, compilation and analysis

Data was collected using Samsung tablets using World Bank Survey Solutions Application. The data so collected was tabulated and analysed using descriptive statistics, especially percentage analysis, Rank-Based Quotient (RBQ) analysis, mean etc. to arrive at meaningful conclusions and recommendable implications. The extent of adoption of the ISM variety was estimated using both survey data and information collected through focus group interactions with key informants. The secondary data on district-level area, production and yields was analysed using GIS maps. The endemic areas of BLB were also identified using GIS maps. The area affected by BLB was quantified and potential areas for diffusion of ISM rice variety were quantified.

Chapter 4

RESULTS AND DISCUSSIONS

Rice is one of the most important food crops of India, accounting for more than one-fifth of the total gross cropped area. It is grown in various agro-ecological environments of the country and is spread across all states. It is a staple food for the majority of India's billion-plus population and, on an average, contributes more than one-fourth to the total calorie intake. The Indian rice sector has undergone remarkable transformation in the past 5 decades, with rice production almost tripling and making India a rice-surplus country. India is now one of the top exporters of rice in the world market. The credit for India's success goes to the advent of the Green Revolution with the development of high-yielding semi-dwarf varieties, improved management practices, and the commitment of the Indian government through support programs for farmers and investment in developing infrastructure. In the past 5 decades, rice scientists have developed more than 1,000 improved varieties and better crop management practices to counter biotic and abiotic threats and to enhance productivity growth to stay ahead of the rising demand.

Map 1: Rice Cropped Area

Map. 2: Classification of Rice on the basis of irrigation (2009-10)

District-level trends in rice productivity in India

Map 3: 1966

Map 4: 1980

Map 5: 1990

Map 6: 2000

Map 7: 2011

District-level productivity levels are depicted in Map 3 to Map 7 from 1966 to 2011. Districts were divided into three categories, with the red colour depicting less yield (less than 1576 kg/ha), yellow colour depicting medium yield (between 1577 to 1926 kg/ha) and the remaining districts with higher yield (more than 1927 kg/ha) marked in green. Rice productivity in India was very low across all the districts during the 1960s, with almost all districts showing red colour.

The same scenario prevailed all over India from north to south. With the onset of the green revolution during the mid-1960s, some districts in Punjab, Haryana and Andhra Pradesh turned into high productivity zones. Improved seeds played a vital role in augmenting agricultural productivity in these zones. These seeds not only helped in increasing agricultural production by 10 to 20 percent, but they also introduced new characteristics in the biological structure of the plant. For example, researchers developed varieties with short duration, providing higher yield and building resistance to insects, diseases and droughts. In India, the success of the green revolution is mainly associated with the use of High Yield Variety (HYV) seeds. With the fruits of green revolution and land reform, Indian agriculture moved from food shortage to self-sufficiency and from self-sufficiency to surplus agricultural produce.

A period of the 1980s witnessed a higher increment in food grain production in comparison to increasing population, which increased the supply of food grains in the economy over the demand (Yadav Krishna Nand, 2005). Initially, rice productivity increased considerably in the 1990s in states such as Punjab, Haryana, Eastern Uttar Pradesh, Andhra Pradesh, parts of Tamil Nadu and Kerala. With the turn of the millennium, more advancement in agricultural technologies came about, such as improved farm machinery that saves time, reduces the cost of production and increases agricultural yield. More awareness about good agricultural practices further boosted rice productivity all over India, with more fruitful results in most districts of south Indian states and parts of North India (Punjab, Uttar Pradesh and Bihar) and eastern states such as West Bengal. In 2011, rice productivity showed even more positive results, with almost all southern India districts seeing growing yield trends. Northern India, parts of Gujarat, large chunks of Uttar Pradesh, Haryana and Bihar also maintained higher yield levels during this period.

4.1. BLB endemic areas and ISM perspective

How destructive BLB is to rice cultivation in India today is a critical question. The need for the ISM variety is well justified with this simple question.

Annually, more than 40% of the world's rice crop is lost owing to biotic stresses such as insects, pests, pathogens and weeds (Hossain, 1996). Among several diseases caused by bacterial, fungal and viral pathogens that devastate rice yields all over the world, BLB, blast, sheath blight, sheath rot and tungro virus are the most important (Velusamy *et al.*, 2006). Crop loss assessment studies have revealed that this disease reduces grain yield to varying levels, depending on the stage of the crop, a degree of cultivar susceptibility and, to a great extent, the conduciveness of the environment in which it occurs.

The disease is very destructive in Punjab, Haryana, Bihar and Uttar Pradesh, where it occurs regularly. It occurred in an epidemic form during 1998 in the Palghat district of Kerala and destroyed the rice harvest. Therefore, the deployment of BLB-resistant genes appeared to be the right strategy for management of this dreaded disease. These findings indicate the need for BLB-resistant varieties in India, and hence it fully justifies the development and spread of the ISM variety.

The list of epidemic areas is given in the following table for the years 1980 to 2000 and 2000 to 2016. The epidemic districts were identified and depicted in Table 6 and 7. The availability of the ISM rice variety seed every year from reliable sources in epidemic areas is important in order to stabilise the area under bacterial blight resistance at a higher level.

Table 6: Bacterial Leaf Blight-vulnerable districts (as measured by the frequency of occurrence) 1980- 2000

State	District	Year
Andhra Pradesh	Nellore	1983, 1984,1991
	West Godavari	1987, 1993,1995
	East Godavari	1988
Assam	Kamrup	1998
	Nalbari	1998
Bihar	Madhubani	1981
	Gopalganj	1981
	Shahpu	1981
	Bhagalpur	1986
	Rohtas	1987
	Bhojpur	1987
	Vaishali	1987
	Darbhanga	1987
	Muzaffarpur	1987
	Samastipur	1987
Gujarat	Surat	1988, 1989, 1990,1992,1995,1996,1998
	Valsad	1988, 1989, 1992,1997
	Kheda	1989,1990
	Panchmahal	1990
Haryana	Kurukshetra	1981,1988,1996,1997,1998
	Karnal	1981,1996,1997
Maharashtra	Raigad	1982, 1990
	Thane	1982
	Sindhudurg	1988
Manipur	Thoubal	1987
	Imphal East and West	1987
	Bishnupur	1987
Madhya Pradesh	Satna	1992
Jharkhand	Dumka	1991
Karnataka	Kodagu	1996
Kerala	Palakkad	1991
Odisha	Puri	1988,2000
	Balasore	1988
	Sambalpur	1989

Punjab	Kapurthala	1981, 1984, 1986
	Patiala	1983, 1990
	Amritsar	1983, 1984, 1985, 1986, 1988, 1989, 1990, 1991- 1993, 1995, 1997
	Jalandhar	1984, 1985, 1986, 1993
	Ludhiana	1984
	Sangrur	1985
	Gurdaspur	1985, 1992, 1993, 1997
	Hoshiarpur	1988, 1989, 1997
	Ferozepur	1992, 1993, 1997-1999
Uttar Pradesh	Faizabad	1987, 1995, 2000
	Gorakhpur	1983, 1986, 1987
	Sultanpur	1987
	Barabanki	1987, 1988
	Basti	1987
	Deoria	1987
	Ghazipur	1987, 1988
	Gonda	1987, 1988
	Azamgarh	1987, 1988
	Ballia	1987, 1988
	Varanasi	1988
	Bahraich	1988
	Jaunpur	1988
West Bengal	Hooghly,	1988
	East Medinipur	1989
	Bankura	2000
Telangana	Karimnagar	1988,
	Khammam	1993, 1994, 1996
	Nalgonda	1994, 1996
Tamil Nadu	Thanjavur	1991, 1996, 1997
	Pudukottai	1991
	Nagapattinam	1996, 1998
	Tirunelveli	1997
	Kanyakumari	1997
	Ramanathapuram	1997

Table 7: Bacterial Leaf Blight Vulnerable districts (as measured by the frequency of occurrence) 2000-2016

State	District	Year
Andhra Pradesh	East Godavari	2010,2014,2015,2016
	Kurnool	2010,2012
Bihar	Rohtas	2003,2015
Chhattisgarh	Raipur	2007, 2014,2015,2016
Gujarat	Valsad,	2002,2003,2015,2016
	Surat	2003,2008,2015
Haryana	Kurukshetra	2001,2003,2005,2007,2009,2011
	Kaithal	2006,2008,2009,2013
	Yamunanagar	2006,2008,2009
	Panchkula	2006,2009
Himachal Pradesh	Sirmaur	2005,2007
Karnataka	Mysore, Shivamogga, Raichur, Koppal, Bellary, Hassan	2015,2016
Kerala	Palakkad	2002,2011,2012
Maharashtra	Raigad	2001,2005,2008,2010,2011,2015,2016
	Thane	2010,2011,2012,2015,2016
Odisha	Sambalpur	2005,2012,2015,2016
Puducherry	Karaikal	2010,2012,2013,2014,2015,2016
Punjab	Gurdaspur	2001,2004,2005,2008,2009,2014,2015
	Amritsar	2001,2004,2007,2008
	Kapurthala	2001,2003
	Ludhiana	2004,2005,2008
	Sangrur	2004,2008
	Ropar	2004,2007,2008
	SBS Nagar	2004,2008
	Taran taran	2006,2007,2008
Tamil Nadu	Erode , Trichi, Thiruvarur, Nagapattinam, Karur, Theni	2004,2005,2006,2008
	Madurai	2008,2011
	Thanjavur	2009,2013,2015
Telangana	Warangal, Khammam	2015,2016
Uttar Pradesh	Faizabad, Gorakhpur	2001,2004,2015,2016
	Sultanpur	2004,2008,2015,2016
	Azamgarh	2004,2010,2016
	Jaunpur	2004,2014,2015,2016
	Ghazipur	2010,2013,2014,2015,2016
	Sonebhadra	2010,2013,
	Chandauli	2012,2014,2015,2016
Uttarakhand	US Nagar	2003-05, 2007,2008,2013

Map 8: Frequency of Bacterial Leaf Blight occurrence (1980-2000)

Uttarakhand

US Nagar

Map 9: Frequency of Bacterial Leaf Blight occurrence (2001-2016)

2003-05, 2007,2008,2013

A major BLB epidemic occurred in Punjab, Haryana and western Uttar Pradesh and plains of Uttarakhand during 1980s, when severe BLB was observed and total crop failure was reported. The disease occurred in Kerala during this period, and since then, it has been observed almost every year. The disease appeared in parts of Andhra Pradesh during 2010 and 2013 and a severe Hudhud cyclone attack was reported during 2014-15 (Yugander *et al.*, 2014). Yield loss due to the disease may be as high as 50% or depending on the variety, rice growth stage, geographical location and seasonal conditions. However, during the last decade or so, the disease has increased both in terms of geographical distribution and intensity and moved to areas that were earlier not considered endemic for BLB. During 1981-1990, BLB was recorded in moderate intensity mainly in Gujarat and parts of eastern India. After this period, the disease was widespread in several rice growing areas of Bihar, Punjab, Gujarat and Uttar Pradesh. The disease was also widespread in moderate intensities in several rice growing regions of undivided Andhra Pradesh and Haryana. In the rest of India, the disease was either not recorded or was present in sporadic intensities.

During 1980-2000, the intensity of the disease was moderate in states such as Haryana, Punjab, undivided Andhra Pradesh and Tamil Nadu (Map 8). However, from 2001-2016, the intensity and spread of the disease dramatically increased in many rice-growing regions of India, especially in coastal Andhra Pradesh, parts of Gujarat, Haryana, Maharashtra, parts of Kerala, Odisha, Puducherry, Punjab, Tamil Nadu and Uttar Pradesh (Map 9). The disease was widespread almost throughout Punjab in moderate to severe form during 2008 (POS, 2008). The disease appeared in Raigad and Thane districts of Maharashtra during 2010 and 2011. It appeared in a severe form in Tamil Nadu from 2008-2015 and varieties such as BPT 5204, ADT 43 and CR 1009 were severely affected. The disease spread like wildfire in coastal regions of Andhra Pradesh, especially in the East and West Godavari districts, in October- November, 2014, following the severe cyclone Hudhud. During the Hudhud cyclone, most of the farmers reported that almost 80% to 100% of the crop was damaged due to severe infestation of BLB. The intensity of disease also increased significantly in Himachal Pradesh, Bihar, Chhattisgarh and West Bengal. It was recorded in low to moderate intensities

in states such as Jammu and Kashmir, Jharkhand and Uttarakhand, where BLB was not much of a problem earlier. Though not widespread in Karnataka, BLB is being increasingly observed in districts such as Bellary, Raichur and Koppal. Focus group discussions indicated that changes in climatic conditions, such as increased rainfall and frequent cyclonic conditions-especially in the eastern coast-narrow genetic base and application of high doses of nitrogenous fertilisers are some of the reasons for the increase in intensity and spread of the disease.

