Study No. 176

Spread of New Varieties of Hybrid Rice and their Impact on the Overall Production and Productivity in West Bengal

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Preface

The present study entitled "Spread of New Varieties of Hybrid Rice and their Impact on the Overall Production and Productivity in West Bengal" has been assigned by the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India as a common study. However, the coordination of the study has been done by this Centre.

Encouraged by the success of hybrid rice technology in enhancing the rice production and productivity in China, the Indian Council of Agricultural Research (ICAR) initiated a national program for development and large scale adoption of hybrid rice in the country in December 1989. The project was implemented through a National Network comprising research, seed production and extension networks. The hybrid rice research network consisted of 11 research centres and many voluntary centres spread across the country. The seed production network consisted of public sector seed production agencies such as National Seed Corporation, State Farms Corporation of India and the State Seed Development Corporations in addition to many private sector seed companies. The extension network consisted of state departments of Agriculture, extension wings of the SAUs, Krishi Vignan Kendras (Farm science centres) and the NGOs. Effective linkages were established within the different sub-components of the network. The entire project was co-ordinated and implemented by the Directorate of Rice Research (DRR), Hyderabad. The project initiated by the ICAR, was strengthened by the technical support from IRRI Philippines, FAO, the financial support from the UNDP, Mahyco Research Foundation (MRF), World Bank funded National Agricultural Technology Project (NATP) and IRRI/ADB Project on Hybrid Rice.

It has been found that the adoption hybrid rice is not being popular in the farmers' fields largely because of inferior grain quality compared with the popular conventional HYVs (inbred). A few implications from the findings of the present study are drawn for policy interventions. Higher yield potential alone does not induce farmers to adopt hybrid variety as shown by the experience of hybrid rice growing farmers. It is the profitability gains from production of hybrid that would motivate farmers, particularly, Commercial farmers to replace existing varieties of HYVs with new hybrids. Hybrid rice would not make the desired impact on the rice economy unless consumer demand for hybrid rice grain is created through grain quality improvement. Therefore hybrid rice research programme need to be reoriented towards the refinement of this technology with a focus on breeding for high value varieties of hybrids.

Hybrid rice is still at an introductory stage in the state of West Bengal. Still farmers devoted more area to inbred varieties. None of the farmers had previous experience in hybrid rice cultivation. Thus subsidizing the seed supply for the popularization of hybrid is the policy option followed by the government. However, subsidy on hybrid seed would not add much extra value to hybrid rice production. What is crucial is the supply of quality seeds. The present study brings out that although,

many of the farmers received seeds from government sources, quality hybrid seeds are not availed of by the farmers. Moreover seeds were not available during planting time and also at reasonable price. As a matter of policy it is thus essential to ensure easy availability of quality seeds in right time to achieve the overall goal of spreading of hybrid rice on a larger scale.

A critical assessment of hybrid adopting farmers' experiences with regard to hybrid rice adoption revealed that consumers perceive hybrid as inferior to inbreed in respect of grain quality. Many of them felt hybrid rice is not suitable for their taste. Majority of the respondents said hybrid rice has poor cooking quality and high stickiness of cooked rice. Obviously, all these would have useful implications on hybrid rice research and strategy and development which should lay more emphasis on improvement of grain quality apart from the improvement in yield. Research infra-structure should be strengthened for evolving farmer- consumer acceptable varieties of rice hybrids.

Considerable progress has been made in the development and release of new hybrids since the development and release of the first hybrids for commercial cultivation in the mid 1990s. Farmers are however still not convinced with the economic superiority of hybrid rice over the inbreeds (conventional HYVs). Rice breeders should therefore develop and evolve input efficient hybrids to popularize the cultivation of hybrid rice. Higher cost of production and lower market price realization has contributed to lower profitability of hybrid rice cultivation even though yield was higher. This calls for improvement of technology to reduce cost of cultivation and enhancing the quality attributes of hybrid rice.

The present study has been conducted under the leadership of Dr. Jiban Kumar Ghosh, former Senior Research Officer of this Centre and the undersigned. The field investigation was carried out by Sri Snehasish Karmkar in association with Sri Deb Sankar Das. The entire tabulation and preparation of tables in computer was done by Sri Das and Sri Karmaka. The secretarial assistance was received from Munshi Abdul Khaleque, Sri Nityananda Maji, Sri Dibyendu Mondal, Sri Amulya Ratan Patra and Sri Samir Sadhu.

On behalf of the Centre, I extend my heartfelt thanks to the Director of Agriculture, Government of West Bengal for his sincere help during the process of data collection. Last but not the least, I wish to place my highest regards to the diligent growers/farmers in West Bengal who have spared their valuable time to share their precious information with our enumerators without which study would have not been completed.

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CHAPTER-I
Introduction

1.1 Background of the study

India has a large agrarian economy with majority of its rural population subsisting on farming. Over the decades since independence, Government of India has made concerted efforts to improve the lot of the farmers. By the mid sixties it was realized that for India to achieve self-sufficiency in food-grains, there was no alternative to technological change in agriculture. The spread of HYV technology resulting in the green revolution in India in the last decades and achievement of self-sufficiency in food-grains represent a success story for the Science and Technology sector. The most widely debated issue about the green revolution was the growing disparities in income between the different regions and the different classes of farmers. This was observed in the early phase of the green revolution i.e. until about the mid seventies. These trends however got reversed after the mid seventies which are typical of a diffusion process characterized by the spread of green revolution to new areas, and the increasing adoption of new technology by the small farmers. Indeed the achievements in agricultural production so far do not fully reflect the strength of our agricultural research system to meet the specific requirements of Indian agriculture in diverse agro-climatic situation. The gains from the green revolution have so far been limited largely to wheat and rice grown more or less in homogeneous tracts – both agro-climatically and socio-economically served with assured sources of irrigation.

The achievements so far in respect of raising yields and reducing variability in the unfavourable agro-climatic regions are not comparable with those realized for the favourable environments. The limited spread of the green revolution can be explained partly by the nature of available technology itself and partly by the uneven development of infrastructure, physical as well as institutional which is pre-requisite for the adoption of improved practices. Against such a background it is necessary to examine the needed changes in agricultural research strategy to boost up agricultural production in the light of emerging agro-climatic and socio-economic challenges. Crop regional imbalances in growth, imparting stability to agricultural output and bringing the benefits of agricultural research technology to the resource poor farmers are the three major concerns. All these had necessitated widening the base of research involving evolution of high yielding seeds incorporating multiple resistances to the biotic (insects and diseases) and abiotic stresses like draught, rainfed upland, saline/alkaline soil condition etc. to cover a large number of crops grown under diverse agro-climatic conditions. Rice being the dominant staple food for millions of people in the country, agricultural scientists and policy makers are constantly making efforts to find solutions to various production problems through

technology development. The research scientists considered hybrid rice technology as a readily available option to shift the yield frontier upward in the face of declining trend of the yield potential of the existing varieties. It was projected that hybrid rice technology would being about another rice revolution in the country. However, although a number of varieties of hybrid rice are released by the Government, the extent of adoption of hybrid rice varieties in the country is too meagre to make an impact on rice production. Against this backdrop, the present study is conceptualised and undertaken at the instance of the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India with a view to assessing the actual spread of hybrid rice varieties replacing the conventional HYVs to make an overall impact of rice production.

Rice is the most important cereal crop in India in terms of area occupied, production and consumption as a principal food and thus occupies a prominent place in Indian agriculture. India produces 99.18 million tonnes of rice (2008-09). It is cultivated over an area of 45.54 million hectares which account for 23.25 per cent of the gross cropped area and 37.08 per cent of the area sown to food-grains. Rice production contributes 42.30 per cent of the total food-grain production in the country.

Over the last four decades, the country witnessed an impressive growth in rice production due to the adoption of semi dwarf high yielding varieties coupled with the adoption of intensive input based management practices. However in recent years the growth in production has decelerated from 4 per cent during 1980s to 1.7 per cent during 1990s. This deceleration is largely on account of slowing down in the growth of yield from 3.6 per cent during the 1980s to 1.3 per cent during the 1990s. Plateuing trend in the yield of HYVs, declining and degrading natural resources like land and water and acute shortage of labour make the task of increasing rice production quite challenging. The current situation necessitates looking for some innovative technologies to boost rice production.

Encouraged by the success of hybrid rice technology in enhancing the rice production and productivity in China, the Indian Council of Agricultural Research (ICAR) initiated a national program for development and large scale adoption of hybrid rice in the country in December 1989. The project was implemented through a National Network comprising research, seed production and extension networks. The hybrid rice research network consisted of 11 research centres and many voluntary centres spread across the country. The seed production network consisted of public sector seed production agencies such as National Seed Corporation, State Farms Corporation of India and the State Seed Development Corporations in addition to many private sector seed companies. The extension network consisted of state departments of Agriculture, extension wings of the SAUs, Krishi Vignan Kendras (Farm science centres) and

the NGOs. Effective linkages were established within the different sub-components of the network. The entire project was co-ordinated and implemented by the Directorate of Rice Research (DRR), Hyderabad. The project initiated by the ICAR, was strengthened by the technical support from IRRI Philippines, FAO, the financial support from the UNDP, Mahyco Research Foundation (MRF), World Bank funded National Agricultural Technology Project (NATP) and IRRI/ADB Project on Hybrid Rice.

Hybrid rice technology is likely to play a key role in increasing the rice production. During the year 2008, hybrid rice was planted in an area of 1.4 m.ha. and an additional rice production of 1.5 to 2.5 m.t. was added to our food basket through this technology. More than 80 per cent of the total hybrid rice area is in eastern Indian states like Uttar Pradesh, Jharkhand, Bihar, Chhattisgarh, with some little area in states like Madhya Pradesh, Assam, Punjab and Haryana. As rice is a key source of livelihood in eastern India, a considerable increase in yield through this technology will have a major impact on household food and nutritional security, income generation, besides an economic impact in the region. In view of this, hybrid rice has been identified as one of the components under the National Food Security Mission (NFSM) launched by the Government of India (GOI) with the aim to enhance rice production by 10 million tonnes by 2011-12. Under the scheme it has been targeted to cover 3 million ha area under hybrid rice by the year 2011-12. The approach is to bridge the yield gap in respect of rice through dissemination of improved technology and farm management practices. Similarly, added emphasis is being given for adoption of hybrid rice under the special scheme (BGREI) of GOI to bring green revolution to eastern India.

Table 1.1: Hybrids currently available for cultivation

	Central releases	State releases
Public Sector	KRH 2, Pusa RH 10, DRRH 2, Rajlaxmi, Sahyadri 4, DRRH 3, CRHR 32	PSD 3, Ajay, CoRH 3, Indira Sona, JRH 8
Private Sector	PHB 71, PA 6129, PA 6201, PA 6444, JKRH 401, Suruchi, GK 5003, DRH 775, HRI-157, PAC 835, PAC 837, US 312, Indam 200-017, NK 5251, 27P11	

Source: BC Viraktmath, Hybrid Rice in India-Current Status and Future Prospects, Directorate of Rice Research, Rajendranagar, Hyderabad-30.

As a result of concerted efforts for over two decades, a total of 46 hybrids have been released for commercial cultivation in the country. Among these, 29 have been released from the public sector while remaining 17 have been developed and released by the private sector. Though 46 hybrids have been released in the country so far, some of them have been outdated,

and some are not in the production chain. Such hybrids related to production chain and available for commercial cultivation are listed in Table-1.1.

The farmers of the country are growing mostly the varieties bred by the research system such as ICAR, State Agril. Universities (SAUs) and other Research Institutions connected to agriculture. The varieties are normally bred taking into consideration, various characters like yield potential, resistance to biotic and abiotic stress of the existing popular variety/varieties. The new varieties are bred by the Research Institutions and screened for their performance at different locations through initial evolution trial and advance varietal trial. A Technical Committee finally considers these varieties and release only those varieties which are found superior over the existing best varieties. While releasing these varieties the Technical Committee also specifies the ecology i.e. the State area within State, season in which the varieties are to be grown. The newly released varieties normally have edge over the existing varieties in yield, resistant to serious pest and diseases, resistant to the abiotic stresses i.e water related problems like drought etc. Although a number of varieties are being released by the Government to meet the demand of the farmers, the spread of these newer varieties in place of the conventional varieties that are grown by the farmers for a longer period has not been assessed properly. There is no comprehensive evaluation study to document farm-level insights into hybrid rice performance except very few studies citing the instance of yield superiority of hybrid rice but less profitable than the inbred varieties i.e conventional Hyvs (Janaiah, 2003, Chengappa et.al 2003).

1.2 Need for the Study

The spread of the newer varieties replacing the older varieties need to be closely monitored to take advantage of the superior characters of these newer varieties released by various Research Institutions. This will help to break the yield plateau that has been experiencing in rice crop in the recent past and to increase the production and productivity of the crop. Though a number of steps are being taken by the Government to popularize these varieties like Frontline Demonstration, minikit supply, organising training programmes (1-21days) for farmers, farm women, seed growers, seed production personnel of public and private seed agencies, extension functionaries of state departments of agriculture, officials of state agricultural universities and NGOs, there is no concrete data to prove that the newer varieties of rice are spreading faster and replacing the older ones. Therefore, it is essential to conduct a study to assess the actual spreading of these newer varieties in terms of area with simultaneous reduction in the area under older varieties for rice crop and the increases in the average yield/ha. This will help the

Government of India to draw a plan for augmenting the spread of the superior newer varieties in place of the age old varieties.

1.3 Objectives of the Study

The specific objectives of the study are

1. to indicate the extent of adoption and the level of participation by the different categories of farmers in the cultivation of hybrid rice;
2. to assess the overall impact on rice production and productivity of hybrid rice cultivation;
3. to study the economics of cultivation of hybrid rice varieties vis-a-vis inbred varieties;
4. to identify factors determining the adoption of hybrid rice varieties;
5. to address various constraints and outline the prospects for increasing hybrid rice cultivation and
6. to suggests policy measures for expansion of hybrid rice cultivation.

1.4 Data Base, Sampling Design, Methodology and Coverage of the Study

The study is based on both secondary and primary data. Secondary data obtained from government publications relating to area, production and productivity of rice, viz. Statistical Abstract, Government of West Bengal and Economic Review, Government of West Bengal are used to arrive at the trends in area, production and productivity. For the sake of comparison, it is usual to compare the performance of rice in the pre-introduction period of hybrid rice with that in post-introduction period as a whole. Keeping in mind that the first hybrids was developed and released for commercial cultivation in India in 1994, the study period was thus divided into three sub-periods viz. 1984-85 to 1993-94, 1994-95 to 2003-04 and 2004-05 to 2009-10. The period-I viz. 1984-85 to 1993-94 refers to the pre-introduction period of hybrid rice while other two period's viz. period-II & III correspond to post-introduction periods.

Primary survey is confined to the National Food Security Mission (NFSM) districts in the state. The two districts viz. Howrah and Uttar Dinajpur having relatively higher concentration of hybrid seeds cultivation within the group of NFSM districts are chosen for the present study. In each of the district, two representative blocks are taken and within each block two villages are selected. In each village, a complete list of cultivating households growing hybrid rice varieties and inbred varieties are prepared and stratified according to four standard land size groups such as marginal (less than 1 hectare), small (1 to 2 hectares), medium (2 to 4 hectares) and large (more than 4 hectares) including SC, ST and women farmers. In each district, 40 hybrid rice growers from the list of hybrid rice growing cultivators are drawn at random from different land

size groups on the basis of their proportion in the universe. In addition to this sample, 10 inbred variety (traditional HYVs) rice growers but non-adopters of hybrid rice are selected randomly from the different land size groups amongst inbred rice growing cultivators following the same procedure. Thus altogether, 50 rice growing cultivators are selected from each selected district. In all, 100 rice growing cultivators in the state equally spread over two selected districts constitute the size of the sample in the study.

For the primary survey, the reference years are 2009-10 and 2010-11. Accordingly, 2 kharif seasons and 2 rabi seasons for the rice crop are covered in the study. Primary data are obtained by administering a structured schedule/questionnaire.

1.5 Analytical Approach

A simple tabular analysis is followed to analyze the farm level data in ascertaining the farm level spread and impact of hybrid rice technology. In order to identify the factors affecting the yield of rice, yield response function separately for hybrid and inbred rice are estimated using Log linear models. Several explanatory variables are regressed upon the dependent variable yield per hectare of rice. The explanatory variables included seed (kg/ha), manure (Rs./ha), fertilizer (Rs/ha), irrigation (number of irrigation/ha), human labour (man days/ha), machinery labour (hrs/ha), plan protection Chemicals (Rs./ha). In finding out the determinants of participation in hybrid rice cultivation logit analysis is done. For secondary data obtained from the official publications, the equation of the exponential curve is used to measure the growth in area, production and productivity of the crop. Besides, in measuring the instability in crop production, the co-efficient of variation technique is used.

1.6 Organization of the Study

The present study is divided into eight chapters. Chapter-I is the introductory chapter which spells out the background, objectives, data base and methodology of the study. Chapter-II describes the status of rice in the state of West Bengal. Chapter-III analyzes the status of adoption of hybrid rice at the farm level. Chapter-IV examines the impact of hybrid rice cultivation on overall production of rice. Chapter-V studies the comparative economics of hybrid and inbred rice cultivation. Chapter-VI analyzes grain quality characteristics of hybrid rice vis-à-vis inbred rice. Chapter-VII discusses the problems faced by hybrid rice growers and examines the prospect for increasing hybrid rice cultivation in the state and finally chapter-VIII provides concluding remarks and policy suggestions emerging from the study.

CHAPTER-II
Status of Rice in West Bengal

Rice is the most important crop in India which played a critical role in food security. It is the important staple food for millions of population. Rice is specifically important to India as it is grown on more than 44 million hectares the highest area ever occupied by a single crop. More importantly rice is a choice crop of the millions of poor and small farmers not only for income but also for household food security. Rice production has a long history of evolution in India which enabled wide adaptability in diverse eco-systems. But India lagged behind in the production front due to low productivity. The productivity of rice compares unfavorably in India as compared to other rice growing countries.

Rice has been an important food crop in India for ages. It is grown in all the zones in the country and is the livelihood of a very high proportion of the farmers and the poor. Among the four zones viz., East, North, South and West in the country, the east zone occupies the major in terms of area while the productivity is the highest in the north zone viz. Haryana, Punjab, due to favourable irrigation and adoption of modern varieties and other methods.

The same in the largest east zone (Synonymous to eastern India) is highly vulnerable and low productivity. Agriculture in eastern India is characterized primarily as rainfed systems where production suffers from drought and floods and accordingly yield fluctuates widely. The rice sector in India has witnessed rapid dynamism in production processes. During the past four decades, rice production grew in a phenomenal pace. At the beginning of the 1950s, the total rice production was barely 32 million tones. The productivity per hectare was as low as a ton per hectare. The production however accelerated in the mid 1960s on account of green revolution. The increase in production was mainly attributed to productivity. Production grew at the rate of 3.62 percent per annum year in the 1980s from 1.95 percent per annum in 1970s. After climbing such a height, the production curves have started showing downward trend in the 1990s growing below 2 per cent mark. The yield curves started showing decelerating trends in the nineties and have also continued thereafter. It thus raised the question of the sustainability of production necessary to cater to the basic need of the vast population. A new wake of technology in increasing rice productivity was indeed needed to keep the rate of output growth above the rate of population growth.

Among various approaches and options available, policymakers considered development and use of hybrid rice technology in the late 1980s as a readily available option to shift upward the yield frontier in the irrigated environments in India. Further, the miraculous success of hybrid rice technology in China which greatly contributed to the growth of rice production in that

country triggered an interest in strengthening research efforts in the early 1990s. After four years of rigorous research, the first rice hybrid was developed and released for commercial cultivation in 1994. Recent breakthroughs in the development of hybrid rice technology is expected to provide an alternative option for raising yield levels for sustained production growth in rice especially in favourable irrigated conditions. In the following analyses, attempt has been made to see the overall impact of hybrid rice cultivation on production of rice at the macro-level with reference to West Bengal.

2.1 The Status of Rice in West Bengal

West Bengal is endowed with rich natural resources and climate conditions favourable for agriculture. In spite of these favourable conditions, for many years, the growth of agricultural production in the state was low compared to the same in other parts of eastern and north-eastern India and lagged behind the national average. There has been ample documentation of this slow growth and many scholarly and official documents attempted to understand the reasons underlying the observed pattern of growth. In a landmark study of agricultural performance in West Bengal, James Boyce estimated that the growth rate of agricultural output between 1949 and 1980 was only 1.74 per cent per annum. By comparison, the annual rate of growth of the rural population and total population was 2.31 per cent and 2.42 per cent respectively (Boyce 1987). At the root of agricultural stagnation was limited growth in the production of *Aman* rice, the most important crop of West Bengal. Boyce found that between 1949 and 1980, growth in yield of *Aman* rice was only 0.24 per cent a year and growth in area cultivated under *Aman* paddy was 0.57 per cent per annum. While the decade of the 1970s was marked by stagnation in agricultural production in eastern India, a noteworthy change occurred in the 1980s. Between 1981 and 1991, rate of growth of agricultural production in the eastern states increased and among them West Bengal grew fastest. Scholars began to notice this change in the late 1980s.

There is a lot of controversy as regards the extent and nature of quantitative growth in West Bengal agriculture. While the rates of growth, as calculated by different scholars had been debated, the central issue in this debate is whether there was a structural break in the trend growth in the 1980s. Using the time series data on total food grains production in West Bengal for the period 1965-1990, *Saha and Swaminathan (1994)* observed that there were changing trajectories of agricultural growth in West Bengal from the beginning of 1980s. The annual growth rate according to *Saha and Swaminathan (1994)* was 6.3 per cent for the period 1981-82 to 1991-92, which was the highest in India for that period. Fitting a semi-log trend on the data for a longer period, *Rawal and Swaminathan (1998)* observed that West Bengal experienced

acceleration in the growth of agricultural production in 1980s. The rate of growth, as experienced in 1980s was 6.5 per cent for food grains and the high growth rate was noticeable in most of the major crops in the state. Rice being the primary crop in West Bengal production grew at the rate of 6.4 per cent annually in the 1980s and at 5 per cent during 1980 to 1995 as compared to 2.2 per cent from 1950 to 1980. The annual rate of growth of production however fell to 2 per cent in the first half of the 1990s. *Khasnabis (2008)*, with a long data set for a 40 year period (1959-60 to 1999-2000) examined whether there was structural trend break in the growth rate of agriculture fitting a semi-log trend. He observed that 1980s had been the decade of high growth for every crop except wheat and pulses. He performed an econometric exercise on the issue and examined the possibility of getting a structural break at 1979-80 with change in both intercept and the slope of the trend line. The technique of dummy variables was applied. The estimated results indicated that there was indeed a structural break at the beginning of 1980s with respect to almost every crop including cereals and rice, the major component of cereals produced in the state. Importantly the growth rate did decelerate in the 1990s. The growth rate of food grains in West Bengal calculated on point to point basis declined from 6.9 per cent per year in the 1980s to 2.4 per cent per year in the 1990s. Rice, the most important crop of the state that came under the green revolution technology in 1980s was growing at the rate of 2.5 per cent per year in the 1990s. This rate was higher than the average growth rate of rice in 1970s. *Khasnabis* noted that the average growth rate of rice in West Bengal in 1990s was lower than the growth rate that it had recorded during 1960s, during the period when the rice crop of the state was yet to switch over to the green revolution technology.

In the present study we perform an exercise on the basis of data set published by Bureau of Applied Economics and Statistics, Government of West Bengal. In order to check whether there was improvement in the performance of rice production in West Bengal after switching over to the hybrid rice technology, we considered the relevant data for a 26 year period (1984-85 to 2009-10). The period was chosen purposively keeping in mind the year of introduction of the first hybrid in India in 1994. The study period is roughly divided into three sub periods viz. 1984-85 to 1993-94, 1994-95 to 2003-04 and 2004-05 to 2009-10. The period-I viz. 1984-85 to 1993-94 refers to the pre-introduction period of hybrid rice while other two periods viz. period-II and period-III correspond to post introduction periods.

2.2 Trend and Composition of Rice in the State

Rice is the primary crop in West Bengal. The three major rice seasons are *Aus* (May to September), *Aman* (*Kharif*, from June to November) and *Boro* (*Summer*, from March to June).

Table-2.1 reports the trend and composition of total rice in the state classified according to seasons. Traditionally the *Aman* crop has been the most important of the three rice growing seasons in terms of output and acreage. Over time the *Boro* rice has grown in significance. We can see the performance of rice in three different periods separately (i) 1984-85 to 1993-94 a period preceding the impact of hybrid technology and (ii) 1994-95 to 2003-04 and (iii) 2004-05 to 2009-10, the periods marked by post hybrid periods.