4.2. An overview of stakeholders' opinion

In severely endemic areas such as Kurnool and East Godavari, farmers opine that the ISM variety performed better than the Samba Mahsuri variety. In some of the villages, there was 100% replacement of Samba Mahsuri with ISM, and the seeds were supplied mainly by National Seed Corporation (NSC) and AP State Seed Development Corporation (APSSDC) and, to some extent, by the BLIGHT-OUT project of CSIR. Interestingly, in a few clusters of villages, private and informal farmer-seed producers are playing a dominant role in diffusion of ISM rice variety. Farmers got pure seed from KVKs and research stations (i.e. through ICAR-IIRR), and they are highly satisfied with the varietal performance, especially with regard to resistance to Bacterial Leaf Blight. However, farmers feel that the seeds supplied through NSC and AP SEEDS had lots of impurities (with mixtures from at least two distinct rice varieties) and complained that tillers from the same hill are matured in different time periods with different grain quality. With impurities and unsynchronised flowering and maturity due to the seed mixture, farmers were not able to harvest crop in time and millers purchased the grain at a discount from the market price. There was a severe problem of spurious seeds in the supply chain of ISM and other paddy varieties. Hence, there is a need for a strategy in maintaining the purity of ISM seed production by NSC and APSSDC and to develop distribution channels to build trust among farmers in order to popularise the ISM variety.

Agricultural officers have the opinion that during the processing/milling, some admixture is taking place, which should be controlled. Often, farmers are not aware of the availability of disease- and pest-resistant varieties, including ISM. Most of the farmers are unable to distinguish among different diseases and pests; they treat all pests and diseases the same and spray the same pesticides for all the diseases and pests. Most of them also cannot distinguish among varieties resistant to different diseases. Even in some epidemic areas, farmers and agricultural officers were not aware of the ISM variety and its specific trait (resistance to BLB) even though there were huge losses due to BLB year after year. Because of lack of a continuous supply of ISM seeds from reliable sources year after year, their adoption has not picked up for vertical diffusion of ISM year after year in epidemic areas. Farmer-to-farmer seed distribution channels were not promoted systematically, which would have generated a lot of interest among the target communities. There is also a need to educate farmers and agricultural officers that this variety is resistant to BLB and ensure that the seeds are available with local seed dealers in selected epidemic areas and not just in East Godavari and Kurnool districts but also in Uttar Pradesh, West Bengal and Odisha, where isolated epidemic areas were identified. Diffusion of the variety can pick up significantly once M/s Metahelix Life Sciences (one of the licensees of the technology) and other firms that have licensed the variety recently with ICAR-IIRR and CSIR-CCMB start producing seeds and distributing them.

4.3. Field-level results

The total number of villages selected for the study in Andhra Pradesh was 33 and in Telangana was 23 (Table 8). The maximum number of villages was selected from the East Godavari and Kurnool districts of Andhra Pradesh. Based on focus group interactions with the key informants, a few samples were collected from other states in proportion to the area under ISM in 2016. The field survey results were presented in this section.

Table 8: Mandals and villages in the study areas

State	Districts	Mandals	Villages
Andhra Pradesh	East Godavari	4	27
	Kurnool	4	4
	Krishna	2	2
Telangana	Karimnagar	1	8
	Nizamabad	3	5
	Warangal	3	6
	Nalgonda	1	4
	Total	18	56

Note: In each village, focus group discussions were conducted with about 40 farmers, totalling 2,240 farmers.

4.3.1. Varietal diffusion models

Based on the field-level experiences, we have presented different varietal diffusion models existing at the village level in this section. The ISM variety was released and mini kits were distributed by different NGOs between 2006 and 2008. ISM replaced the SM variety slowly from 2008 to 2016. The mini kits are generally followed by campaigns and other strategies for large-scale adoption of varietal technologies. It was noticed that mini kits (seed bags) were distributed in isolation of other concerted efforts by the KVKs, which resulted in territoriality, where a few farmers took control within a defined and fixed jurisdictional area. This problem may be compounded through localised criticism of a newly released variety (ISM) in the present context. This could be avoided with the community approach, which could be tried in future to facilitate faster diffusion and adoption of varieties such as ISM.

Fig. 8: Villages with moderate level of private sector competition

In 2000, the area under Samba Mahsuri was 80% of the total area sown in model 1. The private varieties occupied around 20 % of the area. In the subsequent years, *i.e.* after 2000, the area under the SM variety gradually declined every year and the area under private companies increased up to 48-49% of the sown area in the village. With the introduction of the ISM variety in 2008, the area under ISM increased from 5% in 2008 to 40% of the area in 2015-16. SM reached 20% of the

area sown in 2015-16. As the area under ISM increased from 2008, the spread of private varieties decreased from 50% area to 40% area in 2009 to 2010 and achieved a steady trend from 2009-2016, with around 40% of the area under them. The preceding model shows that with an increase in the area under ISM, the area under SM and private varieties decreased.

Fig 9: Villages dominated by private sector varieties

In model 2, it can be seen that the area under the SM variety steadily falls down from 90% of sown area to 60% of the paddy area from 2000-2007. During this period, the area under private seed increased from 10% to 45%. After 2007, the private seed area continued to increase to 60% until 2011 and maintained the same level up to 2016. With the introduction of the ISM variety, the ISM area continuously increased from 5% in 2008 to 30% in 2016. The area under SM decreased slowly from 60% to 50% from 2000 to 2008, and then saw a steep decrease to 10% by 2016. This might be due to the release of the ISM variety in 2008. With the ISM variety gaining popularity, the area under SM decreased. From the preceding model, it can be perceived that in recent years, the area under ISM has increased and the SM area has decreased; the area under other private seeds continues to dominate the area.

Fig 10: Villages with wide diffusion of ISM variety

Model 3 shows that the area under the SM variety was about 90% in most of the villages in 2000, after which it kept constantly reducing until 2007 and came down to 69% of the area. The area under the SM variety showed a steep downward trend since 2008 and shrunk to 10% of the area in 2016. The private seed area gradually increased from 10% area in 2000 to 30% area in 2007 in village 3. It rose to 42 % in 2011 and then started decreasing over the years and reached an all-time low in 2016, when the area under private seeds almost ceased to exist. The ISM area increased from 12% in 2008, the year it was released, to 90 % of the area sown in 2016. The preceding model represents that with the introduction of the ISM variety, the area under SM and private seed varieties decreased. The private seed area increased only to a certain limit even after the ISM release and then declined again.

Fig: 11 Villages with quick diffusion but decline in ISM variety

The area covered by the SM variety shows a steady trend from 2000 to 2007 with 90% area. Private seed also showed a similar movement with 10% area from 2000-2007. ISM was introduced in 2008. It gained popularity and the area progressively increased from 15% in 2008 to 38% in 2012. The area covered by private seed increased from 10% to 32% in 2012 and suddenly declined to 5% in 2015 with increase in area of ISM (90%). The area under SM steeply declined to 60% in 2009 and further decreased to 5 % in 2016. But in 2016, the area under ISM suddenly came down to 40%, and with this, the SM area increased from 5% in 2015 to 50% in 2016. The sudden decline in the area of the ISM variety might be because of the discontinuation of adoption of the ISM variety due to bitter experiences with spurious seeds of ISM distributed in 2015. Because of the spurious seeds, there was a lack of synchronisation in time to maturity even from the same heap of tillers. Farmers' yields reduced steeply, along with reduction in prices due to impurities in harvest. The area under private varieties also slightly increased from 5% area to 10% in 2016.

Three formal marketing channels exist for the distribution of publicly produced certified seed. First, SSDCs and NSC have their own marketing network with many sales centres nationwide. Farmers can purchase TFL-tagged CS from a sales outlet of public-sector seed agencies. The second marketing channel is through licensed private seed dealers. The number of seed sales outlets (seed dealers) in India has increased significantly over the past few years, with 200,000 seed outlets now engaging in marketing of seed (of both the public and private sectors) in India. Now, the moot question is how far this huge network was engaged in the popularisation of ISM. During the stakeholder interaction, it was evident that except the period in which SRI BIOTECH was distributing ISM, the seed of this variety was not available to farmers through this network.

The involvement of additional private companies in the distribution of the ISM seed will greatly help in making the ISM seed available to farmers. CCMB and IIRR have already signed a licensing agreement with M/s Metahelix to produce and market seeds, and recently, MTAs have been signed with various companies to evaluate the potential of the variety and market it. Organisations such as CCMB or IIRR have limitations with their institutional mandates, but they can facilitate formal and informal marketing channels.

4.3.2. Occupation profile

From table 9, it can be seen that agriculture is the main occupation (98%) of the people in the study area. Only a minor proportion of the villagers are casual labourers, job holders or engaged in business or some other activities.

Table 9: Occupation of the population (percent)

Main Occupation	Percent
Agriculture	98.41
Casual labour	0.64
Job	0.48
Business	0.36
Others	0.16
All	100.0

4.3.3. Livestock and machinery

The total number of milk animals per household in the study area of AP was 0.97 and Telangana was 1.31. The total number of draft animals was a little higher in Andhra Pradesh farmers (0.47 per household) compared to Telangana (only 0.37 per household). The number of goat and sheep per household was higher in Telangana (1.72 per household) compared to AP (0.19). The number of tractors per household was more or less the same in both Telangana and AP, with about 0.18 tractors per household (Table 10).

Table 10: Number of livestock and tractors per household

States	No. of milk animals	No. of draft animals	No. of goat and sheep	No. of tractors
Andhra Pradesh	0.97	0.47	0.19	0.18
Telangana	1.31	0.37	1.72	0.20
Total	1.02	0.45	0.41	0.18

4.3.4. Operational holding

The area under operational land in AP was 5.77 acre, while it was little higher in Telangana at 6.26 acre. The average size of operational holding was 5.87 acre, as shown in table 11. On average, about 2 acres were leased-in in AP, while only one acre was leased-in in Telangana. The leased-out area was meagre in both the states.

It may be noted here that the average size of holdings in India declined from 5.75 acre in 1970-71 to 3.35 acre in 2000-01 and 63% of land holdings belong to marginal farmers with less than 2.5 acre. The average size of marginal holdings is only 0.6 acre at an all-India level. The average size of small holdings is 3.55 acre. In this context, it can be said that ISM has come with a constraint of not being able to reach out to small and marginal farmers. This could be attributed to random extension efforts in place of organised efforts and well-articulated extension plans. Future diffusion strategies should take care of this important point and try to encourage adoption among small and marginal rice farmers.

Table 11: Size of operational holdings (acre/household)

State	Own land	Leased-in	Leased-out	Total operational land
Andhra Pradesh	3.72	2.35	0.21	5.77
Telangana	5.34	1.08	0.00	6.26
Grand total	4.05	2.13	0.17	5.87

4.3.5. Frequency of seed replacement

About 90% of the farmers replace seed either every season or every year, as shown in Table 12. This indicates that even in self-pollinated crops such as paddy, farmers prefer to purchase seed every year due to subsidy provided by the government and storage problems in preserving harvested grain for one year to use as seed in the next year and losing the germination percentage due to lack of proper storage facilities. Hence, it is important for seed companies and the Department of Agriculture (National Seeds Corporation) to supply sufficient quantity of newly released improved variety seeds such as ISM in the endemic areas for wider adoption. There is a need for increasing awareness about the benefits of using own seed for at least up to 2 years, and construction of good seed storage structures is also important.

In seed production and distribution, a multi-agency approach needs to be followed. Utilising the services of public, private, public-private, public-private-community-based organisations in seed production and distribution needs to be encouraged. In many developing countries, NGOs and cooperatives usually promote community-level seed production, often through farmers' organisations. NGOs in India actively promote community-level seed production, especially for non-hybrid crops, such as rice. In Andhra Pradesh and Telangana, the public sector (mostly SDA, SSDCs and the local SAU) is directly involved in promoting community seed production through programs, including the Seed Village Program. It appears that there was no activity undertaken during the project period in this regard. Community-based seed systems can be built with a group of well-trained and committed farmers, who process seeds from a range of individuals or groups who share seeds among themselves. These groups 'learn-by-doing' the best management options to ensure seed purity and the quality of seeds they produced on-farm. Presence of local champions, strong support from local executives and NGOs for technical assistance, farmer volunteers, capacity building and community empowerment are some of the success factors that can be tried out.

Considering the limited funds sanctioned under the BLIGHT OUT project of CSIR800 (which focused on production and distribution of quality seed in a limited way), it was not possible for either IIRR or CCMB to undertake all these activities under the project.

Table 12: Frequency of seed replacement

Variety	Samba Mahsuri %	Improved Samba Mahsuri %
(a) Every season	32.6	34.8
(b) Every year	56.0	55.6
(a+b)	88.6	90.4
More	3.2	3.0
Once in 3 years	1.8	1.5
Once in two years	6.4	5.1

There appears to be a small lacuna in the design and approach adopted by the CSIR project while popularising and promoting seed replacement with ISM. For example, during the same period

as ISM (2008-15), stress-tolerant rice varieties (tolerant of abiotic stresses such as submergence, drought and salinity) were promoted by IRRI (it may be noted here that the funding amount is different in both cases). In the past decade, several stress-tolerant varieties have been developed and disseminated in South and Southeast Asia. Important submergence-tolerant rice varieties include Swarna-Sub1, Samba Mahsuri-Sub1 and IR64-Sub1 in India; BBRI dhan52 (BR11-Sub1) and BRRI dhan51 (Swarna-Sub1) in Bangladesh; and Samba Mahsuri-Sub1 and Swarna-Sub1 in Nepal. Similarly, drought-tolerant variety Sahbaghi dhan was released recently in India, Bangladesh (with the name of BRRI dhan56) and Nepal. The distribution of stress-tolerant rice varieties in South Asia started in 2008 under the project Stress-Tolerant Rice for Africa and South Asia (STRASA). It coordinated seed multiplication with local counterparts and distributed stress-tolerant rice variety seeds through NGOs and government agencies using mini kits and demonstrations. Seed distribution expanded exponentially in India after the National Food Security Mission (NFSM) of India picked up the distribution of stress-tolerant rice variety seeds in 2010. Similar concerted efforts would have strengthened the case of ISM. With the limited budget, integrating BLIGHT OUT with the NFSM activities could have further strengthened the efforts.

4.3.6. Comparison of yield harvests

During the unfavorable years, there was significantly less yield for SM compared to ISM, while there was no significant difference in the yield of ISM and SM. The gap in the yield between ISM and SM was especially significant during the years of the BLB epidemic. Our focus group discussions indicated that in the years there was severe infestation of BLB, SM yields reduced to below 5-10 quintal per acre, whereas ISM yields were stable.

Table 13: Average yield harvest by the households (bags/acre)

Variety	Yield in bad years	Yield in good years
ISM	24*	32
SM	22	34

Note: *Indicates significant at 5% level

Table 14: Pest and disease resistance

	BLB endemic areas		Non-endemic areas		All	
	ISM	SM	ISM	SM	ISM	SM
Pests and diseases						
BPH	43	45	42	42	42.5	43.5
Bacterial Leaf Blight	7	32	5	15	6.0	23.5
Blast	16	19	13	23	14.5	21.0
Tungro	5	4	4	7.5	4.5	5.8
Stem borer	8	14	6	13.9	7.0	14.0
Leaf folder	2	2.1	2.1	3.9	2.1	3.0
Sheath blight	1.3	1.4	1.6	2	1.5	1.7
Stem rust	0.2	0.4	0.4	4	0.3	2.2

Note: Endemic area and non-endemic areas were based on the farmers perceptions: if the BLB attack was severe

In the study localities, more frequent pests and diseases are BPH, BLB, blast and stem borer. We examined the reported occurrence of diseases and pests by each farmer who grew both SM and ISM rice varieties. The results are presented in Table 14 and show that the reported diseases and pests are slightly higher in SM compared to ISM for most of the pests and diseases, but they are not statistically significant, except BLB. Samba Mahsuri is highly susceptible to BLB compared to

ISM, especially in BLB-affected areas, where farmers reported BLB infection of 32% for the SM variety and 7% for ISM. In non-endemic areas, 15 % of the farmers reported BLB in SM and an eligible percentage of farmers reported in ISM. The difference between SM and ISM is significant in both BLB-affected areas and non-affected areas. **Reports of the limited occurrence of BLB in ISM could actually be a case of mis-diagnosis of the disease by farmers.** Overall, there was no significant difference in the occurrence of diseases and pests in BLB-affected areas and non-affected areas. ISM is also less affected by the blast disease, with only 14.5% occurrence compared to 21% in case of SM. Among pests, Samba Mahsuri was more susceptible to stem borer attack (14.0%) than ISM (7%). Other diseases, such as heath blight and stem rot, occurred negligibly.

4.3.7. Frequency of BLB occurrence – diffusion strategy

Table 15 presents the frequency of occurrence of BLB in Samba Mahsuri and ISM varieties in both Telangana and Andhra Pradesh. The highest frequency of BLB occurrence in AP was seen in 2015 in the Samba Mahsuri variety, with 18% farmers reporting that their paddy fields were damaged significantly due to BLB; in case of Telangana, only 6.5% of the SM farmers reported that their fields were damaged due to BLB. Overall, looking at the frequency of occurrence in cyclone-affected years (2014 and 2015), one can see that out of the total sample of 633, 28.4% farmers were affected by BLB in 2015 and 22.3% were affected by BLB in 2014. BLB infestation was low in 2012 (only 6% farmers reported), while in 2016 and 2013, infestation was moderate at about 15 to 17%.

BLB incidences in states can be seen increasing for four years until 2015 and suddenly declining to 54 reported cases in 2016. This might be due to the drought conditions in 2016. The occurrence of BLB in ISM is not much in all the years in both Telangana and Andhra Pradesh. This indicates that the ISM variety is resistant to BLB both in endemic and non-endemic areas and also in epidemic and normal years.

Table 15: Variety-wise frequency of occurrence (percentage of the total sample farmers) of BLB in the last 5 years

State	Variety	2012	2013	2014	2015	2016
Andhra Pradesh	Samba Mahsuri	4.4	10.7	14.1	18.6	8.5
	ISM	0.0	0.8	1.4	2.4	2.7
Telangana	Samba Mahsuri	1.6	3.2	6.3	6.5	5.4
	ISM	0.0	0.0	0.0	0.0	0.2

Although varietal adoption is dependent on many factors, there is a need to look at characteristics of varieties being adopted in terms of agronomics, grain quality and stress resistance. ISM has been, by and large, targeted to districts/regions where epidemics of bacterial blight have been reported. However, even within these regions, it would have been helpful if preliminary surveys were conducted to identify villages/mandals that were the most prone to BLB. Targeting of areas and then planning varietal diffusion strategy would have given wider visibility to the ISM variety in rice-growing areas. In future, this can be taken care of. From Table 16, it can be observed that the intensity of the attack is low to medium, but the loss due to BLB has been the highest in 2014 and 2015.

The highest number of cases of bacterial blight was seen in 2015, with 28.4% farmers, followed by the year 2014, with 22.3% farmers. The highest percentage of farmers (35.5% of the farmers) reported only 0-10% loss, about 33.8% of the farmers reported 10-20% loss and 13.4% of the farmers reported 20-30% loss during the last five years. Few farmers report more than a 30%

loss. It can be seen that the disease occurred mostly in low severity (0-10% and 10-20% category) across the studied districts. Now it can be said that not with standing the best variety available at hand, there was a lacuna in the preliminary planning stage in identifying the best areas (where more than 30% damage was experienced by the farmers due to BLB). Due to this the windfall impacts could not be realised.

It may be noted here that BLB incidences change year on year. An area that has 30% incidence this year may have only 5 % next year depending on the climatic conditions. The study tried to focus on areas where BLB was reported in the past and Samba Mahsuri was cultivated. This is evident from major efforts in East Godavari and Kurnool districts, as there have been recent reports of epidemics in these areas. In Telangana, there have been reports of BLB in a few areas, and seeds were distributed in these areas based on feedback from the agriculture department. Varietal diffusion strategy would have given wider visibility to ISM variety in rice growing areas.

Table 16: Loss percentage because of Bacterial Leaf Blight (2012-16)

Loss percentage	2012	2013	2014	2015	2016	Average
0-10%	2.2	4.4	8.5	11.4	9.0	7.1
10-20%	2.5	7.7	8.2	10.7	4.6	6.74
20-30%	0.9	2.4	3.3	4.1	2.7	2.68
30-40%	0.3	0.3	1.3	0.6	0.3	0.56
40-50%	0.0	0.0	0.6	0.8	0.2	0.32
50-60%	0.0	0.2	0.0	0.8	0.0	0.2
60-70%	0.0	0.2	0.3	0.0	0.0	0.1

Table 17: Reasons for bacterial leaf blight occurring in paddy

Causes for BLB	Percent (%)
Weather change/floods	46.5
Spurious seeds	19.5
Excessive usage of N-fertilisers	15.4
Field-to-field irrigation	8.7
Soil quality	6.9
No crop rotation	2.7
More irrigation of water	0.4
Grand total	100

Table 17 presents farmers' opinion about the major reasons for BLB occurrence in their paddy fields. The highest percentage (46.47% of farmers) believed extreme weather changes such as floods are the reason for BLB occurrence in their fields, followed by spurious seed (19.50% farmers) and excessive use of nitrogen fertilisers (15.4% of the farmers). Farmers opined that field-to-field irrigation and soil quality are also major factors in the disease occurrence. In the kharif season, farmers mostly grow Samba Mahsuri-type paddy varieties. Farmers believe pests and diseases are the major constraints in increasing and stabilising the paddy yields in the Samba Mahsuri variety. During 2014 and 2015, there was a severe infection of bacterial leaf blight, especially in Godavari districts. In some villages, farmers reported up to 70% yield loss due to BLB in Hudhud-cyclone-affected areas in the year 2014. The ISM variety was resistant to BLB even under these conditions

of severe disease epidemic. Seed distribution under CSIR800 has helped in the introduction and popularisation of ISM in this district. BLB mostly occurs in areas with high frequency of floods and cyclones and places that are close to forest areas and where there is excessive use of fertilisers such as urea (for example, East Godavari and Nandyala areas of the Kurnool district). However, BLB is not a serious problem in districts of Telangana State.

4.3.8. Existing mechanisms to combat the disease

Traditionally, farmers also practice some precautionary measures based on their past experience to avoid BLB occurrence. It has been observed that a majority (77.4%) of the farmers in the study area go for blanket spraying of insecticides for the control of the diseases as they are not aware of the actual control mechanisms for BLB and other prominent diseases. Farmers spray chemicals that are widely used for other diseases for BLB as well. About 9% of the farmers tried to exercise control through balanced use of fertilisers such as application of optimum dose of potassium. Only 8.1% of the farmers are of the opinion that the use of best quality seeds will overcome the BLB infestation. About 4% of the farmers said that keeping fallow for one or two seasons will reduce pest infestation. A few farmers adopted wider spacing to avoid the disease attack.

Table 18: Precautionary measures taken by the farmers to prevent BLB

Precautionary measures	% of farmers
Blanket spraying of chemicals	77.4
Balanced use of fertilisers	9.0
Using best seeds	8.1
Keeping fallow	3.7
Wider spacing in transplanting	1.7

4.3.9. ISM replacement pattern

The study also probed about which varieties were replaced with ISM. Results (Table 19) show that about 81.8% of the farmers replaced SM with ISM. Varieties such as 555 (6.3%), Swarna (5.0%), RNR 15048 (2.3%) etc. were also replaced by ISM, though in small proportions. In certain pockets, RNR was given as mini kits and farmers reverted to ISM due to several reasons. In the study area, out of the 633 sample farmers, a total of 400 farmers replaced the present varieties with ISM over the last decade. The reason behind this replacement might be their belief in the bacterial-blight-resistant characteristic of the ISM variety. As BLB causes yield and income loss, people wanted to adopt a resistant variety i.e. ISM, especially wherever ISM seed was available in endemic areas such as Godavari districts and parts of Kurnool.

Table 19: Rice varieties replaced by the ISM

Variety replaced by the ISM	Percentage of farmers
Samba Mahsuri	81.8
555	6.3
Swarna	5.0
RNR-15048 (Telangana Sona)	2.3
Other Varieties	4.8
Total	100

4.3.10. Consistency in adoption

Table 20 shows the change in area under ISM by sample farmers. The ISM adoption rate increased from 2011 to 2017. The area under ISM by sample farmers has also been increasing over the years from 152 acres in 2011 to 1,468 acres in 2017 in the study area. The number of farmers who cultivated ISM also increased from 83 in 2011-12 to 400 in 2016-17 out of 633 sample farmers. Overall, the growth is reasonably good given the more number of varieties are released and marketed for cultivation both from public and private sectors over the years.