Aman, the *Kharif* rice is the most important of the three rice growing seasons both in terms of acreage sown and production (table-2.1). In 2009-10, *Aman* rice accounted for 66.9 per cent of total rice output and 70.8 per cent of total area cultivated under rice. The importance of *Aman* rice output in total production has however fallen from 76.1 per cent in 1984-85 to 66.9 per cent in 2009-10 while that of *Boro* crop has risen significantly from 17.9 per cent in 1984-85 to 29.8 per cent in 2008-09 exceptionally at 17.9 per cent in 2009-10. Decline in share in output in case of *Aman* is due to decline in share in acreage from 78.8 per cent in 1984-85 to 70.8 per cent in 2009-10. For *Summer* rice, increased share in production is attributable to increase in both area and production. The relative importance of *Autumn (Aus)* rice has also sharply fallen both in terms of acreage planted and production. The relative share of *Autumn* rice in total production declined from 8.2 per cent in 1984-85 to 3.3 per cent in 2009-10. The *Boro* or *Summer* rice was introduced in the 1960s and area cultivated with *Boro* increased rapidly thereafter. The share of *Boro* (*Summer* rice) in total rice acreage increased from 9.1 per cent in 1984-85 to 25.4 per cent in 2009-10 as against the figure of 26.2 per cent in 2008-09. As *Boro* has always been an irrigated crop based on high yielding varieties of seed, yields have always been relatively high and yield growth has been a major contributor to growth of output. It is important to note that average rice yield in West Bengal increased to 2547kg per hectare in 2009-10 which was 2061kg in 1993-94 and 1556kg in 1984-85, the period when rice crop of the state was yet to switch over to the hybrid technology. In case of *Summer* rice, yield rate increased from 2698kg per ha. in 1984-85 to 3101kg in 1993-94, which again increased to 2991kg per ha. in 2009-10. For *Winter* rice (*Aman*) yield level increased from 1504kg per ha. in 1984-85 to 2407kg in 2009-10 through 1885kg in 1993-94. *Autumn* rice recorded yield levels of 2179kg per ha. in 2009-10 which was 1683kg in 1993-94 as against 1046kg in 1984-85. In short, there has been overall increase in rice production during the period under study 1984-85 to 2009-10. Such an increase in production is driven by increases in productivity of rice of three major rice seasons whereas *Summer* rice (*Boro*) contributed to the enhancement of rice output both in terms of acreage and production.

Table 2.1: Trend and Composition of Rice in the state

Year	Autumn rice			Winter rice			Summer rice			Total rice		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
1984-85	631.4(12.1)	660.6(8.2)	1046.2	4096.4(78.8)	6161.9(76.1)	1504.2	470.7(9.1)	1270.0(17.9)	2698.1	5198.5(100.0)	8092.5(100.0)	1556.7
1985-86	483.1(9.5)	540.6(6.8)	1119.0	4083.3(80.4)	6023.2(75.4)	1475.1	512.3(10.1)	1427.2(24.3)	2785.9	5078.7(100.0)	7991.0(100.0)	1573.4
1986-87	637.4(11.9)	710.1(8.4)	1114.1	4059.2(75.5)	5694.1(67.3)	1402.8	679.4(12.6)	2058.8(26.8)	3030.3	5376.0(100.0)	8463.0(100.0)	1574.2
1987-88	616.2(11.3)	655.3(7.1)	1063.5	4067.2(74.3)	6127.2(66.1)	1506.5	792.2(14.5)	2489.3(18.5)	3142.3	5475.6(100.0)	9271.8(100.0)	1693.3
1988-89	720.6(12.8)	1071.1(10.1)	1486.4	4180.9(74.4)	7537.5(61.4)	1802.8	720.5(12.8)	1951.2(20.7)	2708.1	5622.0(100.0)	10559.8(100.0)	1878.3
1989-90	616.2(11.0)	890.6 (8.2)	1445.3	4241.2(75.5)	7771.8(61.1)	1832.5	756.9(13.5)	2261.2(25.5)	2987.4	5614.3(100.0)	10923.6(100.0)	1945.7
1990-91	610.3(10.5)	906.3(8.7)	1485.0	4306.5(74.1)	6865.8(65.8)	1594.3	896.1(15.4)	2664.4(23.9)	2973.3	5812.9(100.0)	10436.5(100.0)	1795.4
1991-92	540.4(9.5)	879.0(7.4)	1626.6	4244.5(74.3)	8212.7(68.7)	1934.9	934.4(16.4)	2862.5(22.5)	3063.5	5713.3(100.0)	11954.2(100.0)	2092.3
1992-93	532.5(9.4)	915.3(8.0)	1718.9	4301.4(75.5)	7955.1(69.5)	1849.4	860.7(15.1)	2575.0(26.8)	2991.8	5694.6(100.0)	11445.4(100.0)	2009.9
1993-94	539.6(9.2)	908.2(7.5)	1683.1	4290.9(73.0)	7961.2(65.7)	1855.4	1045.0(17.8)	3241.5(24.6)	3101.9	5875.5(100.0)	12110.9(100.0)	2061.3
1994-95	518.8(9.0)	837.9(6.8)	1615.1	4210.6(72.9)	8385.0(68.5)	1991.4	1043.3(18.1)	3013.0(28.7)	2888.0	5772.7(100.0)	12235.9(100.0)	2119.6
1995-96	510.5(8.6)	854.5(7.2)	1673.8	4282.8(71.9)	7615.2(64.1)	1778.1	1160.1(19.5)	3417.3(26.1)	2945.7	5953.5(100.0)	11887.0(100.0)	1996.6
1996-97	461.7(8.0)	775.5(6.1)	1679.7	4282.4(73.8)	8566.4(67.8)	2000.4	1056.4(18.2)	3294.9(27.0)	3119.0	5800.6(100.0)	12636.8(100.0)	2178.5
1997-98	423.1(7.2)	752.0(5.7)	1777.4	4270.3(72.4)	8915.1(67.4)	2087.7	1206.9(20.5)	3569.5(37.0)	2957.6	5900.3(100.0)	13236.6(100.0)	2243.4
1998-99	425.0(7.2)	740.6(5.6)	1742.6	4028.6(68.2)	7653.8(57.5)	1899.9	1450.5(24.6)	4922.0(32.5)	3393.3	5904.1(100.0)	13316.4(100.0)	2255.4
1999-00	427.2(6.9)	828.0(6.0)	1938.2	4248.9(69.1)	8463.3(61.5)	1991.9	1474.3(24.0)	4468.4(36.5)	3030.9	6150.4(100.0)	13759.7(100.0)	2237.2
2000-01	394.0(7.2)	683.9(5.5)	1735.8	3639.5(67.0)	7202.8(68.0)	1979.1	1401.8(25.8)	4541.3(28.9)	3239.6	5435.3(100.0)	12428.0(100.0)	2286.5
2001-02	402.5(6.6)	841.8(5.5)	2091.4	4211.6(69.4)	10000.0(65.5)	2374.4	1455.0(24.0)	4414.9(29.2)	3034.3	6069.1(100.0)	15256.7(100.0)	2513.8
2002-03	385.0(6.6)	796.6(5.5)	2069.1	4051.0(69.3)	9394.0(65.3)	2318.9	1406.1(24.1)	4198.6(29.3)	2986.0	5842.1(100.0)	14389.2(100.0)	2463.0
2003-04	339.8(5.8)	719.2(4.9)	2116.5	4126.7(70.5)	9653.6(65.8)	2339.3	1390.1(23.7)	4289.4(28.6)	3085.7	5856.6(100.0)	14662.2(100.0)	2503.5
2004-05	320.8(5.5)	653.1(4.4)	2035.8	4086.4(70.7)	9974.7(67.0)	2441.0	1376.4(23.8)	4257.1(27.9)	3092.9	5783.6(100.0)	14884.9(100.0)	2573.6
2005-06	288.1(5.0)	605.7(4.2)	2102.0	4112.9(71.1)	9858.1(67.9)	2397.0	1382.0(23.9)	4047.0(30.7)	2928.0	5782.9(100.0)	14510.8(100.0)	2509.0
2006-07	283.9(5.0)	575.3(3.9)	2027.0	4001.9(70.4)	9649.9(65.4)	2411.0	1401.2(24.6)	4520.7(33.5)	3226.0	5687.0(100.0)	14745.9(100.0)	2593.0
2007-08	281.6(4.9)	565.8(3.8)	2009.0	3926.5(78.6)	9227.6(62.7)	2350.0	1511.6(26.4)	4926.1(29.0)	3259.0	5719.8(100.0)	14719.5(100.0)	2573.0
2008-09	292.4(4.9)	605.0(4.0)	2069.0	4086.6(78.8)	10074.3(67.0)	2465.0	1556.7(26.2)	4358.0(29.8)	2800.0	5935.7(100.0)	15037.2(100.0)	2533.0
2009-10	214.1(3.8)	466.7(3.3)	2179.8	3986.3(70.8)	9598.0(66.9)	2407.7	1429.7(25.4)	4275.9(17.9)	2990.8	5630.1(100.0)	14340.6(100.0)	2547.1

Note: Figures in the parentheses indicate percentages of total rice

A = Area in thousand hectare, P = Production in thousand tonnes, Y = Yield in Kg/ Hectare.

Table 2.2: Trend and Composition of HYV Rice in the state

(Area in 000ha)

Year	Aus		Aman		Boro		Total	
	Area	% to total area	Area	% to total area	Area	% to total area	Area	% to total area
1995-96	495.2	97.0	2698.2	63.0	1160.1	100.0	4353.5	73.1
1996-97	452.5	98.0	2954.9	69.0	1056.4	100.0	4463.8	77.0
1997-98	423.1	100.0	3204.2	75.0	1206.8	100.0	4834.1	81.9
1998-99	416.5	98.0	3104.3	77.1	1450.5	100.0	4971.3	84.2
1999-00	420.0	98.3	3475.0	81.8	1474.3	100.0	5369.3	87.3
2000-01	387.6	98.4	3024.5	83.1	1401.8	100.0	4813.9	88.6
2001-02	398.2	98.9	3555.2	84.4	1455.0	100.0	5408.4	89.1
2002-03	380.9	98.9	3423.2	84.5	1406.1	100.0	5210.2	89.2
2003-04	336.4	99.0	3507.7	85.0	1390.1	100.0	5234.2	89.4
2004-05	318.3	99.2	3473.4	85.0	1376.4	100.0	5168.1	89.4
2005-06	285.8	99.2	3578.1	87.0	1381.9	100.0	5245.8	90.7
2006-07	281.8	99.3	3481.6	87.0	1400.0	100.0	5163.4	90.8
2007-08	288.2	99.4	3325.0	87.5	1511.6	100.0	5124.8	91.5
2008-09	292.4	99.4	3584.6	87.7	1556.7	100.0	5433.5	91.5
2009-10	214.1	99.4	3986.3	87.7	1429.7	100.0	5630.0	91.5

Note: Figures in the parentheses indicate percentages of total

2.2.1 Trend and Composition of HYV Rice in the State

In the case of *Aus* and *Aman* rice the major contributor to increased production of rice was growth in yield. Yield increases are likely due to changes in input use including greater use of high yielding variety seeds. The following is thus an attempt to analyze the trend and composition of HYV rice in the state. Related data are displayed in table-2.2 Notably data pertaining to the area under HYVs are only available in published from obtainable from Economic Review, Government of West Bengal. It is evident that the coverage of HYV seeds in *Aman*, *Aus* and *Boro* rices increased over the time span of 1995-96 to 2009-10. In 1995-96, 97 per cent of area under *Aus* and 63 per cent of area under *Aman* was sown with HYV seeds. In 2009-10, the corresponding figures were 99.4 per cent and 87.7 per cent respectively. *Boro* rice experienced rapid adoption of high yielding variety technology during the period. Evidently, 100 per cent of the *Boro* crop was planted with HYV seeds. For rice produced grown in the three seasons combined, HYVs accounted for over 90 per cent of the total area under rice in 2009-10 which was 73.1 per cent in 1995-96. Thus in terms of coverage of HYV seeds in *Aus*, *Aman* and *Boro* rice cultivation, all the varieties of rice experienced increase in acreage under HYVs. Now if we take 1994-95 as the beginning of hybrid technology, there is no instance of declining area coverage under HYVs, both in absolute and relative terms, after the introduction of hybrid rice cultivation in the state. Importantly, however data pertaining to area, production and yield of hybrid rice were not available at all by virtue of which one can guess the rate of substitutability between HYVs and hybrid rice in total rice cultivation.