Table 20: Adoption of ISM variety in the last five years among the respondent farmers

Year	Average Area (Ac)	Number of farmers	Total area (acre)	Percentage increase in the ISM area over the previous year
2011-12	1.83	83	152	
2012-13	2.59	93	241	59
2013-14	3.36	101	339	41
2014-15	3.23	175	565	67
2015-16	3.81	295	1124	99
2016-17	3.67	400	1468	31

4.3.11. Innovation attributes

In terms of cooking quality, grain quality, yield and market price, SM ranked better than ISM, although the difference is not significant. SM has a significant edge in these four attributes compared to all other dominant varieties. There was no significant difference in grain quality between ISM and SM, but in terms of bacterial blight resistance and maturity period, farmers preferred ISM over SM. In the study area, it was seen that ISM is almost on par with SM in all other characteristics, such as pest and disease resistance, maturity period and fodder quality, compared to ISM (Table 21).

Table 21: Average aggregate rank of popular paddy cultivars grown by the farmers

Indicators	ISM	SM	Popular variety-1	Popular variety-2
Cooking quality	4.04	4.21	3.33	3.27
Yield	4.02	4.20	4.19	4.29
Market price	4.01	4.13	3.81	4.02
BLB resistance	4.50	3.02	3.05	3.00
Grain quality	3.94	4.04	3.53	3.60
Milling quality	3.84	3.89	3.60	3.52
Maturity period	3.35	3.23	3.57	3.78
Fodder quality	3.31	3.61	3.46	3.67
Resistance to other diseases	3.20	3.07	3.07	3.33
Resistant pests	3.18	3.00	3.18	3.31
Hollow grain	3.11	3.30	2.94	3.00

Table 22: Benefits of Improved Samba Mahsuri

Type of benefit compared to the existing variety	Yes %	No %
Reduction in loss due to BLB	71	29
Increased grain yield	68	32
Fetching remunerative market price	62	38
Reduction in the losses due to other pests and diseases	57	43
Increased fodder yield	57	44
Reduction in crop risk	56	44
Reduced cost of cultivation	53	47
Reduced duration	53	47
Suitable for mechanisation	53	47
Others	15	85

Maximum number of respondents (71%) opined that ISM reduces BLB losses, about 68% of the farmers said that ISM yields are higher and 62% consider that it fetches higher price than other local varieties, on par with SM (Table 22). ISM's equal pricing with that of SM indicates that whatever minor differences in quality may exist are indeed minimal. About 57% of the farmers said that ISM is also tolerant to other pests and diseases, reduces crop risk and increases fodder yields. About 53% revealed that because of ISM use, there has been a reduction in pesticide use; as a result, costs would decrease. The ISM variety also benefits farmers in terms of reduced loss due to less pest and diseases. Both varieties were found to be quite suitable for mechanisation. Some farmers also expressed that the duration of the ISM variety was about 5-10 days less than SM, resulting in them not facing extreme events and reduced risk.

Table 23: Important traits farmers look for in new rice varieties

Important traits	% of farmers
High yield	66
Pests and disease resistance	31
High market price	19
Short duration	10
Less water required	8
Quality seed	7
Seed that suits all lands	3

Majority of the farmers (66%) demand high yielding traits of rice varieties, followed by pest and disease resistance (31%), as shown in table 23. 19% of farmers also look for good quality grain (slender with good cooking quality) as they fetch higher market prices. Short duration varieties were also preferred by about 10% of the farmers, as they escape drought and floods and reduce the risk of losses due to unseasonal rainfall. Further about 8% of the farmers preferred varieties that require less water. The availability of quality seed was counted as one of the desirable attributes by about 7% farmers and only a negligible proportion of the respondents (3%) wanted seeds that suited all types of lands.

4.3.12. Communication channels

The agricultural department plays an important role in disseminating information to farmers regarding rice varieties, cultivation practices and management of pest and diseases. Seed companies

also provide information on rice varieties as well as guide farmers with proper management of pest and diseases. About 15.2% of the farmers are members of SHGs and about 11.5% of the farmers are members of rythu-mitra/farmer clubs (Table 24). About 20% of the farmers get information on improved varieties from local progressive farmers. Hence, it is important to disseminate newly released varieties through the agricultural department, private seed companies as well as progressive farmers. It has been noted that the CSIR800 project distributed ISM seeds through the agricultural department, Krishi Vigyan Kendras and progressive farmers. Except the period in which ISM was distributed by M/s Sri Biotech, the role of private seed companies has been limited. The role of Rythu-mitra and farmers clubs has also been limited, though there have been efforts in this direction. The role of the input supplier exists as well, but only to a limited extent. In the East Godavari district, Department of Agriculture, Govt. of AP, is popularising the variety under the "Chandranna Rythu Nestham" program, but to a limited extent.

Table 24: Type of networks available in the village

Type of Network	Seed Company	Agri. Dept.	Input supplier	Progressive farmers	SHGs	Rythu-mitra/farmers club
Any family member is a member	NA	NA	NA	NA	15.2	11.5
Information about rice variety	25.8	43.3	12.5	21.0	3.5	10.0
Information about cultivation practices	15.2	31.0	8.2	18.3	1.4	7.7
Information about pest/disease management	25.4	43.8	13.4	22.4	2.7	10.0

It appears that the CSIR project has focused on the agriculture department, Krishi Vigyan Kendras and progressive farmers but has not seen extensive involvement of other stakeholder organisations such as input suppliers, SHGs and farmers clubs to generate awareness and to help farmers have better access to improved seeds. This is mainly due to the limited budget of the project and also due to its limited mandate (i.e. promoting the diffusion of ISM among 10,000 farmers). In future, a seed distribution network might be established across BLB endemic areas coupled with trainings. Regional/district agro dealers with the intention to bring a reliable and efficient seeds distribution nearer to farmers would have helped the cause of ISM. In Telangana state, varieties such as *Telangana Sona* and *Bathukamma* are marketed only by PJTSAU and State Department of Agriculture and not by any private sector player. In future, we need to probe the success factors in the effective diffusion of these varieties. In future, ISM can draw lessons from these initiatives.

4.3.13. Crop insurance

As the ISM variety is basically introducing the trait of BLB resistance to reduce losses in case of disease epidemic, the study examined farmers' strategies to reduce risk through institutional support, for example, taking crop insurance. About 52% paddy farmers were aware of crop insurance, but only 17% farmers had taken crop insurance (Table 25). All the insured farmers are loanee farmers, as it is mandatory for loanee farmers to pay premium for crop insurance, which will be deducted while the banks are giving out the loans. On the other hand, for non-loanee farmers, crop insurance is voluntary and they generally do not opt for crop insurance. It has also been seen that about 5.40% of the farmers in the study area availed claim. Overall, only 5% of the farmers availed benefits from crop insurance even though the flagship program of the government of India on crop insurance, Prime Minister Fasal Bhima Yojana (PMFBY), was implemented in 2015. Many farmers feel that even though their crops were damaged due to pests and diseases, they

did not get any type of compensation from the government. This indicates that there should be more focus on the development of risk-reducing varieties and popularising them in endemic areas is important in order to alleviate risk in paddy cultivation.

Table 25: Crop insurance awareness

Crop insurance	Yes %
Aware of crop insurance	52
Taken crop insurance	17
Availed any claim	5

4.3.14. Results from non-endemic areas

In non-endemic areas such as Nalgonda, Warangal and other Telangana districts, the occurrence of BLB is rare and loss due to BLB was just about 5% in the affected areas. In these districts, the performance of ISM was on par with Samba Mahsuri. But given the historical preference for the Samba Mahsuri paddy variety by farmers and millers, farmers still prefer Samba Mahsuri in these districts, and hence in many places, farmers are marketing ISM under the name Samba Mahsuri. In Telangana districts, various private companies are aggressively marketing Samba Mahsuri type paddy varieties under different brand names, such as HMT, with attractive packaging, branding and marketing strategies. Farmers also prefer these private company seeds. Along with the seed, private companies also provide seed treatment kits and supplementary material. Saleability and market price of private company seed such as HMT are also higher compared to both SM and ISM. Millers and traders came to paddy fields and purchase the harvested paddy even with high moisture content.

Farmer's opinion

The ISM variety matures 10 days before SM, which is advantageous as it saves input costs and saves from untimely rains. Many farmers have expressed the opinion that ISM was more resistant to lodging than SM and Swarna rice varieties. This contributed to the increased popularity of ISM in the Godavari and other districts, where water logging has been observed. An additional benefit observed in the Nandhyal area of Andhra Pradesh is that this variety is also tolerant to bacterial leaf streak disease, for which there are very few reported sources of tolerance in rice varieties.

4.3.15. Seed purchase behaviour

A more important change that has occurred in the farmers' seed purchase behaviour during the past decade is the purchase of new seed every season. The farmers-to-farmer exchange and own seed use was predominant in earlier periods and drastically reduced even though paddy is a self-pollinated crop mostly dominated by varieties. Farmers are not averse to purchasing new seed every year, as seed rate ranges between 15 to 25 kg/acre and cost may not be higher than Rs.700 per acre. Farmers are of that opinion that if yields increase even by two to three quintals per acre because of the new seed, they could reap an additional benefit of Rs.3,000 with the additional cost of only Rs. 700 per acre. Under this scenario, there was a need for promoting seed production and distribution of good public varieties such as ISM by multiple agencies, for example, progressive-farmer-turned-small-seed-producers, small and medium local seed companies and dealers as well as through large private companies. The capacity of public seed production and distribution in meeting this gigantic demand for paddy seed is rather limited.

4.4. Case Study: Varietal diffusion of ISM in two mandals of the Kurnool district

Varietal diffusion of ISM was studied in two mandals, Bandi- Atmakur and Mahanandi and one village from each mandal was selected for the study. In Kurnool, traditionally, 100% of the kharif area was under paddy; farmers cultivate only Samba Mahsuri (SM) varieties such as Kurnool Sona. As SM is a dominant variety and there were incidences of BLB in this area. Two mandals were selected for an intensive study on varietal diffusion. In the mandals, farmers used to cultivate sunflower, turmeric and maize previously, but for the last 10 years, they reduced the area under other crops and started cultivating paddy varieties such as Nandyal Sona, BPT-1 to 5, Chitty Sona and ISM.

In the Mahanadi mandal, the SM rice variety occupied about 78% of the area, with another 15% area under different rice varieties in 2011 in the kharif season. Only 3-4 % of the area was under turmeric and maize. Farmers heard about the ISM variety from the agriculture department and input dealers in 2011. Farmers purchased seed from local progressive-farmer-turned-seed producer from 2012 and started ISM cultivation. Gradually, the area under SM reduced to 70% and other rice varieties reduced to 10% and were replaced by ISM. Even the area under turmeric and maize was converted into paddy fields. Now, the ISM area in the mandal is about 20% of the total area (Table 26.A).

Table 26.A: Patterns of varietal replacement related to ISM (in percentage) from 2011-2016 in the kharif season (Mahanandi block)

Year	SM	Turmeric	Maize	Other rice varieties	ISM	%
2011	78%	3%	4%	15%	-	100%
2012	80%	3%	3%	14%	-	100%
2013	80%	3%	2%	10%	10%	100%
2014	75%	3%	2%	10%	10%	100%
2015	75%	-	-	10%	15%	100%
2016	70%	-	-	10%	20%	100%

Fig. 12: Varietal diffusion at the mandal level (Mahanandi)

Table 26.B: Patterns of varietal replacement related to ISM (in percentage) from 2011-2016 in the kharif season (Bandi- Atmakur mandal)

Year	SM	Turmeric	Maize	Other rice varieties	ISM	%
2011	70%	5%	5%	20%	-	100%
2012	76%	4%	5%	15%	-	100%
2013	80%	-	-	10%	10%	100%
2014	75%	-	-	10%	15%	100%
2015	70%	-	-	10%	20%	100%
2016	65%	-	-	5%	30%	100%

The Bandi-Atmakur district is also dominated by SM, which occupies about 70% of the area, with another 20% area occupied by other rice varieties. The remaining 10% area was occupied by turmeric and maize (Table 26 B). With the introduction of ISM through mini kits of CSIR-800 and progressive farmers since 2012, there was an expansion of the area under ISM. The area expanded to 30% of the total kharif paddy area. ISM replaced SM and other paddy varieties. It should be noted that at the mandal level, the diffusion percentage does not exceed 30%, whereas at the village level, in some villages, the ISM area expanded to 80-90% of the paddy area. In some villages in East Godavari, at the village level, the area under ISM even reached 100%.

Fig. 13: Varietal diffusion at the mandal level (Bandi- Atmakur)

Table 27: Main pests and diseases in the paddy varieties cultivated by the farmers in their fields

Variety	Major diseases/pests	Pesticides used
Sona Mahsuri	BPH	Truper
Nellore Mahsuri	Root rot	Seethnar
Kurnool Sona	Blast diseases, sucking mosquitoes	Fatera, Confide, Bheem
ISM Variety	BPH	Truper

The major diseases and pests are given in Table 27. BPH, root rot, blast and sucking mosquitoes are big problems in the Kurnool district. Farmers mostly use chemical control methods to reduce losses.

Table 28: Total production cost and total production value and net profit to the farmer per acre

Variety	Production cost	Production value	Net profit	
			Own land	If the land is leased
ISM variety	20,000	50,000	30,000	22,500
555 and other	20,000	48,000	28,000	20,500
Sona Mahsuri (Samba Mahsuri)	21,000	45,000	24,000	16,500
Nellore Mahsuri (NLR-1444)	21,000	45,000	24,000	16,500
Kurnool Sona (Samba Mahsuri)	21,000	45,000	24,000	16,500

Field results shows that the cost of cultivation was higher in SM, NLR-1444 and Kurnool Sona compared to ISM and 555. The cost of cultivation per acre was about Rs.1,000 less in ISM than other traditional varieties. The yields are on par with the other varieties, sometimes higher than other varieties. The prices received by ISM varieties are also similar to those of SM. With lesser costs, stable yields and higher prices than SM, ISM farmers get net profit of about Rs.22,500 per acre compared to Rs.20,500 in case of 555 and Rs. 16,500 in case of SM (Table 28).

4.5. Diffusion of ISM in terms of area

This was calculated based on interactions with agricultural officers, KVKs, SAUs, officials of SRI-BIO Tech and ICAR-IIRR; it was also cross-checked by the field-level data on varietal adoption and preferences. Based on these various interactions and field studies, we found that the variety has been cultivated in the states of AP, Bihar, Chhattisgarh, Karnataka, Tamil Nadu Maharashtra and Telangana.

Table29: Area (in hectares) under ISM from 2011-2016

State/project	Districts	2011	2012	2013	2014	2015	2016
AP	Kurnool	200	500	2500	4000	5320	5064
	East Godavari (Kharif)	500	1000	2500	5000	9766	11970
	East Godavari (Rabi)					5000	5350
Private company (mostly in AP and Telangana)	Sri-Bio	18000	23940	5148	1030		
AP and Telangana	CSIR-800		200	400	400		800
	DRR (IIRR)	1176	2048	2552	2429	1819	2500
Karnataka	Raichur, Gangavati				2000	4000	4000
Tamil Nadu						500	500
Chhattisgarh							100
Bihar							1000
	Total	19876	27688	13100	14859	26405	31284
	Cumulative area	133212					

No organisation or agency, including the government, has documented the variety-wise area in paddy. In the absence of documentary evidence and sources of data, estimating the actual area under the ISM variety in such a huge area and from multiple sources of seed supply is a difficult exercise. One can only make approximate estimations. We collated information from multiple sources and cross-checked with field visits and arrived at an estimate of about 1.3 lakh hectare

cumulative area under ISM since 2011 to 2016. We have not taken into consideration varietal spread based on breeder seed indent, which came from the states of Uttar Pradesh, West Bengal and Odisha. During the year 2016, ISM was cultivated in 31,284 ha area across six states. The implementation of the CSIR800 project and the allied efforts by other stakeholders have helped reach this number. Compared to the total area of rice cultivated in these states, this is negligible. It should be noted here that farmers who adopted ISM were happy cultivating ISM, but the diffusion across the locations appear to be limited. With appropriate strategising, it should be possible to have an annual adoption rate of 1 lakh hectare for ISM. The next phase of the CSIR project should focus on developing strategies and including new stakeholders to make this possible.

With an outstanding product such as ISM, the extension efforts need to be strategized to include multiple agencies in production and marketing. ISM was widely adopted within certain clusters but failed to make an impact on more distantly related people. Rather, limited diffusion often refers to diffusion that does not reach or approach 100% adoption due to its own weaknesses, competition from other innovations or simply a lack of awareness. In this case, the CSIR800 project and other allied initiatives have created sufficient awareness about ISM. The real difficulty appears to be the challenge of producing seed that's sufficient enough to meet the demand of covering larger areas in epidemic locations. Future projects should keep this in mind and involve as many stakeholder organisations as possible, including institutional suppliers of seed, for better targeting and impacts.

As of now, our preliminary estimates of 1.3 lakh hectares should be considered an approximate estimation of the area under ISM the actual area may be much higher than this figure. The trend in the area under ISM is shown in Figure 14.

Fig. 14. Area in hectare under Improved Samba Mahsuri (ISM)

From the figure, it can be seen that ISM was highly adopted in the years 2011 and 2012, as it was marketed by a private company called SRI-BIO Tech during these years; subsequently, there was a sharp decrease in the area under ISM when they stopped marketing of ISM due to their withdrawal from the seed business. These figures point out the importance of having an institutional method of seed delivery for the popularisation of ISM. Subsequently, post 2014, the area under ISM again increased primarily because it performed very well in the district of East Godavari after cyclone Hudhud and increased indent through local- and district-level agricultural officers for mitigating losses due to BLB. The seed supplied in East Godavari primarily comes

from National Seed Corporation (NSC) and APSSDC. One difficulty that has been noticed in the field-level survey is that the seeds which have been supplied in East Godavari through these two sources had a lot of impurities and caused a lot of disquiet. However, the seed supplied under the CSIR-800 scheme was of high quality and demonstrated true worth of the variety as well as built trust among farmers about the variety's BLB resistance. Further more, the CSIR-800 scheme should also have focused on building collaborations between various organisations, including farmers' organisations, in seed multiplication and delivery. As such, there is a tremendous demand for ISM seed in BLB epidemic areas, especially the East Godavari and Nandyal areas of the Kurnool district of Andhra Pradesh.

4.6. Value of produce in farmers' hand

The total cumulative production of ISM paddy from 2011 to 2016 was 7 lakh tones based on farmers' feedback of the average yield of 5.7 tonnes per hectare, as shown in table 30. It was estimated that the value of the total produce was Rs. 1,249 crore (based on 2016 prices). The trait value is Rs. 240 crore, and it represents the value that farmers obtained by cultivating ISM instead of SM. This represents the estimated reduction in loss that was prevented due to the adoption of ISM owing to its BLB-resistant trait.

Table 30: Value of produce in farmers' hand

	2011	2012	2013	2014	2015	2016	Total
Average yield (T)	5.7	5.7	5.7	5.7	5.7	5.7	
Production (lakh ton)	1.15	1.6	0.8	0.9	1.5	1.7	7.6
Price (Rupees)/ton	16500	16500	16500	16500	16500	16500	
Value (Lakh Rs)	18939	26383	12482	14159	24208	28761	124933
Trait (%)	20	23	5	30	30	7	
Trait value (Lakh Rs)	3788	6068	624	4248	7262	2013	24003

Table 31: Cost and benefits of developing ISM

Year	Agency/ Institute	Purpose	Cost	Benefit
2000	CCMB-IIRR	Research	52.39 lakh	
2010	CCMB-IIRR	Licensing		6.00 lakh
2015	CCMB-IIRR	Licensing		8.00 lakh
2015-16	CCMB-IIRR	Popularisation	110.85 lakh	1249 crore 240 crore (Trait value)
Total			163.24 lakh	1249 crore 240 crore trait value

Table 32: Computation of Internal Rate of Return

Sl. no.	Year	Cost (lakh rupees)	Benefits (lakh rupees)	C-B
1	2000	52.39	-	-52.39
2	2001	-	-	0
3	2002	-	-	0
4	2003	-	-	0

Sl. no.	Year	Cost (lakh rupees)	Benefits (lakh rupees)	C-B
5	2004	-	-	0
6	2005	-	-	0
7	2006	--	-	0
8	2007	-	-	0
9	2008	-	-	0
10	2009	-	-	0
11	2010	-	6*	6
12	2011	-	3,788	3,788
13	2012	-	6,068	6,068
14	2013	--	624	624
15	2014	-	4,248	4,248
16	2015		8*+7,262	7,270
17	2016	111	2,013	1,902
	TOTAL	177	24,017	23,853
	Internal Rate of Return			61.2%

* Benefits accrued in terms of licensing

The IRR has been calculated using the cost and benefit data available from the year 2000 since the inception of the research component of the project. The IRR comes up to about 61.2%.

Other benefits of ISM cultivation

The ISM variety matures 10 days before SM, which is advantageous as it saves input costs and saves from untimely rains. Many farmers have expressed the opinion that ISM was more resistant to lodging than SM and Swarna rice varieties. This contributed to the increased popularity of ISM in the Godavari districts and other districts where water logging has been observed. An additional benefit that was observed in the Nandyal area of Andhra Pradesh is that ISM variety is also tolerant to bacterial leaf streak disease, for which there are very few reported sources of tolerance in the rice varieties.

Shortfall

A few farmers reported that grain filling is not complete in this variety and that the variety does not exhibit uniform flowering due to contamination of seed sold by NSC and APSSDC. Another deficiency is the fact that Samba Mahsuri and its derived variety, ISM, have an incomplete emergent panicle, which results in incomplete grain filling; the latter might be because of seed admixtures. However, researchers need to keep this in mind when developing future varieties that have more complete panicle emergence compared to Samba Mahsuri and ISM.

Potential areas under ISM

As of now, the variety is primarily cultivated in the East Godavari and Kurnool districts of Andhra Pradesh and adjoining areas of Karnataka. There is a potential for this variety spreading to areas of Chhattisgarh, UP, Bihar, Tamil Nadu and areas where Samba Mahsuri and other fine grain rice varieties are cultivated and BLB is a serious constraint.

Chapter 5

RECOMMENDATIONS

- **Institutionalized supply of seed**

Overall, Improved Samba Mahsuri has shown significant impact in areas where Samba Mahsuri is cultivated and Bacterial Leaf Blight is a constraint. However, there has been a significant unmet demand from farmers for seeds. Varietal adoption by farmers was mostly driven by timely supply of seed in adequate quantities from reliable sources. We recommend that there should be strong institutionalized supply of seed.

- **Involvement of private seed companies**

It should be noted that in 2011 and 2012, there was a significant area under ISM and this should be attributed directly to the marketing of this variety by SRI-BIO Tech. It would be great if additional private players can be brought in the business of production and distribution of ISM. Efforts should be made to involve seed companies in the sale of this variety.

National Seeds Corporation has come forward to distribute ISM seeds, but there have been issues regarding the quality of seed (admixture with other varieties), especially in the East Godavari district of Andhra Pradesh. In contrast, there have been very few complaints of seed purity from the Nandyal area, where primarily small private players have been involved in seed production and distribution. ICAR-IIRR and CSIR-CCMB may also supply pure, breeder's seed of ISM to NSC, APSSDC and other public sector seed production companies so that the diffusion of pure seeds of ISM can take place at an accelerated pace. It is indeed encouraging to note that additional private firms have approached ICAR-IIRR and CSIR-CCMB for licensing ISM for seed production recently. The presence of additional private players can significantly enhance ISM adoption.

- **Community approach**

With regard to the CSIR-800 project, we recommend that the focus be on areas where BLB is a problem and seed be distributed in a cluster-wise manner. It has been noted that mini kits were distributed in isolation of other concerted efforts, which resulted in territoriality, where a few farmers took control within a defined and fixed jurisdictional area. This could be avoided with the community approach, which was not tried.

- **Focused vertical expansion**

More focus should be given to vertical expansion of the variety in identified epidemic areas rather than horizontal expansion in areas that are not seriously affected by the disease. Furthermore, there were very few small and marginal farmers who were early adopters of ISM. This number can go up with stratified targeting.

This can be done through continuous supply of seed year after year in epidemic areas where losses due to BLB are more than 10% so that farmers feel that there are significant benefits due to adoption of BLB-resistant ISM.

It is recommended that surveys be conducted to identify villages/mandals that are the most prone to BLB. Targeting of areas and then planning a varietal diffusion strategy would have given wider visibility to the ISM variety in rice-growing areas. This can be taken care of in future.