2.3 Growth and Instability of Rice Production in the State

Given the important position occupied by rice in West Bengal agriculture, it is pertinent to note that a breakthrough in rice production is indispensable for the good overall agricultural growth performance. As the yield potential of existing varieties of HYVs was declining, it was projected that hybrid rice technology would bring about another rice revolution in the state. The research scientists considered hybrid rice technology as a readily available option to shift the yield frontier upward particularly in intensive irrigated environments. Keeping in mind that the first hybrid was developed and released for commercial cultivation in India in 1994, the study period (1984-85 to 2009-10) for examining the trend of rice production in the state was divided into three sub-periods viz. 1984-85 to 1993-94, 1994-95 to 2003-04 and 2004-05 to 2009-10. The period-I i.e. 1984-85 to 1993-94 refers to the pre-introduction period of hybrid rice cultivation while other two periods viz. period-II and period-III correspond to post-introduction periods. The objective is to study the impact of hybrid rice technology on overall rice production in the state. We have estimated growth trends of area, production and productivity of rice in each of the three rice seasons separately for the three sub-periods and for the study period as a whole fitting a semi-log trend using exponential model. Table-2.3 reports the estimated rates of growth for total rice production in all seasons combined and also separately for the three rice growing seasons.

It is evident that growth in production of rice was significantly higher in the pre-introduction period of hybrid rice than that in the post-introduction period and that this growth was driven more by increases in productivity than in area. Rice production grew at the rate of 1.41 per cent annually in the post-introduction period (1994-95 to 2009-10) which was to 5.13 per cent in the pre-introduction period (1984-85 to 1993-94). Hybrid rice was introduced in 1994-95. Immediately after the introduction of hybrid rice, rice production grew at around 2.30 per cent per annum between 1994-95 to 2003-04 but subsequently during the latter period 2004-05 to 2009-10, there was a decline in the production front. Most of the rice production increases during the pre and post-introduction periods of hybrid rice have come from yield enhancements. Decline in area and increase in yield has been the phenomenon observed in post-introduction period of hybrid rice in the state. However, there has been a visible deceleration in rice yield growth in the post-introduction period of hybrid rice. Yields increased at a compound growth rate of 3.62 per cent per year during the period 1984-85 to 1993-94 which slowed down to 2.29 per cent per year during the period 1994-95 to 2003-04. Again in the subsequent period 2004-05 to 2009-10 there was a marginal (0.09 per cent) decline in growth of yield. Notably the period 2004-05 to 2009-10 is characterized by decline in production of rice by 0.23 per cent per annum accompanied by decrease in both area (0.14 per cent) and productivity (0.09 per cent).

Table 2.3: Compound Growth Rates of Area, Production and Productivity of Rice in the state

(Per cent per annum)

Period	Autumn rice			Winter rice			Summer rice			Total rice		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y
1984-85 - 1993- 94	-1.05	5.23	6.34	0.72	3.99	3.24	8.08	9.23	1.06	1.46	5.13	3.62
1994-95 - 2003- 04	-3.97	-0.98	3.11	-0.65	1.82	2.49	3.70	4.15	0.43	0.01	2.30	2.29
2004-05 - 2009 - 10	-5.51	-4.74	0.82	-0.46	-0.48	-0.03	1.80	0.95	-0.83	-0.14	-0.23	-0.09
1994-95 - 2009-10	-4.90	-3.13	1.86	-0.39	1.57	1.97	1.94	1.95	0.01	-0.17	1.41	1.58

A=Area, P=Production, Y= Yield

Next we turn to the season-wise rates of growth of rice production (table-2.3). Production of *Aman* grew at the rate of 1.57 per cent annually during the post-introduction period of hybrid rice i.e. 1994-95 to 2009-10 which was 3.99 per cent in the pre-introduction period (1984-85 to 1993-94). In both the periods productivity has been the major contributor of growth in rice production. Importantly in the post-introduction period (1994-95 to 2009-10) area has been the declining component of the growth in rice production. There has been a decline in production of *Aus* consistently after the introduction of hybrid rice. During the post-introduction period of hybrid rice, area always has been the declining component although the period experienced positive growth in yield rates, showing deceleration in rice yield growth over the period 1994-95 to 2009-10 as compared to the pre-introduction period of hybrid rice i.e. 1984-85 to 1993-94. The *Boro* or *Summer* crop which was introduced in the mid sixties grew significantly at high rates of 8.08 per cent and 9.23 per cent in terms of acreage and output respectively in the pre-introduction decade of hybrid rice cultivation viz. 1984-85 and 1993-94 as compared to 1.94 per cent and 1.95 per cent respectively in the post-introduction period 1994-95 to 2009-10. Notably during both the periods, yield growth has not been a major contributor to growth of output. Yield of *Summer* rice grew at the rate of 1.06 per cent in the pre-introduction period of hybrid rice which fell abnormally to 0.01 per cent in the post-introduction period. There has been a visible deceleration in *Summer* rice output in the decade of post 1994 period (year of introduction of hybrid rice) viz. 1994-95 to 2003-04. Output of *Summer* rice grew at 9.23 per cent annually between 1984-85 and 1993-94 which slowed down to 4.15 per cent per year during the period between 1994-95 and 2003-04. Decline in growth in production has been due to more in decline in growth of yield than in area. In short, while the overall increase in rice production for all seasons combined is attributable to increase in productivity, an increase in crop acreage has contributed to the growth in *Boro* rice cultivation during the reference period. The principal reason for slow down in yields of *Summer* rice is that yields have almost plateaued with the existing inbred varieties and acreage expansion under hybrid rice has not been enough to

compensate for the loss in yield of inbred varieties and consequently on output of *Summer* rice. The rice producing economy of the state now fails to attain even a modest growth rate, not to speak of attaining the growth rate that it recorded during the 1984-85 to 1994-95 when there was no hybrid technology in rice production.

2.3.1 Growth of High Yielding Varieties of Rice (HYVs) in the State

In order for understanding the growth performance of HYVs, time series data pertaining to area under HYVs for the period 1995-96 to 2009-10 were used. It was the period when the rice crop of the state switched over to hybrid rice technology. Compound growth rates were estimated on the basis of such data. The fitted semi-log trend revealed that rice crop that came under the green revolution technology in the mid-sixties was now (1995-96 to 2009-10) growing only at the rate of 1.24 per cent per annum (Table 2.4). This rate was higher at 2.35 per cent during the period 1995-96 to 2003-04 but subsequently the rate of growth in acreage slowed down to 1.51 per cent per year during the period 2004-05 to 2009-10 making an overall increase of 1.24 per cent in acreage under HYVs during the time span of 1995-96 to 2009-10. There was thus a deceleration in the growth of HYVs during the period experiencing hybrid rice technology. Might be that hybrid rice occupied the area previously occupied by HYVs which however has not been possible to explore due to non-availability of data on area coverage under hybrid rice.

Table 2.4: Compound Growth Rates of Area under HYV Rice in West Bengal

Period	Aus	Aman	Boro	Total
1995-96 - 2003-04	-3.69	2.83	3.25	2.35
2004-05 - 2009-10	-5.26	1.87	1.80	1.51
1995-96 – 2009-10	-4.77	1.76	1.62	1.24

2.3.2 Instability of Rice Production

Growth rates alone cannot account for the complete rice production scenario unless we take into account the amplitude of fluctuations over time in area, production and productivity. In fact, it is difficult to conceive of a neutral relationship between growth of rice output and the amplitude of weather induced fluctuations in yields or we can think of a unique relationship between the two. Because weather is not only the factor affecting yield rate. Yield levels may vary according to the pattern of investment or the methods by which growth is brought about. For instance, irrigation form perennial sources e.g. tube wells, river-lift etc may counteract the vagaries of weather. Thus in the following analyses, we present a measure of fluctuations in area, production and productivity of rice in the state giving the measure of instability in rice crop

output. Instability is measured by the coefficient of variation technique. Table-2.5 gives measure of instability in rice crop production.

Table 2.5: Coefficient of variation (CV) in Area, Production and Productivity of Rice in the state

Period	Autumn rice			Winter rice			Summer rice			Total rice		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y
1984-85 - 1993- 94	11.59	19.99	19.41	2.44	13.68	11.76	23.57	27.14	5.44	4.71	15.49	11.52
1994-95 - 2003- 04	12.93	7.43	10.38	4.77	10.76	9.72	13.03	15.87	4.94	3.27	8.39	7.43
2004-05 - 2009 - 10	12.62	10.84	3.04	1.81	3.15	1.63	5.16	6.85	5.82	1.83	1.71	1.21
1994-95 - 2009-10	23.65	16.63	9.85	4.06	10.36	10.47	11.42	13.41	5.10	2.92	7.95	8.01

A=Area, P=Production, Y= Yield

It is revealing that in case of total rice production, relatively area has been the stable component of growth of output as compared to productivity. In other words, variation in production of rice is largely contributed by variation in yield. Importantly however, instability in rice crop production has got reduced after the introduction of hybrid rice technology. As a whole, the pre-introduction period of hybrid rice, showing highest growth rates of rice in respect of area, production and productivity was associated with higher instability. In contrast the post-introduction period characterized by low growth is associated with lower instability. For *Summer* rice, yield has been the stable component as compared to area. There is thus an indication that variation in area has largely accounted for variation in production of *Summer* rice during the period preceding the introduction of hybrid technology and also during the post-introduction period. Similar to *Summer* rice, for HYVs variation in area has been the declining component as between the pre and post introduction periods of hybrid rice (table -2.6).

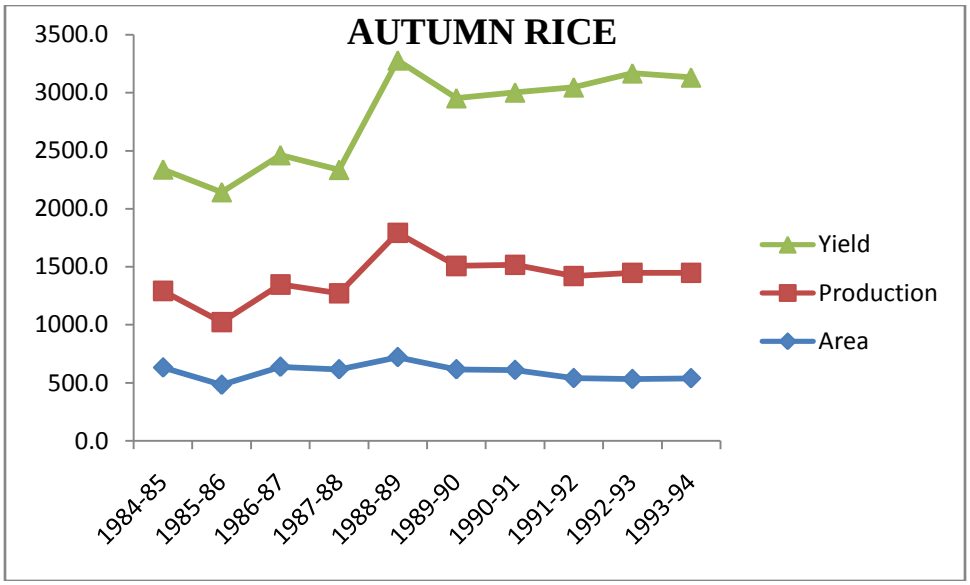
Table 2.6: Coefficient of variation (CV) in Area under HYV Rice in West Bengal

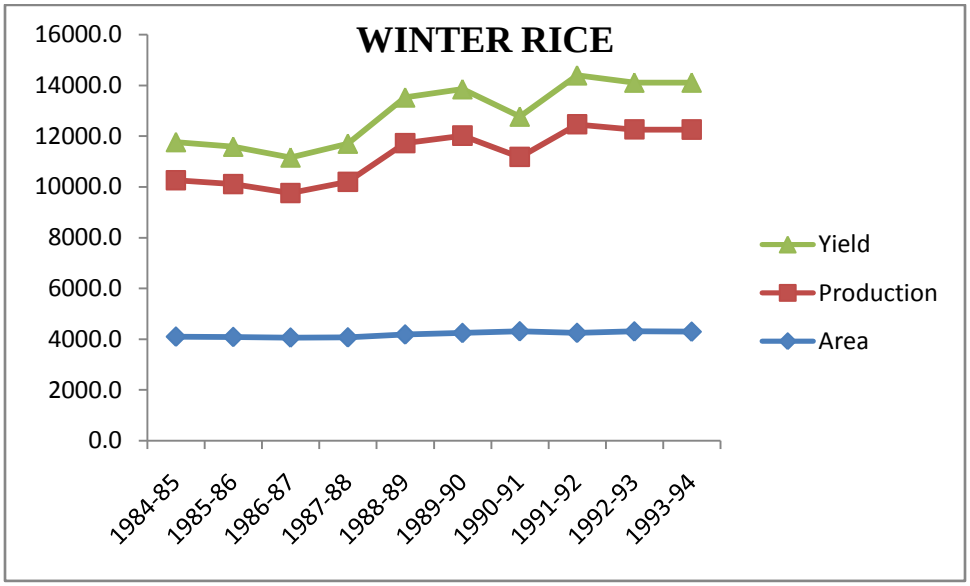
Period	Aus	Aman	Boro	Total
1995-96 - 2003-04	10.93	9.17	11.38	7.67
2004-05 - 2009-10	12.44	6.27	5.17	3.74
1995-96 – 2009-10	21.70	9.42	9.80	6.94

In short, despite the technological advancement in the form of introducing the innovation of hybrid technology in rice after the mid nineties, the growth rate of output of rice as a whole, has decelerated during the decade 1994-95 to 2003-04 and over the whole period from 1994-95 to 2009-10 compared to the previous decade ending 1993-94. The output of rice grew at the rate

of 2.30 per cent per annum during the decade 1994-95 to 2003-04 as against 5.10 per cent in the previous decade 1984-85 to 1993-94. In the subsequent period 2004-05 to 2009-10, the annual growth rate in the output of rice decreased by 0.20 per cent per annum. If we regard 1994-95 as the base year for the introduction of hybrid rice technology, then over the whole period of hybrid technology, 1994-95 to 2009-10, the annual growth rate in output of rice declined from 5.10 per cent to 1.41 per cent between the pre and post introduction period of hybrid rice.

During the decade 1984-85 to 1993-94, the cropped area grew at the rate of 1.50 per cent per annum. Since the actual growth rate of rice output in this decade was 5.10 per cent per annum, about 70 per cent of the increase in output (at 3.60 per cent) could be attributed to the increase in productivity per cropped acre. During the period after the introduction of hybrid technology 1994-95 to 2009-10, the growth rate of cropped area declined by 0.17 per cent per annum. Since the output of rice grew at the rate of 1.41 per cent per annum during this period, there has been marked acceleration in productivity per cropped acre (1.58 per cent) compensating the loss in acreage under rice during the period.

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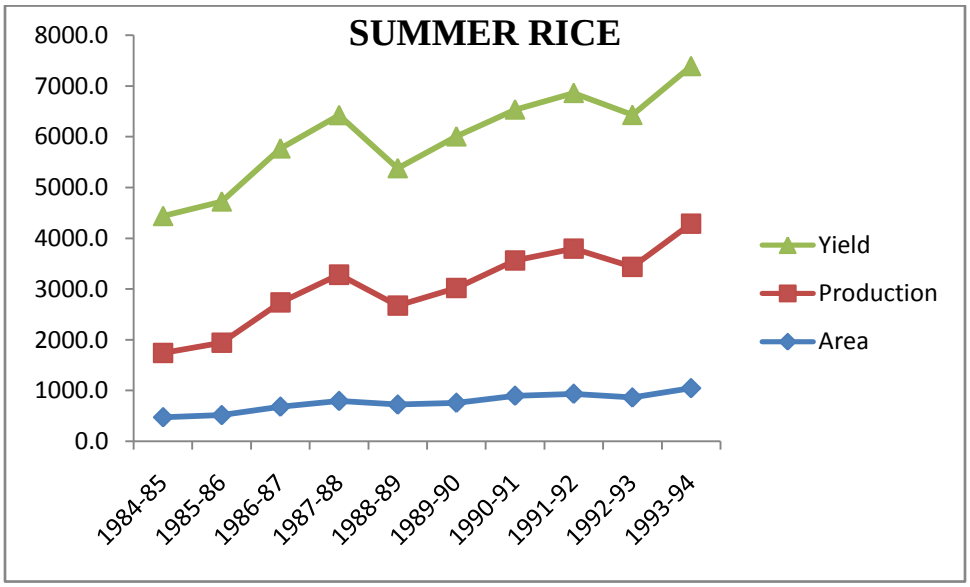
Yield
Production
Area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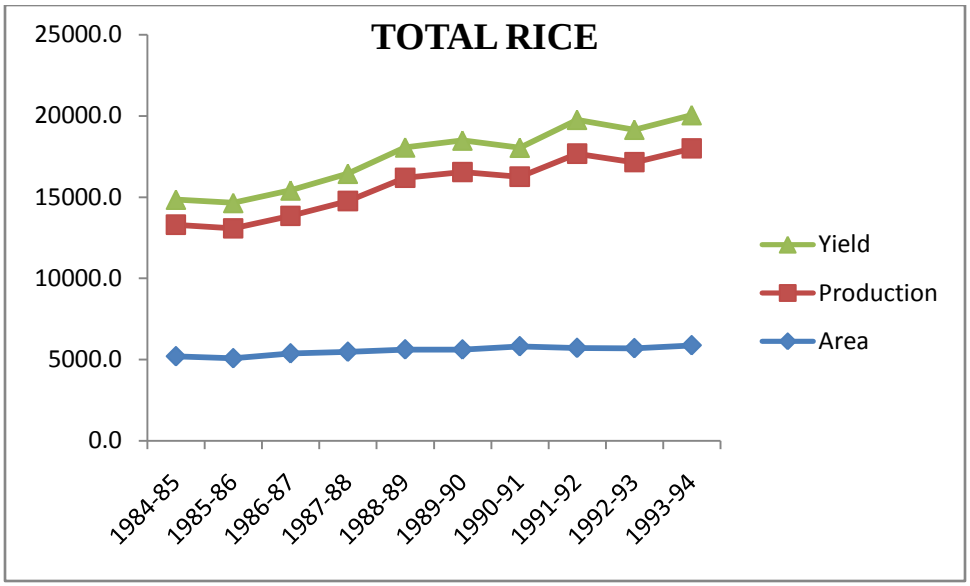
Production
Area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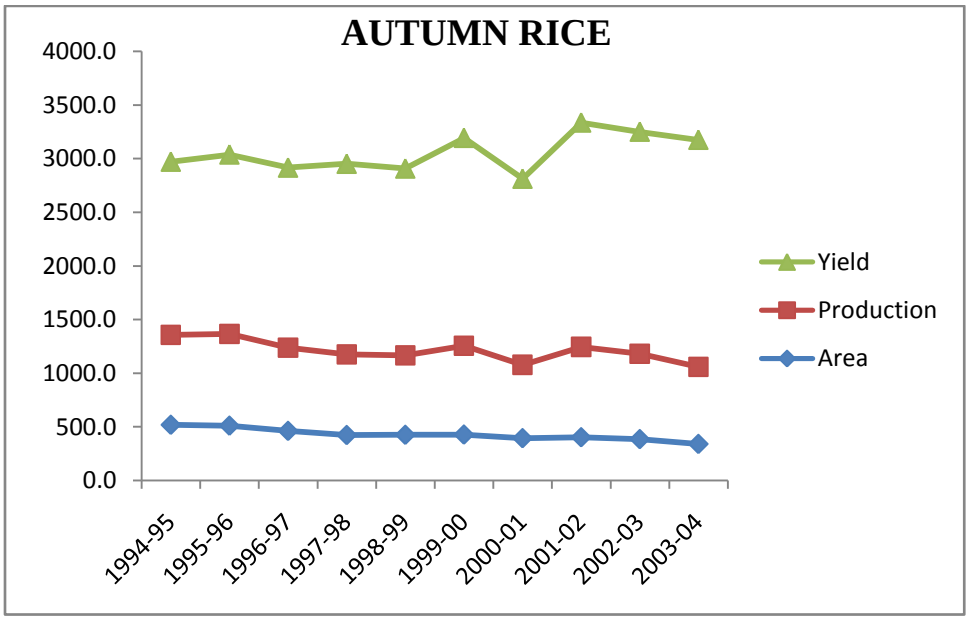