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ANNEXURES

Annexure 1

Review of Literature

S. No.	Year of Publication	Author	Title	Methodology	Conclusion
1	2004	A.Mot-tram	Impact of new upland rice varieties in eastern India from client-oriented breeding		Evidence from whole village surveys reported that after the introduction of two new upland rice varieties (Ashoka 228 and Ashoka 200F), its adoption rate has been high and increasing every year. By doing a village-level survey of seven villages in select seven districts of Odisha, Jharkhand and West Bengal, the author found that formal seed distribution through GVT (Graminvikas trust) and farmer-to-farmer seed distribution played an important role. By doing preference ranking among different rice varieties, the author found that Ashoka varieties got the highest score because of yield, drought resistance, less cooking time, straw quality, disease resistance and high market price
2.	2005	J.O. Saka	Adoption of Improved Rice Varieties among Small-Holder Farmers in South-Western Nigeria		Farmers are responding appreciably to intervention programmes that promote the cultivation of improved rice varieties with an adoption rate of 67%. The empirical result also indicated that the choice of adoption of improved rice varieties is jointly influenced by the size of rice farms, yield and frequency of extension.
3.	2015	Marites Tiong-co and Mahabub Hossain	Adoption of Modern Varieties and Rice Varietal Diversity on Household Farms in Bangladesh		Farmers who acquired seed from informal sources i.e. from their own farms or neighbouring farmers are more likely to adopt MVs. This is because there is neither a formal seed market nor a formal seed distribution system that farmers rely on to acquire seeds. In addition, if modern and traditional seeds are available to farmers in the market, they will likely reduce use of seeds from their own harvest, thereby avoiding not only lower yields, but also genetic erosion. Empirical evidence suggests that adoption of MVs lowers varietal diversity at the farm level.
4.	2015	Khondoker A. Mottaleb <i>et al</i>	Factors influencing hybrid rice adoption: a Bangladesh case		Econometric results indicated that general land characteristics, loan facilities and general infrastructure improve allocation in favour of hybrid seeds and MVs. Information about various variables is gathered and econometric studies such as multinomial logit model, the seemingly unrelated regression estimation, the Lagrange Multiplier Test are being used to estimate the effects. So, it was concluded that in addition to the government efforts, the socio-economic factors should also be paid attention to.
5.	2012	D Behra <i>et al</i>	Diversity, spatial distribution and the process of adoption of improved rice varieties in Odisha		During the wet season most of the varieties used are TV's, whereas in dry season most of them are MV's. The distribution is different according to the different agro ecological conditions. Variety Swarna – Popular in wet season and Lalat – popular in dry season. Reasons for preferring a variety are high yield, good taste of cooked rice, lodging resistance, shorter duration, etc. Major source of information are other farmers. Major seed source is their own

S. No.	Year of Publication	Author	Title	Methodology	Conclusion
					harvest. Takes 4 years for full adoption. Reasons to reject TV's are low yield and for MV's are pest susceptibility and relatively low yield. Yield can be increased by focusing on environmental stress and new traits like micronutrients that could be incorporated in the identified popular varieties.
6.	2012	B.D. Bagchi <i>et al</i>	Diversity, spatial distribution and the process of adoption of improved rice varieties in West Bengal		TVs are used in areas with high salinity and inundation. MVs are use with irrigated areas. Reasons for preferring a variety are high yield, good taste of cooked rice, lodging resistance, shorter duration etc. Major source of information is other farmers. Major seed source is the farmer's own harvest. Takes 5 years for full adoption. Reasons to reject TVs are low yield, longer maturity period and for MVs are relatively longer maturity period, relatively less yield, lodging problems and less milling recovery. Yield can be increased by focusing on disseminating varieties with micro nutrients, environmental stress, expansion of irrigation, pure line selection of TVs.
7.	2006	G. Joshi and S. Bauer	Farmers' Choice of the Modern Rice Varieties in the Rainfed Eco-system of Nepal	The multinomial logit (MNL) model was used to analyse the factors affecting the choice of these varieties. The MNL is based on the random utility model. The utility to an adopter of choosing a particular alternative is specified as a linear function of the farm and farmer characteristics (β) and the attributes of that alternative (X) as well as a stochastic error component (e): $U=Bx+e$	Key and significant variables affecting farmers' demand for variety are both production and consumption attributes valued by the households and farm and farmer characteristics. They are easy thresh ability, usage of grains for preparing special products, early maturity of the variety, less irrigation requirement, sources of seed, education and the experience of the farmers.
8.	2015	Raju Ghimire <i>etal</i>	Factors Affecting Adoption of Improved Rice Varieties among Rural Farm Households in Central Nepal		Education, extension services and seed access play significant roles in adoption decisions. Additionally, farm and field characteristic variables, such as farm size, endowment of favourable land type (e.g. lowlands) and animal power (e.g. oxen) were the key factors influencing the probability of adopting NIRVs. The results showed that technology-specific variables (e.g. yield potential and acceptability) were significant for explaining adoption behaviour, implying that it is important to take farmers' preferences for varietal characteristics into consideration in the design of a research and development program.
9.	2012	Akhter U. Ahmed <i>etal</i>	Adoption of stress-tolerant varieties rice varieties in Bangladesh		The authors analysed modern rice technology promoted in USAID's Feed the Future (FTF) zone of influence in the south and southwest regions of Bangladesh. Theyfound out that the adoption of a set of modern stress-tolerant paddy varieties promoted by the Cereal Systems Initiative for South Asia (CSISA) project

S. No.	Year of Publication	Author	Title	Methodology	Conclusion
					has been very low. Authors argued that plausible explanation for the relatively low adoption of the stress-tolerant rice varieties could be that small and marginal farmers are risk-averse. They also attributed it to education and the role of complementary technologies.
10.	2012	Khondoker A. <i>etal</i>	Ex Ante Impact Assessment of a Drought Tolerant Rice Variety in the Presence of Climate Change		Economic benefits of a new drought-tolerant rice variety more than outweighed the cost of developing this new variety, especially in light of global climate change. In addition, results from partial equilibrium market models suggested that production, consumption, and rice exports in South Asia would be higher with the drought-tolerant variety
11.	2012	H. Wang <i>etal</i>	Patterns of varietal adoption and economics of rice production in Asia		The impact of improved stress-tolerant varieties was likely to be higher in Cambodia, given the lower average yield and the dominance of rainfed production systems. Among the households, the impact was higher for those that have a higher share of rice income in their total income. Similarly, a higher poverty impact is likely to be generated if the dissemination strategy targets those households that derive most of their income from rice production.
12.	2007	Yadavendra, J.P <i>etal.</i>	The impact of new maize and rice varieties on the livelihoods of poor farmers		The important traits of early maturity, high grain yield and high grain quality in all the three rice varieties (Ashoka 200F, Ashoka 228 and Kalinga III) were the important traits that were preferred by farmers. However, all three were inferior for fodder production. The new varieties gave rise to benefits beyond doubt.
13.	2006.	Mahabub Hossain <i>etal</i>	Adoption and productivity impact of modern rice varieties in Bangladesh		Bangladeshi farmers have been replacing MV, particularly if they were of shorter maturity and the yield was higher compared to the existing ones. A production function analysis confirmed higher productive efficiency in the first and second generations MV, but the increase was small compared to that of the initial shift from TV to MV. The productive efficiency was higher for MV of Indian origin but the difference was not statistically significant for MV produced in Bangladesh. The important findings also showed that MV2, MV3 and MV-Indian were all more or less equally productive, but they were more productive than TV and MV1 and clearly highlighted the important contribution that the National Rice Research Institution, BRRI, made toward improving rice yields in Bangladesh.
14.	2009	J. O. Saka and B. O. Lawal	Determinants of adoption and productivity of improved rice varieties in south-western Nigeria		The results showed that farmers responded appreciably to intervention programmes that promoted the use of improved rice varieties with an adoption rate of 68.7%, which resulted in an estimated proportional production increase of 19.4%. The mean yield of improved rice varieties (1.601 t/ha) was significantly higher than the yield of the local varieties (1.154 t/ha), with a yield advantage of 38.7%. In addition, rice yield for adopters of improved rice varieties (1.90 t/ha) was significantly higher than that of non- adopters (1.07 t/ha).

S. No.	Year of Publication	Author	Title	Methodology	Conclusion
15.	2010	A.N. Wiredu- <i>etal</i>	Impact of improved varieties on the yield of rice producing households in Ghana		The rate of adoption of improved rice varieties was estimated at about 46%. Adoption had a positive impact on farmers' rice yields. Experience, gender (male) and expectations about the yield and performance of improved technologies had a positive effect on the yield. Proper targeting of beneficiaries of interventions and effective training in good agricultural practices were expected to increase adoption rates and improve the level of performance.
16.	2001	Morris <i>etal</i>	Adoption and Impacts of Improved Maize Production Technology: A Case Study of the Ghana Grains Development Project		During 1997, more than half of the sample farmers (54%) planted MVs on at least one of their maize fields, and a similar proportion (53%) implemented the plant configuration recommendations. Adoption rates varied by agro-ecological zones, with the adoption of all three technologies lowest in the forest zone. Adoption rates were higher among male farmers than among female farmers, except in the case of fertilisers, in which no significant difference was found. The data generated through the CRI/CIMMYT survey provided factors that could influence the adoption process. These were: (1) characteristics of the technology; (2) characteristics of the farming environment into which the technology is introduced; and (3) characteristics of the farmer making the adoption decision. The survey revealed that adoption of GGDP-generated maize technologies has been extensive.
17.	2012	Hossain and Jaim	Diversity, spatial distribution, and the process of adoption of improved rice varieties in Bangladesh		Extension officials are the dominant source of first information about a new variety, but the extension contact is biased in favour of big farmers. For small and marginal farmers, enterprising farmers are the major source of information about an improved variety. A new variety spreads quickly once farmers are convinced about its good traits that are of their liking. It takes about 3 years to diffuse a variety to its potential area in a village after its introduction. The area covered, however, does not go beyond half to two-thirds of the area.
18.	2012	Behura <i>et al</i>	Diversity, spatial distribution, and the process of adoption of improved rice varieties in Orissa State of India		The role of radio, television, seed companies and NGOs in disseminating first-time information about modern varieties was negligible. The survey revealed that for modern varieties, farmers used their own seeds in about 88% of the cases, whereas only about 8% of the farmers bought seed from government seed sale centres. On average, it took 4–5 years for full adoption of most of the popular modern varieties in Odisha. However, by the fourth year, most of the popular modern varieties were fully adopted. The survey also identified the extinction of a considerable number of both traditional and modern varieties. Low yield was the main reason for rejecting traditional varieties, whereas, for modern varieties, pest susceptibility and relatively low yield were the two dominant reasons.

S. No.	Year of Publication	Author	Title	Methodology	Conclusion
19.	2012	Lakra <i>et al</i>	In the report on Diversity, spatial distribution, and the process of adoption of improved rice varieties in Jharkhand		Pioneer was the most popular and covered 43% of the hybrid area. 14 improved varieties were grown in medium lands and IR36 was the most popular variety, covering the highest area (28%), followed by Lalat (23%). High yield was the most important trait in selecting a rice variety, which was reported by more than 70% of the respondents. About half (47%) of the farmers reported that they used their own harvested seeds for the next season. 30% of the farmers bought seeds from traders. Seed traders were the main source of improved varieties. A majority of the respondents reported that they obtained information about popular improved varieties from other farmers. About 72% of the farmers reported that it took 2 years for full adoption of IR36. On the other hand, it took 3 years or a little more for full adoption of Swarna, Lalat, IR64 and Sita.
20.	2012	D Behra <i>et al</i>	Diversity, spatial distribution and the process of adoption of improved rice varieties in Orissa		It has been observed that during the wet season, most of the varieties used are TVs, whereas in the dry season most of the varieties are MVs. The distribution is different according to the different agro ecological conditions. The Swarna variety is popular in the wet season and Lalat is popular in the dry season. Reasons for preferring a variety are high yield, good taste of cooked rice, lodging resistance, shorter duration etc. A major source of information are other farmers. Major seed source is their own harvest. It takes 4 years for full adoption. Reasons to reject TVs are low yield and for MVs are pest susceptibility and relatively low yield. Yield can be increased by focusing on environmental stress and new traits, such as micro-nutrients that could be incorporated in the identified popular varieties.
21.	2012	Gauchan <i>etal</i>	Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas of Nepal		Farmers have adopted modern varieties on a major part of their rice farm, covering about 71% in Tanahun, 84% in Siraha and 98% in Banke. Yields of MVs are significantly superior to the yields of TVs across all sites. Yield effects, however, vary by site. The yield effects of MVs are stronger at Tanahun and Banke sites than in Siraha. Newer generation MVs account for about 40% of the total MV area at the study sites. The dominant newer generation MVs are Radha-4 in Banke and Tanahun and Radha-11 (Meghdoot) in Siraha. The yield of newer generation rice varieties is not superior to that of old generation MVs despite their better adaptability to rainfed conditions (e.g., Radha-4 and Radha-11). However, new MVs are relatively better at performing in lowland fields in moisture-stressed rainfed conditions.