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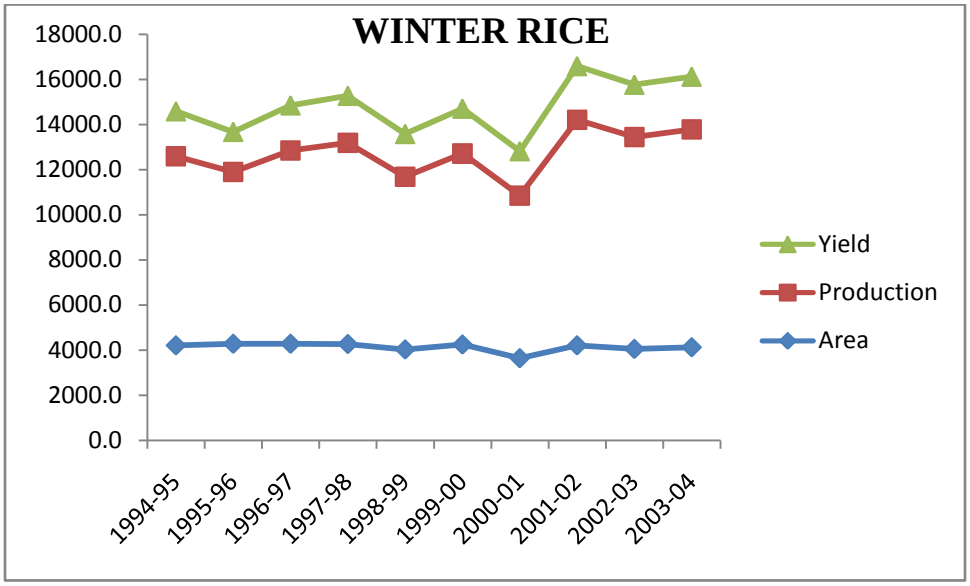
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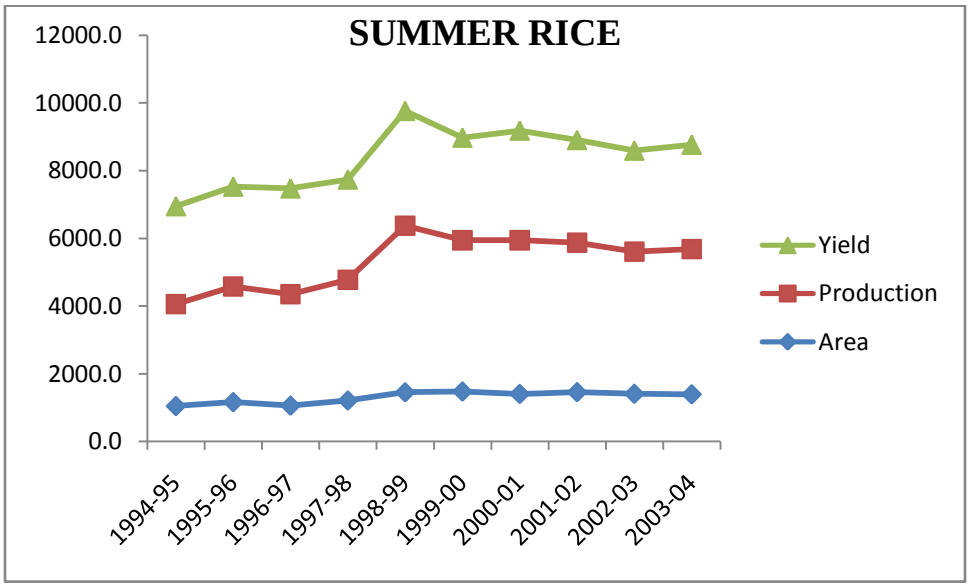
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Yield
Production
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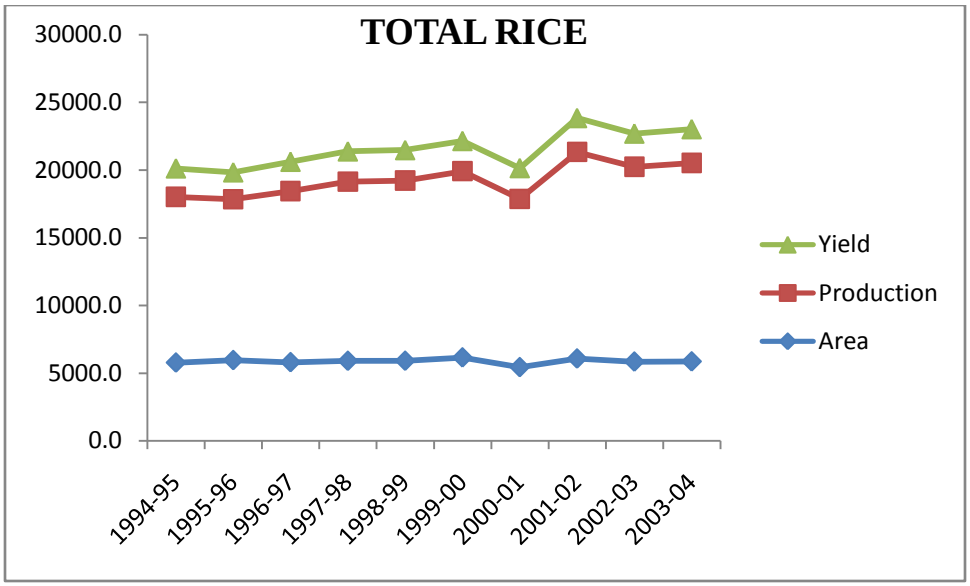
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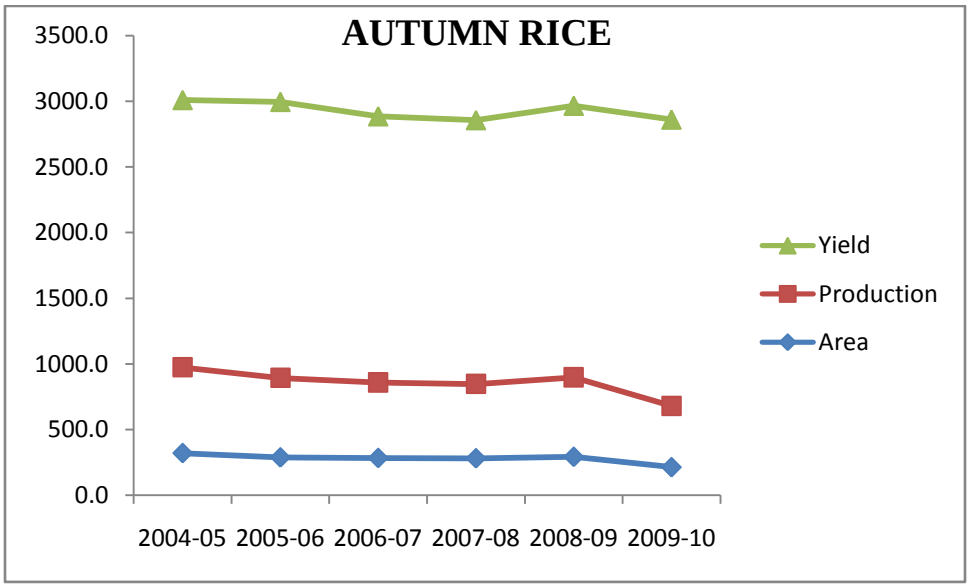
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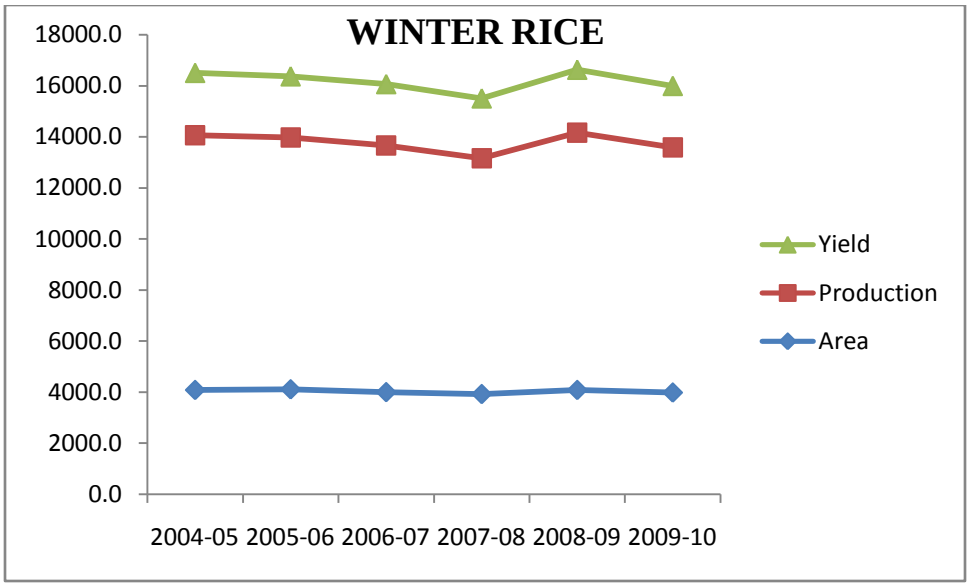
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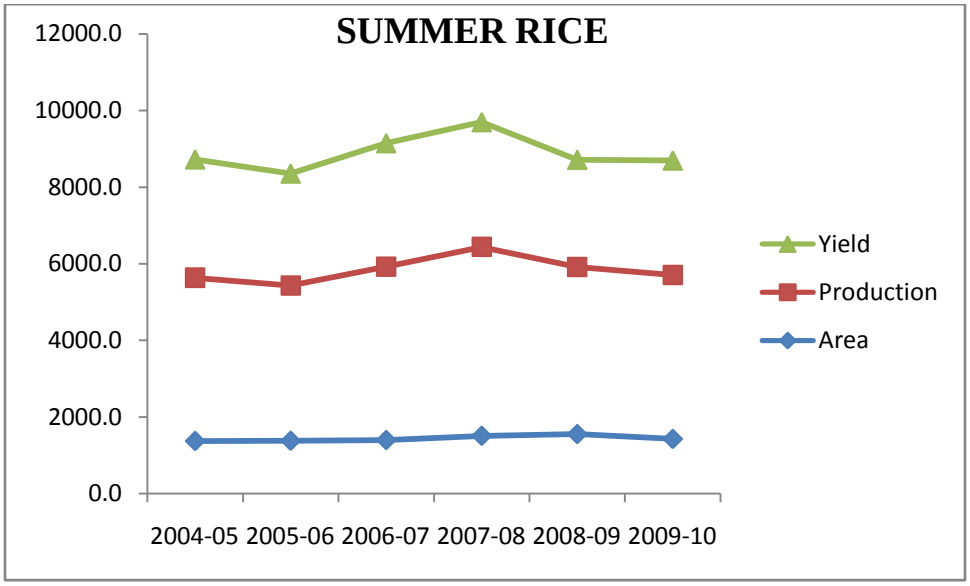
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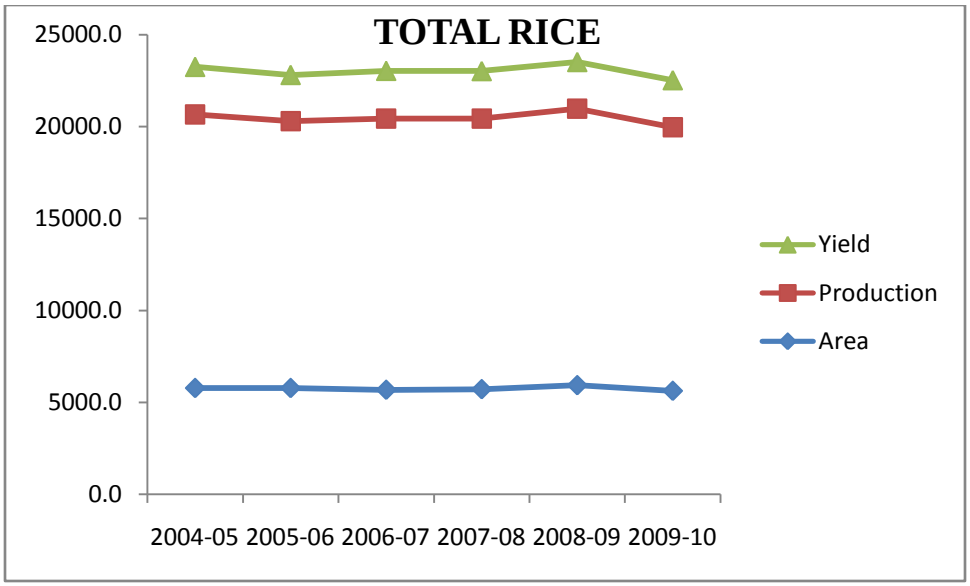
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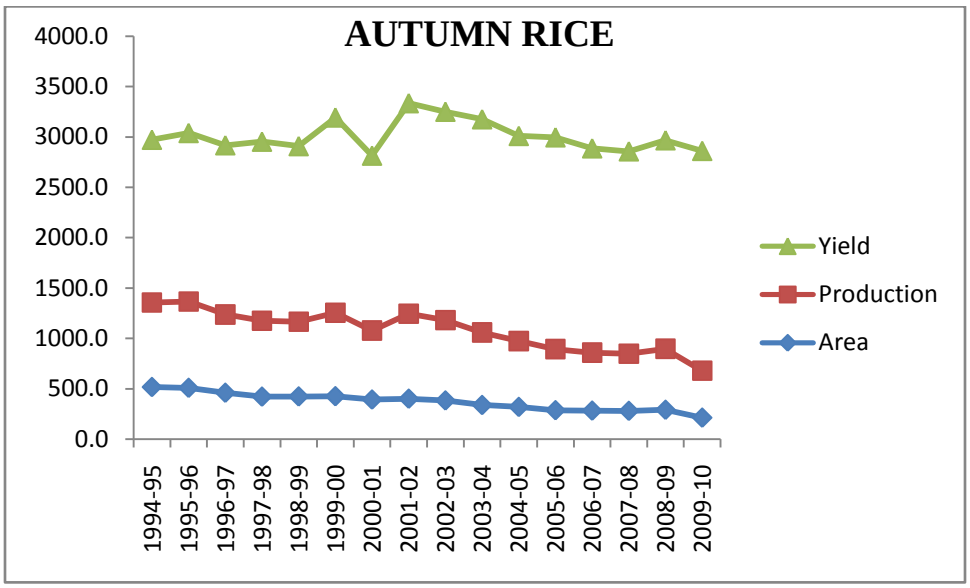
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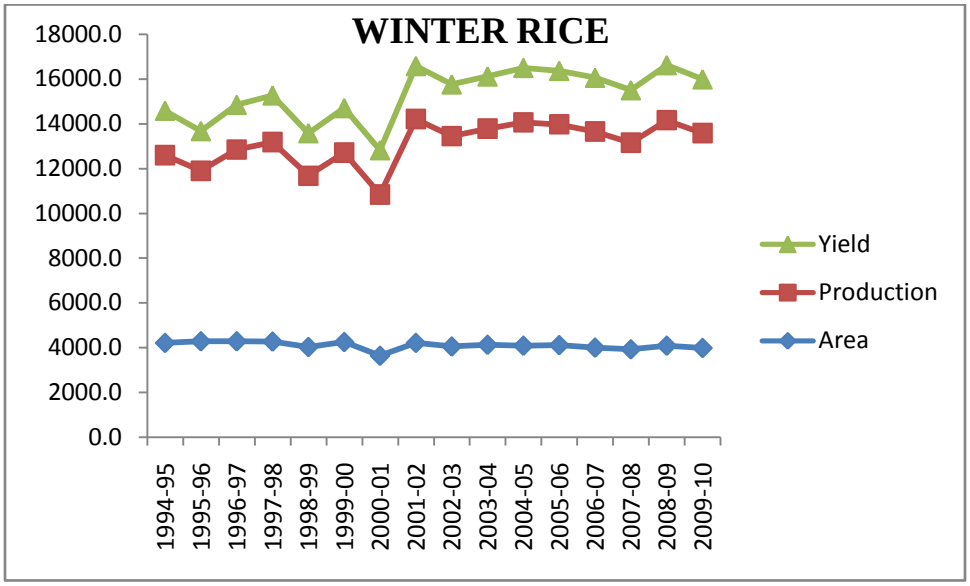
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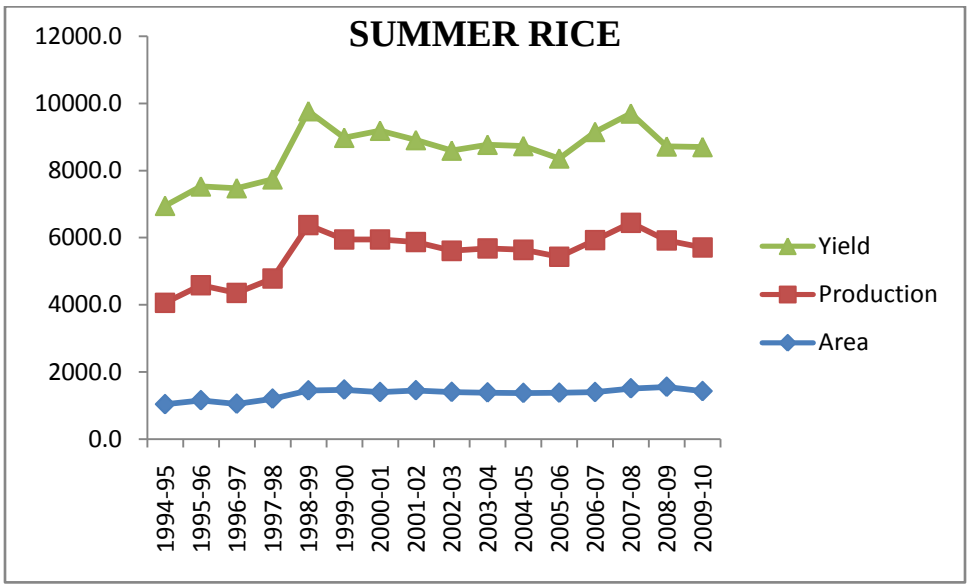
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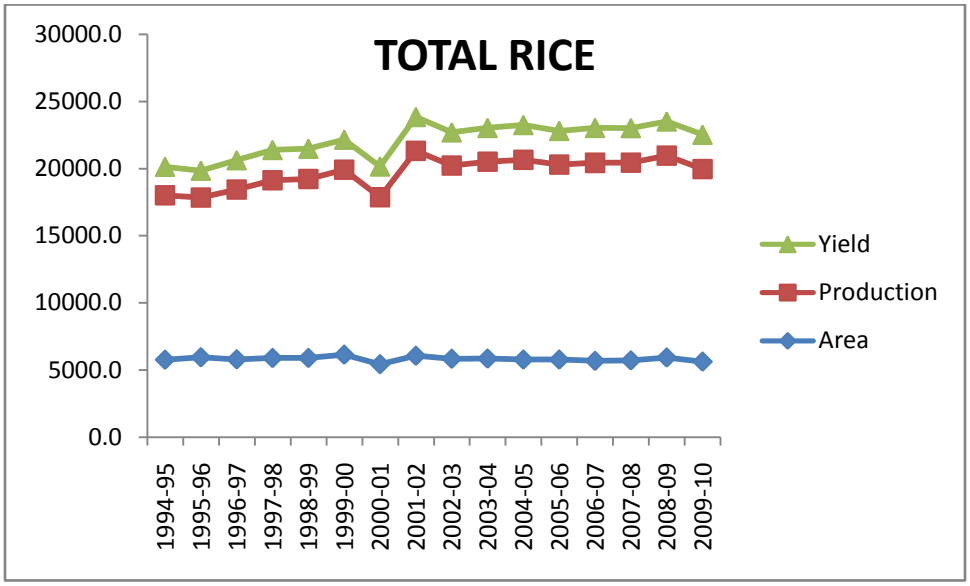

2.3.3 Contribution of hybrid rice technology

Usually, the contribution of technological change is obtained through the production function analysis where all the traditional as well as the technologically new factors are identified and introduced explicitly as input variables. Such an analysis is ruled out at present. We may however adopt a modest course that can provide a meaningful, even though rough estimate of the contribution of hybrid technology. Here we form an idea as to the growth of output that would have occurred in the absence of the hybrid technology, the difference between the observed growth and the hypothetical growth would give a rough measure of the contribution of hybrid technology.

It is reasonable to regard 1994-95 as the base year because hybrid technology in case of rice was introduced in Indian agriculture on commercial basis in the year. From a comparison of the growth of output of rice achieved during pre-introduction period 1984-85 to 1993-94, it appears that output of rice would have grown by about 5 per cent per annum in the absence of hybrid technology. There are reasons to believe that even without the hybrid technology; the growth rate of output would have been maintained at about 5 per cent per annum. Now if it is assumed that output of rice would have grown at 5 per cent per annum without hybrid technology, the contribution of hybrid technology on rice production amounts to nothing. This is discernible from the fact that despite technological innovation in the mid 1990s, the growth rate

in the output of rice as a whole decelerated during the period 1994-95 to 2009-10 compared to the pre-introduction decade 1984-85 to 1993-94, although output of rice has shown an upward trend in the post introduction period. In fact decelerating growth in productivity per cropped acre accounted for the growth in output of rice whatever occurred during the period 1994-95 to 2009-10. The declining trend of productivity of rice which started during the early 1990s is still not arrested even after the introduction of hybrid rice technology.

CHAPTER-III
Status of Adoption of Hybrid Rice at the Farm Level

In the event of changing scenario in the field of technological development, rice in the state of West Bengal emerges as important and strategic crop. The state has the sizeable area suitable for rice cultivation and follows unique practice of cultivation in three rice growing seasons in a year. The state has good water (55 per cent of the net sown area irrigated facilities) and dependable rainfall in some parts of the state. Therefore, changing pattern of technological development has thrown open the opportunity to utilize the ample potential for rice production in the state and enhance their role in the food security. Hybrid rice technology is likely to play a key role in increasing rice production which is however dependent upon the rate of adoption of the technology at the farmers' level. This chapter thus intends to examine the status of adoption of hybrid rice technology at the farm level.

3.1 Sample Farmers and Their Distribution According to Farm Size

West Bengal agriculture is small farm dependent where the marginal (below 1ha) and small (1ha – 2ha) sized land holdings form the bulk of the farm holdings in the state. These two size classes together accounted for more than 95 per cent of the total holdings. In the rural economy of West Bengal, the absence of alternative opportunities of gainful employment has compelled the farm families to depend primarily on agriculture and land being the primary resource in agriculture, its possession determines their accessibility to other resources and hence their production decisions as to how much to invest in land, what crops to grow and how intensively to cultivate land. Thus knowing the pattern of land distribution is crucial for understanding the position of rural households in the farm economy.

The land distribution pattern in West Bengal reflects the preponderance of small and marginal farmers. The two sample districts chosen for the study namely Howrah and Uttar Dinajpur are no exception to this as revealed from our survey data. Table-3.1 displays the distribution of sample farmers in our surveyed districts. It can be seen that small and marginal farmers together account for 97.50 per cent of the total sample farmers among hybrid adopters. The incidence of such farmers among non-adopters is 95 per cent of total sample farmers. As between small and marginal farmers, the latter constitute more in both the categories of sample farm households accounting for 75 and 80 per cent among hybrid adopters and non-adopters respectively.

Table 3.1: Distribution of sample farmers according to farm size

Size classes of operational holdings (ha)	Hybrid adopters		Non-adopters	
	No of farms	Percent of farms	No of farms	Percent of farms
Below 1ha	60	75.00	16	80.00
1 – 2	18	22.50	03	15.00
2 – 4	02	02.50	01	05.00
4 – 10	00	00.00	00	00.00
10 ha and above	00	00.00	00	00.00

Data source: Primary data

3.2 Socio-Economic Characteristics of Sample Farm Households

The purpose of this section is to give an account of sample farm household characteristics. More precisely, it analyzes demographic and social characteristics of households, occupational pattern, average size of holding and average size of irrigated land.

A close look at the demographic profile of the respondents (table 3.2) reveals that the size of the household varies among adopters and non-adopters. The relatively larger size is to be found among the adopters who have an average size of 6 members per household. In contrast, non-adopters have an average size of 5. The average number of males is 3 and females are 2 per household in case of hybrid adopters. The pattern of distribution is somewhat different across adopters and non-adopters. The number of workers is estimated at 3.04 per adopter household whereas for non-adopters the figure comes to 2.55. Average education of majority of the adopters (56.25 per cent) and non-adopters (65.00 per cent) is up to secondary level. A total of 37.50 per cent of adopters studied up to primary standard as against 30 per cent of non-adopters.

Caste composition of households reveals that 25 per cent of adopter households belong to scheduled castes, 1.25 per cent of the households belong to other backward castes whereas the balance 73.75 per cent of the households goes to general castes. Caste composition of non-adopter households is not exactly similar to those of adopter households. For such households, there is no such household which may be categorized as OBCs. The proportion of scheduled caste and general caste is of the order of 25 per cent and 75 per cent respectively. There was thus preponderance of general castes both among the hybrid adopters and non-adopters. Judging by the primary occupation of the head of the households, our survey data reveals that among the adopter households, 88.75 per cent have the main occupation farming, 8.75 per cent are salaried, 1.25 per cent is engaged in business and the rest 1.25 per cent are wage earners working as agricultural labourers. Within the group of non-adopters, 90 per cent are engaged in farming and the rest 10 per cent are employed in self business. The average size of ownership holdings works out to 0.72 ha for adopter households and 0.67 ha for non-adopters. The average size of holdings as measured by the size of operational holdings is estimated at 0.77 ha for adopters as against

Table 3.2: Socio-economic characteristics of sample farm households

Characterizes		Hybrid adopters	Non-adopters	Aggregate
Household size	Male	3.48	2.95	3.37
	%	55.94	50.00	54.80
	Female	2.74	2.95	2.78
	%	44.06	50.00	45.20
	Total	6.21	5.90	6.15
	%	100.00	100.00	100.00
Size of worker	Male	1.93	1.50	1.84
	%	63.37	58.82	62.59
	Female	1.11	1.05	1.10
	%	36.63	41.18	37.41
	Total	3.04	2.55	2.94
	%	100.00	100.00	100.00
Age group (Head of the family)	< 18	0	0	0
	%	0.00	0.00	0.00
	18 – 60	79	16	95
	%	98.75	80.00	95.00
	> 60	1	4	5
	%	1.25	20.00	5.00
	Total	80	20	100
	%	100.00	100.00	100.00
Educational status	Illiterate	3	0	3
	%	3.75	0.00	3.00
	Up to Primary	30	6	36
	%	37.5	30.00	36.00
	Up to secondary	45	13	58
	%	56.25	65.00	58.00
	Up to Graduate	2	1	3
	%	2.5	5.00	3.00
	Above Graduate	0	0	0
	%	0.00	0.00	0.00
	Total	80	20	100
	%	100.00	100.00	100.00
Caste	SC	20	5	25
	%	25.00	25.00	25.00
	ST	0	0	0
	%	0.00	0.00	0.00
	OBC	1	0	1
	%	1.25	0.00	1.00
	General	59	15	74
	%	73.75	75.00	74.00
	Total	80	20	100
	%	100.00	100.00	100.00
Main occupation of the head	Self-employed Farming	71	18	89
	%	88.75	90.00	89.00
	Self-employed Non-farming/ Business	1	2	3
	%	1.25	10.00	3.00
	Salaried Person	7	0	7
	%	8.75	0.00	7.00
	Agriculture Labour	1	0	1
	%	1.25	0.00	1.00
	Non-agricultural Labour	0	0	0
	%	0.00	0.00	0.00
	Pensioner,	0	0	0
	%	0.00	0.00	0.00
	Household Work	0	0	0
	%	0.00	0.00	0.00
	Student	0	0	0
	%	0.00	0.00	0.00
	Others (specify)	0	0	0
	%	0.00	0.00	0.00
	Total	80	20	100
	%	100.00	100.00	100.00
Average size of holding (ha)	Ownership holdings	0.72	0.67	0.71
	Operational holdings	0.77	0.71	0.76
Season wise average size of irrigated land (ha)	Kharif	0.55	0.50	0.54
	%	39.48	45.12	40.42
	Rabi	0.33	0.18	0.30
	%	24.02	16.06	22.69
	Summer	0.51	0.43	0.49
	%	36.50	38.82	36.89
	Total (All Seasons)	1.39	1.11	1.33
	%	100.00	100.00	100.00

Data source: Primary data

0.71 ha for non-adopters. The average size of irrigated land (all seasons combined) is estimated to be 1.39 ha for adopter households as against 1.11 ha for non-adopters. Out of the total gross

irrigated area, about 60 per cent of area receives irrigation during *rabi/summer* seasons in case of adopter households while the corresponding figure stood at 54.88 per cent for non-adopters.