S. No.	Year of Publication	Author	Title	Methodology	Conclusion
22.	2012	Deka and Gauchan	Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas of Assam		Farmers have adopted modern varieties on a major portion of their rice farms. Only a handful of MV rice dominates the rice area at the study sites. The dominant MVs are Ranjit, Mahsuri, Bahadur, Luit and Pankaj. Swarna was also grown by some farmers in a small proportion of the area. Newer generation MVs account for about 55% of the total MV area at these sites. The major newer generation MVs are Ranjit (released in 1992), Bahadur (released in 1994) and Luit (released in 1997). MVs out-yield TVs on all land types and across all sites. However, the yield of newer generation rice varieties is not significantly superior to that of old MVs despite some of their preferred traits of tolerance of diseases, pests and some submergence (e.g., Jalashree, Jalakunwari). High yield, high market price and good taste (eating quality) are the most preferred traits for the cultivation of MVs.
23.	2012	Bagchi and Emerick	Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas of West Bengal		MV adoption is very high at the survey sites. Most lands, regardless of type and season, are grown to MVs. During the boro season, the total rice area of the sample households is planted to MVs, while 7% to 10% of the rice area is planted to TVs during the aman season. The major rice varieties at the submergence site (Nadia) are Ranjit (new) and Swarna (old) during aman and Nayanmoni, Sankar, and Satabdi (new MVs) during boro season. At the drought-prone site (Purulia), old-generation MVs such as Lalat and Swarna are the major aman rice varieties. The varietal attributes desired by sample farmers include high yield, good taste and good quality of grains. Overall, the yield of MVs (3.07 t/ha) is higher than that of traditional varieties (2.70 t/ha) during the aman season. The yield of MV rice is higher at submergence sites (3.85 t/ha) than at drought sites (2.92 t/ha) during the aman season.
24.	2010	A.N. Wiredu	Impact of improved varieties on the yield of rice producing households in Ghana		The rate of adoption varied by location. The rate of adoption of improved rice varieties was estimated at about 46%. Adoption had a positive impact on farmers' rice yields. Experience, gender (male) and expectations about the yield and performance of improved technologies had a positive effect on the yield. Proper targeting of beneficiaries of interventions and effective training in good agricultural practices were expected to increase adoption rates and improve the level of performance.
25.	2007	Ogunsunmi <i>et al</i>	Economic Impact Assessment for Technology: The Case of Improved Soybean Varieties in Southwest Nigeria		The study assessed the economic returns due to improved soybean varieties. The result of internal rate of returns of 38 percent was observed from the streams of net returns from research that produced soybean varieties in Nigeria between the years 1975 and 1999; the pay-off to soybean production investment is attractive during the period, and it was well above the average interest rate of 15 percent during the period. There was a justification for the investment on soybean variety research

Village-level observations (East Godavari)

- BPT paddy variety is susceptible to BLB, which affects 10-25% of the cropped area and causes 10-25% yield loss
- According to the farmers, spurious seeds and climate change are two major reasons for BLB occurrence in the village.
- Bondalu and 1010 are other two varieties that are affected by the BLB disease in the village.
- Villagers/farmers don't take any precautionary measures to prevent BLB on paddy
- Primary sources of ISM seed supply in the village are government outlets and private dealers.
- Percentage of area covered by different varieties in East Godavari villages is shown as follows:

- According to the farmers, 200-500 acres of area under ISM can be increased in the next 5 years
- Farmers are willing to pay 25-30% more for BLB-resistant varieties
- In terms of yield, the lowest yield of ISM during a bad year was 6563kg/ha and the best yield during a good year was 7125kg/ha.
- In terms of input cost, ISM costs less than SM and other varieties, taking into account fertilisers, seeds, manure, plant protection uses (data in table 29 indicates that input costs for ISM are less than for other varieties)
- ISM price increased from 1,400 Rs./qtl in 2014-15 to 1,700 Rs./qtl in 2016-17

Farmer suggestions for promoting welfare of rice-growing farmers

1. Provide good quality seeds
2. Create a good market price
3. Provide good quality fertilisers and pesticides

Adoption and impact of ISM in four districts in Telangana (general observations)

- BLB is not a major problem; in most of the villages, a couple of farmers reported that about 3-5% BLB is observed in very few villages, which does not reduce the main production.
- Samba Mahsuri (BPT) is the major paddy variety in all surveyed villages in the kharif season, with an average yield ranging from 22-25/acre.
- It is the best variety in terms of food consumption, taste and durability. It gives better yield in all soil types and can be easily purchased by millers and traders whenever farmers want to sell.
- Rice is the major crop in all villages both in kharif and rabi seasons
- Rainfed land is limited and farmers grow cotton, chillies, pigeon pea, maize and soybean also.
- ISM seed was distributed in surveyed villages through KVK. A 10 kg bag was given to select farmers (2-10 farmers in a each village) without charging any price, covering 8-10 villages in different mandals.
- Proper monitoring and supervision was undertaken by KVK or CCMB. Farmers did not get information indifferent stages of the crop-growing period.
- Some farmers who got the seed did not grow due to small quantity. They gave it to other farmers and close friends.
- Many people did not benefit from growing ISM as it was not superior to existing BPT.
- Yield performance was similar to BPT or lower than BPT. Pest and disease resistance was found to same in both varieties.
- ISM producers reported that they did not get any additional benefits compared to the existing rice varieties.
- Traders did not buy ISM paddy due to its small quantity. The price offered is Rs. 200-300 lower than BPT even though ISM and BPT have similar characteristics, so farmers mixed ISM production with BPT and then sold it in the market.
- Very few farmers prepared food from ISM paddy in two-three villages and reported that there was no difference in taste, cooking quality and flavour
- Some farmers reported that they observed a mixture of other variety rice plants in ISM crop, i.e. purity of seed was not received.
- Almost all ISM growers did not keep their production for seed purpose next year. They are expecting that KVK would provide the seed for ISM again. So, the chances of growing ISM is negligible in the next year
- BPT, Ganga Kaveri, MTU-1010, RNR Bathhakamma, Warangal -14,1001, JIL- 384, Puja, HMT, Puja, Jai Sri Ram are important rice varieties in surveyed villages. Some varieties are grown both in kharif and rabi seasons. Productivity is very high in some of the varieties (RNR,1010, Ganga Kaveri, HMT)
- Almost all (except one or two) are susceptible to pest and diseases. Stem borer, blast, smut, plant hopper, BPH, sheath blight, neck blast, leaf folder, brown plant hopper are important pest and diseases. Farmers have been spraying chemicals four to six times in order to control these diseases.

- Use of more irrigation water and water logging soil type, use of more nitrogenous fertilisers, infected irrigation water and change in the climatic conditions are important reasons (perceptions) for BLB occurrence (only perceptions)
- Farmers reported that crop rotation, better water management, using different rice varieties in different seasons, maintaining better spacing in plants, seed and soil treatment and applying tank silt and green compost and manure crops are important measures that may control BLB.
- Most farmers purchase paddy seed every year from seed companies, co- societies or local seed dealers. Some farmers use own production and exchange with other farmers. Input suppliers at mandal levels are major sources of seed.
- The cost of cultivation for different paddy varieties is almost the same, except a few varieties that are drought- and pest-resistant and have a short duration, for example, MTU1010, Ganga Kaveri and Batthakamma varieties. The profitability is more than BPT because of their higher production (28-30qt/ acre).
- Drought, water shortage in resources, high wage rates and weed population and high rates of inputs (pesticides and fertilisers) and fluctuations in the paddy market price are important constraints.
- Farmers are willing to pay double than the existing price for new seed with the following traits:
 - a) Higher yield than the existing yield level
 - b) Resistant to BPH and other pest and diseases
 - c) Short duration with less water requirements
- **There is a chance to increase the area under ISM provided the following issues are solved:**
 - a) Good quality seed should be supplied through local seed dealers at a reasonable price
 - b) Awareness needs to be created by implementing farm days
 - c) Traders need to accept ISM paddy at a good market price
 - d) The ISM variety should have better characteristics than BPT, particularly yield, pest and disease resistance
 - e) There should be free supply of seed fertilisers and pesticides for at least 1-2 years so that it will be taken up by a majority of the farming community
 - f) Advice should be provided by scientists at different stages of the crop-growing period, particularly crop cultivation practices, type of chemicals and quantity etc.
 - g) The government (FCI or the society) should fix an attractive harvest price (stable) before the crop season so that farmers are attracted to the high prices
- **Farmers suggested the following measures for promoting welfare of rice-growing farmers:**
 - a) Stable market price throughout the year
 - b) Market should be declared before the crop-growing season
 - c) More subsidies on fertilisers and pesticides
 - d) Villages should be considered units for declaring crop insurance instead of mandals
 - e) MGNREGS programme should be linked to farm work

- f) Supply of pure quality seed should be facilitated through seed dealers so that other seed mixtures in the production can be minimised
- g) Loan amount for unit of land needs to be increased by banks and financial institutions
- h) Suitable technologies for transplanting, harvesting and threshing, low cost machinery need to be developed

Seed production

Paddy seed production is important in many villages during the rabi season in Jammikunta and other mandals in the Kareemnagar district. Many companies, such as Syngenta, Pioneer, Bio-seeds, Kaveri c –tech, Trimurthi, Pro-Agro, Dhanuka, have taken up seed production of different rice varieties. Farmers reported that seed is supplied by the seed company and other inputs are spent by the farmer. Price is fixed by the company at the time of the agreement. All operations are monitored by the company field staff. Farmers felt that seed production is profitable.

Estimation of the cost of cultivation

1	Preparing land with tractor six times (6*1200 rupees)	7,200
2	Seed cost (25kg/acre)	700
3	Nursery raising cost for 1 month	1000
4	Transplanting (15 labour @250 rupees)	3750
5	Fertilisers (DAP- 100 kg, Urea- 150 kg, Potash- 50 kg, Granule 4G- 8kg)	4500
6	1-2 times weedicide and 4-6 times pesticide application	2500
7	Irrigation cost	2000
8	Harvesting and threshing (harvester-1.5 hrs)	3000
9	Drying paddy and transport	7000
10	Total cost (excluding land rent)	31650
11	Output paddy (25qt@1650 Rs)	41250
12	Fodder	3000
13	Gross return (11+12)	44250
14	Land rent 10-12bags/acre for one season (7qt @ 1650)	11550
15	Net returns (13-10)	12600
16	Net returns for the tenant (13-10-14)	1050

Expert opinion:

Theme I: Varietal preferences by the farmers

Introduction:

1) Reasons for production of rice are:

- a) Relatively stable crop
- b) Easy to cultivate
- c) Emotional attachment – to eat what you produce
- d) Traditional methods of cultivation
- e) Rich and inexpensive source of calories
- f) Price support and procurement policies
- g) Adaptability to diverse agro ecologies
- h) Easy marketability
- i) Less input costs

2) Varietal preferences by farmers are emphasised by:

- a) Ecological compulsion of the farmer
- b) Trade situation (consumer-oriented)

3) Varietal traits preferred by the farmer are:

- a) Higher yield
- b) Short duration: drought resistance
- c) Lodging resistance
- d) Monsoon situation and water availability
- e) Fine grain
- f) Cooking quality
- g) Miller's preferences
- h) Dealer's preferences and interest
- i) Trade-specific preferences (inherent capacity to replace existing varieties)
- j) Tolerance to biotic and abiotic stresses
- k) Marketability
- l) Credibility of seed source

4) Problems:

To identify the problems in adoption of rice varieties of farmers, we have to identify:

- a) What the optimal route for varietal adoption is
- b) Channels by which these varieties are reaching the farmer

The problems are:

- a) Large ecological differences

- b) New varieties do not reach the interested farmers
- c) Many varieties are developed but very few are adopted
- d) Challenge of ISM – how to reach the farmers
- e) Lack of strategy in publicising the variety
- f) No feedback mechanism
- g) Mismatch in the demand and supply of varieties
- h) Lack of state-wise and variety-wise data about adoption
- i) Survey techniques do not reach beyond 1% of the farmers
- j) Many complexities in the surveying techniques
- k) Varieties mixing – loss of purity
- l) Lack of stability of the varieties over the years
- m) Lack of extension services
- n) Concentration on the kharif season
- o) Spurious seeds
- p) Main focus on yield, neglects the problem of pests and disease
- q) ISM is BLB-resistant but yield is low or similar to Samba Mahsuri
- r) Poor linkage between farmers and scientific institutions
- s) Farmers have limited resource related knowledge

5) Recommendations:

- a) Strong database about the state-wise distribution of varieties
- b) New varieties should be supported with technology
- c) Synergy between various public sector departments
- d) Improved surveying techniques
- e) Popularising new varieties through investment and research
- f) Popularising varieties with farmers in mind
- g) Field demonstrations and mini kit distribution of new varieties
- h) Strengthening the extension programs and extension trailing
- i) Cross-checking the survey method through expert opinion
- j) Developing new varieties such as coloured shoots for distinguishing weedy rice from the main crop
- k) Focusing on only two-three grain types
- l) Popularising varieties that cover 10% of the rice area
- m) Focusing on seeds that are commercially viable for the private sector too
- n) More surveys about varietal preferences by institutions and specialised officers
- o) Informed breeding must be improved
- p) Public breeding system should take farmers' demands into consideration
- q) Secondline of varieties should be available if the present variety goes out of trend

Theme 2: Varietal adoption in different states

1) Introduction: India has different agro-ecological zones and hence the state-wise adoption of varieties is different. Considering the Seed Replacement Ratio, we understand:

- ❖ SRR for Punjab, Haryana and rest of north India is more than 80%
- ❖ SRR for south-eastern states is very low
- ❖ SRR is the highest in AP
- ❖ SRR is the lowest In Odisha
- ❖ SRR for horticulture and floriculture is almost 100%
 - Across the country, the preference is for fine grains
 - 50% of rice production in UP is for export
 - People from Karnataka, Kerala, Tamil Nadu prefer rice for parboiling
 - In AP and Telangana, Samba Mahsuri is sold as Sona Mahsuri
 - There is a high demand for rice bran in the West Godavari district
 - In Punjab, there is a tremendous extension method so that the improved varieties reach the farmers. Farmers accept the varieties first and thus the millers have to accept them too. This approach is said to be one of the best agricultural extension models.

2) Problems:

- a) Boro rice: lack of opportunities of producing Boro rice in Bihar (single season, location-specific)
- b) Problem of weedy rice in West Bengal, Odisha
- c) In eastern states, there is not much development in SRR: lack of seed diffusion from the government.
- d) Public sector varieties such as MTU are grown largely in WB and Bihar
- e) Lack of adoption of seeds from other states
- f) There is no situation-specific variety (e.g. for drought conditions)

3) Recommendations:

- a) The effects of green revolution should spread to the eastern states too
- b) Farmer-to-farmer distribution should be encouraged so that the spread of the varieties is rapid across the states
- c) Region-specific agents should be asked to survey and different people should be put on rotation so that there is no bias
- d) There should be a mechanism to receive unauthorised information as well
- e) Distribution of seeds to new people each time for higher spread of varieties (5 kg seed packet distribution)
- f) Demand-driven research
- g) Location-specific farmers should be asked for judgments
- h) Different state governments and academic institutions should hold hands and work towards region-specific growth

Theme 3: Socio-economic impacts and problems faced by rice farmers

1) Introduction: Why do farmers grow rice even when it's not profitable? Because it has an employment generation capacity. Farmers get around 40% income only from the farm. The government has announced doubling of farmer income by 2020, but it is difficult to do that because of lack of strategies and the current agricultural scenario. If we have to fulfil this objective, seed is the most critical input for sustainable farm income growth. There is a competition among seed companies, which sometimes does not benefit the farmers.

2) Recommendations:

- a) There is a need for a national extension policy
- b) There should be availability of infrastructural facilities for farmers to avoid losses, both in terms of research and post harvest
- c) To gauge resource allocation in the development of varieties, grain preference should be kept in mind and varieties should be developed according to the market demand
- d) Products that have a huge potential of profit must be encouraged through extension programs, e.g. rice bran and broken rice

Theme 4: Policies and institutions for increasing adoption of improved varieties

1) Introduction: We have to bridge the gap between research stations and farms. For every rupee spent, there should be a benefit for the farmer. 1,200 new rice varieties were introduced; only 5-10 are dominant at the farm level. When a new variety is introduced, farmers are more concerned about the prices than the variety.

2) Current scenario:

- a) Distribution of successful varieties is not too good.
- b) There is no one to maintain the cycle of the seed variety, which is a loss for research .
- c) India is not maintaining its own seed genomes and varieties. We have to source these varieties from other countries.
- d) There is a lack of evaluation of existing and popular varieties as well as the rest of the varieties.
- e) The private sector spends a lot more on marketing than on research. The public sector lacks in the marketing front.
- f) The private sector adopts a typical breeding system. The breeder can't make all the decisions.
- g) 100% SRR is not idle. It leads to input dealers' lobby (oligopoly).
- h) There is no real local time data on variety impact.
- i) Confidence in the state department is low; thus, their involvement is not encouraged by farmers.
- j) It's difficult to replace BPT and Swarna.
- k) Government subsidies distort the seed market. Subsidies don't lead to systematic demand creation and can compromise the quality of the seeds.

3) Recommendations:

- a) Consumer preferences can be measured by area: this should be documented. Matrix needs to be developed based on market and potential market size in the coming 4-5 years.

- b) A national institution needs to be set up for in situ conservation to collect and maintain our varieties.
- c) Rather than SRR, we should concentrate on the required SRR.
- d) Extension needs to be popularised through media, institutions, advertisements etc.
- e) There has to be some percentage of market share from SAUs/institutions in order to counter the private sector monopoly.
- f) Front line demonstrations and mini kit distribution.
- g) Independent third-party evaluation.
- h) The government, KVKs, NGOs and the private sector should provide feedback to NSC.
- i) Private sectors should be licensed by the government.
- j) Different state-level institutions should be re-evaluated to take up seed multiplication.
- k) Desensitise the government-central as well as state-to the issue of seeds
- l) Organise Krishi melas on a large scale for distribution of seeds in large quantities.
- m) Universities and institutions should be empowered so that private sector interference is reduced.
- n) Revival of defunct state seed farms.
- o) Seed village programs should be adopted for reduction of spurious seeds.
- p) Role of FPOs should be defined as they can create a great distribution model.
- q) Integration of all government institutions.
- r) "Right time, right seed and quantity" should be followed by the government.
- s) Estimation of seed demand should be made by the Department of Agriculture and the information should be sent to the SSC.
- t) Scientists should be allowed to share their knowledge directly with farmers through ICT.
- u) There should be a segregation regarding who produces and who markets.
- v) Investments should be turned into tangible benefits for the farmers.

Theme 5: Problems and solutions in seed marketing and seed marketing channels in public and private sectors

- 1) Introduction:** Projection for seed business. The total value of the seed sector by 2020 will be Rs. 284 bn.

Table 33: Share of seeds in terms of volume and value

	Volume	Value
Rice	25-30%	21%
BT Cotton	30-40%	29%
Oilseeds	18%	6%
Vegetables	1%	16%
Maize	6%	11%

The public sector is more concerned with volume and the private sector is more concerned with value. After the land, all the issues or focus will be regarding seeds. Varietal demand is very dynamic. It is a continuous process that involves economists and agro-extension scientists for development. The suitability of a variety is dependent on multiple years' data.

2) Problems:

- a) Vast mismatch between demand and supply of seeds
- b) Marketing is mostly considered the last leg, but it is the first leg of development in any input
- c) Existing varieties are not readily accepted by the consumer
- d) There is a time lag between seed production and seed distribution
- e) Not all breeder seeds go for certification. Only 60% go for the certification process. Breeder seed loss is around 30%.
- f) There is a lot of political interference in the seed sector
- g) Lots of confusion in the naming of the seeds
- h) Seed companies fail to supply seeds in right amount at the right time
- i) Lots of intermediary agencies are a major block between research development and farmers
- j) Cultural and economic practices are ignored
- k) Spurious seeds
- l) High seed usage by farmers
- m) Institutional frameworks are in place but there is no one to carry them out

3) Recommendations:

- a) Input supply shops should be established in APMCs across the country.
- b) NSC should be made a nodal and regulatory body. Private players should get the same incentives that NSC gets (ultimate goal: deliver quality seeds to farmers).
- c) There should be micro-level consultative involvement.
- d) Demand must be driven by farmers.
- e) The government should introduce a bar coding system for the seed sector, similar to what is done for pesticides. This helps collect real-time data for seed adoption.
- f) If the government takes up promotion and distribution of improved varieties, farmers will readily adopt them.
- g) Effective use of breeder's seeds.
- h) Naming of the seed varieties should be paid attention to.
- i) States should follow Maharashtra government's policy that in order to get a seed license, it should be presented to the SAUs, and if accepted, an old variety's license will be canceled and replaced with a new one so that the number of varieties in the market remains the same.
- j) Indian Institute of Agricultural Marketing should be given more importance.
- k) The private sector should become time-oriented, active and farmer-friendly.
- l) New Seeds Act Must be developed and emphasised further.
- m) Seed pricing should be considered.

ISM is also being sold by NSC in Bihar and Maharashtra. These states have given tenders for the procurement of certified ISM seeds by their regional offices in Patna and Pune.

Estimation of area based on breeder seed indent

Table 34: Indent of Breeder Seed for Kharif-2015

	AP	BI	CG	OR	TN	UP	WB	Total for 7	Total
Total breeder seed	60	172	398	443	8	77	42	1199	1803
ISM breeder seed						17		17	27
Area (1000ha)	1635	3181	3809	3865	1641	5842	4086	24059	44100
Production (1000 t)	4241	6377	6175	7291	5110	12092	10321	51607	105500
Yield (kg/ha)	2594	2005	1621	1886	3114	2070	2526	15816	2391
Estimated ISM area (ha)	0	0	0	0	0	6840	0	6840	10720

Table 35: Indent of Breeder Seed for Kharif-2016

	AP	TEL	BI	CG	KR	OR	TN	UP	WB	Total for 9 states	All India
Total breeder seed	261	131	305	1024	3	905	38	174	174	3014	5044
ISM breeder seed (q)						20	2	8	1	31	33
Area (1000ha)	1635	920	3181	3809	1000	3865	1641	5842	4086	25979	44100
Production (1000 t)	4241	2751	6377	6175	2573	7291	5110	12092	10321	56931	105500
Yield (kg/ha)	2594	2990	2005	1621	2573	1886	3114	2070	2526	21379	2391
Estimated ISM area (ha)	0	0	0	0	0	8000	600	3200	400	12200	13240

Table 36: Indent of Breeder Seed for Kharif-2017

	AP	TEL	BI	CG	KR	OR	TN	UP	WB	Total for 9 states	All India
Total breeder seed	197	342	793	0	795	185	112	159	268	2850	5116
ISM breeder seed	2				20		3	9	2	36	37
Area (1000ha)	1635	920	3181	3809	1000	3865	1641	5842	4086	25979	44100
Production (1000 t)	4241	2751	6377	6175	2573	7291	5110	12092	10321	56931	105500
Yield (kg/ha)	2594	2990	2005	1621	2573	1886	3114	2070	2526	21379	2391
Estimated ISM area (ha)	800	0	0	0	8000	0	1200	3600	800	14400	14800

Table 37: Target for production of ISM by three states

State	Year	Target for production through organiser (in qtls)
Andhra Pradesh	2013-14	5,000
Bihar	2013-14	3,000
Maharashtra	2015	1,000

Source: POS

Improved Samba Mahsuri is giving high yield in farmers fields.....

Improved Samba Mahsuri is highly resistant to bacterial blight.....

(farmer's fields: Pithapuram, E. Godavari, AP)

Samba Mahsuri: Highly affected by the disease

Improved Samba Mahsuri: Free from disease

Improved Samba Mahsuri is highly resistant to bacterial blight.....

(farmer's fields, Nandyal, AP)

Samba Mahsuri vis-à-vis Improved Samba Mahsuri at Gangavathi, Karnataka

Samba Mahsuri – Heavy natural bacterial blight (BB) infection

Improved Samba Mahsuri – free from BB