3.3 Cropping Pattern

This section intends to look into the behaviour of crop pattern for the years 2009-10 and 2010-11. For the purpose of analyzing crop pattern, based on the share of each crop to the total gross cropped area, percentages were worked out separately for the years 2009-10 and 2010-11 and are presented in table 3.3. A perusal at the table indicates that rice, maize wheat, betel leaf (pan), jute and maskalai are dominant crops in order of importance amongst the hybrid adopters

Table 3.3: Cropping pattern for the years 2009-10 and 2010-11

Seasons/Crops	Hybrid adopters				Non-adopters			
	2009-10		2010-11		2009-10		2010-11	
	Area (ha)	percent	Area (ha)	percent	Area (ha)	percent	Area (ha)	percent
Kharif	**46.29**	**43.74**	**44.89**	**42.82**	**10.24**	**47.92**	**10.24**	**47.92**
Hybrid Rice	1.20	1.13	2.73	2.60	0.00	0.00	0.00	0.00
Inbred Rice	39.43	37.26	37.50	35.77	9.67	45.25	9.67	45.25
Jute	2.53	2.39	1.53	1.46	0.20	0.94	0.20	0.94
Betel leaf (Pan)	3.13	2.96	3.13	2.99	0.37	1.73	0.37	1.73
Rabi	**22.27**	**21.05**	**23.00**	**21.94**	**2.87**	**13.43**	**2.86**	**13.38**
Wheat	8.23	7.78	7.83	7.47	0.80	3.74	0.60	2.81
Maize	10.27	9.71	11.80	11.26	1.27	5.94	1.53	7.16
Mustard	1.67	1.58	1.47	1.40	0.40	1.87	0.33	1.54
Potato	0.47	0.44	0.50	0.48	0.10	0.47	0.10	0.47
Maskalai	1.63	1.54	1.40	1.34	0.30	1.40	0.30	1.40
Summer	**37.26**	**35.21**	**36.94**	**35.24**	**8.26**	**38.65**	**8.27**	**38.70**
Hybrid Rice	10.13	9.57	12.87	12.28	0.00	0.00	0.00	0.00
Inbred Rice	26.20	24.76	20.87	19.91	8.13	38.04	7.20	33.69
Maize	0.93	0.88	3.20	3.05	0.13	0.61	1.07	5.01
GCA	**105.82**	**100.00**	**104.83**	**100.00**	**21.37**	**100.00**	**21.37**	**100.00**

Data source: Primary data

in the study area. These crops together covered 98.13 per cent of the gross cropped area. During the period under review i.e. between 2009-10 and 2010-11, aggregate share of these crops in the total gross cropped area increased marginally from 97.98 per cent in 2009-10 to 98.13 per cent in 2010-11. It is however noticeable that the share of hybrid rice in the total gross cropped area increased from 1.13 per cent in 2009-10 to 2.60 per cent in 2010-11 during *kharif* season. During summer (*boro*) season too, hybrid rice increased their share in the cropping pattern from 9.57 per cent in 2009-10 to 12.28 per cent in 2010-11. In contrast, there has been decline in the share of conventional varieties of HYV (inbred rice) during the period under review. Inbred rice shared

35.77 per cent of gross cropped area during *kharif* in 2010-11 which was 37.26 per cent in 2009-10. During summer season the share of inbred rice declined from 24.76 per cent in 2009-10 to 19.91 per cent in 2010-11. Hybrid rice is thus mainly grown during summer and upgraded its status in the cropping pattern over the period under study.

Kharif rice and summer rice being the two components of total rice jointly demonstrated decline in their area share from 72.72 per cent in 2009-10 to 70.56 per cent in 2010-11. However within rice crop, inbred rice (conventional HYVs) constituted the major where about 55.68 per cent of the gross cropped area was covered by inbred rice as recorded in 2010-11. The corresponding figure was 62.02 per cent in 2009-10 and thus inbred rice suffered loss in acreage during the reference period. Correspondingly, hybrid rice gained in share in acreage in gross cropped area from 10.70 per cent in 2009-10 to 14.88 per cent in 2010-11. Hence loss in acreage under inbred rice is to a large extent compensated by the gain in acreage under hybrid rice and the overall marginal changes in the cropping pattern that occurred during the reference period was due to fall in acreage under inbred rice and correspondingly compensatory increase in acreage under hybrid rice.

Among the non-adopters the staple crop is rice which is raised on an area accounting for 78.94 per cent of gross cropped area in 2010-11. The corresponding figure was 83.29 per cent in 2009-10. Thus during the reference period land given up to rice declined by 4.35percentage points. The bulk of the rice crop is sown in the kharif and its percentage share remained constant at 45.25 per cent during both the periods whereas the corresponding proportion for the rice sown in the rabi had declined from 38.04 per cent in 2009-10 to 33.69 per cent in 2010-11. The net effect is thus the loss in relative share of rice in the cropping pattern in case of non-adopters of hybrid seeds. Other crops grown on the field of non-adopters are maize, wheat, mustard and maskalai in order of importance. Aggregate share of these crops in the total gross cropped area marginally decreased from 12.95 per cent in 2009-10 to 12.91 per cent in 2010-11. Within the food grain group, maize occupying the position after rice improved its share significantly from 5.94 per cent in 2009-10 to 7.16 per cent in 2010-11. Wheat suffered a loss in their percentage share from 3.74 per cent in 2009-10 to 2.81 per cent in 2010-11. Acreage sown to other crops remained stationery during both the periods.

3.4 Extent of adoption of hybrid rice at the farm level

The rice output growth under widespread adoption of high yielding varieties (HYVs) was largely contributed by yield improvement particularly in favourable irrigated environments. However the economically exploitable yield of existing high yielding varieties called inbred

varieties has almost reached the saturation point. Now among various options, scientists and policy makers considered development and use of hybrid rice technology as a readily available option to shift upward the yield frontier of rice. However a new agricultural technology in order to be acceptable to the farmers should normally have the following attributes; (i) suitability, in the sense of its appropriateness to the soil climatic condition in which the farmers operate; (ii) stability; in the sense of smaller range of yield fluctuation than that under the existing technology reducing risk of cultivation (iii) economic viability or profitability and (iv) conformity with the socio-institutional attributes of the farmers. Government policy has role to play to create conditions making all these attributes favourable to output growth. Deficiency in the first two may be taken care of by proper research programmes leading to generation of technology. The third calls for devising low cost farm practices and looking for cheaper alternatives to the costly components. The forth calls are for vigorous extension and training programmes.

The research efforts in the field of developing hybrid rice technology have resulted in the release of many hybrid varieties. Notably however rice hybrids have not been well accepted by farmers and accordingly the spread of hybrid rice varieties has been slower. Thus in the following analyses attempt has been made to examine the extent of adoption of hybrid rice technology at the farm level and to see how they are motivated to grow hybrid rice in lieu of conventional HYVs.

Table 3.4: The extent of adoption of hybrid rice technology by farm size

(For hybrid adopters only)

Farm size classes (ha)	2009-10						2010-11					
	Average farm size (ha)	Average rice area (ha)	Average rice area (ha) under		Percent of rice area under		Average farm size (ha)	Average rice area (ha)	Average rice area (ha) under		Percent of rice area under	
			HYVs	Hybrid	HYVs	Hybrid			HYVs	Hybrid	HYVs	Hybrid
Below 1ha	0.52	0.60	0.49	0.11	81.97	18.03	0.52	0.58	0.44	0.14	75.34	24.66
1 – 2	1.28	1.62	1.42	0.19	88.00	12.00	1.28	1.55	1.25	0.30	80.43	19.57
2 – 4	2.50	3.76	3.33	0.43	88.48	11.52	2.50	3.56	3.03	0.53	85.02	14.98
4 – 10	-	-	-	-	-	-	-	-	-	-	-	-
10 ha and above	-	-	-	-	-	-	-	-	-	-	-	-
All sizes	0.77	0.96	0.82	0.14	85.27	14.72	0.77	0.92	0.73	0.20	78.91	21.09

Data source: Primary data

Although hybrid varieties of rice are size-neutral in the sense that they are perfectly divisible and can be used irrespective of the size of farm, invariably they are not resource neutral. It is highly probable that in case of small farmers, the land augmenting character of this innovation might be the major factor favouring their adoption while labour saving character of new seeds might be an important factor favouring their adoption among large farmers. Since

large farmers have a better command over resources and since their risk bearing capacity is greater than that of the small farmers, one should expect the adoption of hybrid technology to be more extensive among the large farmers. Evidently, however show that the average planted area under hybrid as a ratio to the average rice area declines with the increase in the size of holding (Table 3.4). That is smaller farms allocated a larger proportion of area to hybrids as compared to the larger sized farms, the percentage of the rice area actually allocated to the hybrids appears to be somewhat lower among the larger sized farmers.

It can be seen that during the year 2009-10 the proportion of rice area allocated to hybrid rice accounted for 18.03 per cent in marginal sized land holdings which declines consistently with the rise in the size of holding to 11.52 per cent. Such a decline in the ratio of hybrid rice area to total rice area is accompanied by the corresponding increase in the harvested area under HYVs as a ratio to the total area allocated to rice. Similar relationship is also observed during the year 2010-11. Considering all the farm sizes together, the percentage of rice area allocated to hybrid rice is 21.09 per cent in 2010-11, which was 14.72 per cent in 2009-10. Thus the adoption of hybrid rice at the farm level in rather low but showed an increasing tendency in the proportion of harvested rice area allocated to hybrid rice over the years. It has picked up during the reference period obviously because of increasing popularity amongst the farmers. Over the farm sizes, the currently available hybrid rice is not so attractive to the larger sized land holdings those who are commercially motivated and produce rice mainly for the market. On the contrary, small and marginal farmers who produce mainly for household consumption have shown interest in hybrid rice. The smaller sized farms have an advantage over the larger ones in regard to the traditional labour intensive farming where as hybrid rice cultivation is more labour intensive as compared to conventional HYVs. Needless to say, hybrid technology has vast potential for improving the level of productivity of rice. But the dissemination of hybrid rice technology at the farm level is much more important.

3.5 Access to hybrid rice technology

In order for the successful adoption of hybrid technology, there is emerging need of demonstrating the technology at farmers' level. Traditionally the field level extension workers of the state department of agriculture periodically provide supervisory inputs who obtain scientific knowledge from research institutes in the form of training of field staff. However despite all these, farmers very frequently obtain information on technology from their fellow farmers. Sometimes the progressive farmers render the required services in the village. However it is believed by many that farmers do not get adequate information on modern agricultural

technology. Thus in order to study farmers' access to various sources of information, we have gathered information regarding access to hybrid rice technology by farmer households. In particular it gives the proportion of households accessing various sources of information on hybrid rice technology such as training programme organized by the government, frontline demonstration programme conducted by the government, krishi vigyan kendra, extension worker of state department of agriculture, television, radio, input dealer, progressive farmer, private agency including NGOs, output buyers or food processor, credit agency and so on.

Table 3.5A: Farmers accessing source of information on hybrid rice technology

(For Hybrid adopters only)

Source	Number of farmers reporting	Percent of farmers reporting
Frontline demonstration programme conducted by government	-	-
Participation in training programme organized by the government	61	76.25
Krishi Vigyan Kendra	-	-
Extension worker of state department of agriculture	65	81.25
Television	-	-
Radio	-	-
Newspaper	-	-
Input dealer	-	-
Progressive farmer	-	-
Private agency/ NGO	-	-
Output buyers/food processor	-	-
Credit agency	-	-
Others	-	-

Data source: Primary data

Table 3.5B: Farmers reporting quality of information received among those accessing the source

(For hybrid adopters only)

Source	Hybrid adopters reporting quality of information received		
	Good	Satisfactory	Poor
Participation in training programme conducted by the government	32 (52.46)	29 (47.54)	0 (0.00)
Participation in demonstration programme organized by the government	-	-	-
Extension worker of state department of agriculture	34 (52.31)	31 (47.69)	0 (0.00)
Krishi vigyan Kendra	-	-	-

Data source: Primary data
Note: Figures in brackets indicate percentages

Table-3.5A presents the proportion of farmer households accessing information on hybrid rice technology through the above mentioned sources. Evidently, among the sources, the most popular one was the extension worker of the state department of agriculture (81.25 per cent)

followed by training programme organized by the government (76.25 per cent). When asked about the quality of information received among those accessing the source, mixed response was received in case of both the sources (table-3.5B).

Farmer households when asked whether they adopted recommended package of practices in rice cultivation, 58 per cent of the hybrid rice adopters obtaining knowledge from the training programme undertaken by the government held the view that they have adopted package of practices as recommended by the source. About 57 per cent of hybrid growers those who have accessed information from the extension worker of the state department of agriculture reported that they have followed the recommended package of practices (table-3.5C).

Table 3.5C: Farmers reporting adopted recommended package of practices in rice cultivation

(Percent of farmers reporting)

Source of information	Hybrid Adopters		Non-Adopters
	Hybrid Rice	HYV Rice	HYV Rice
Participation in training programme conducted by the government	58	-	-
Participation in demonstration programme organized by the government	0	-	-
Extension worker of state department of agriculture	57	-	-
Krishi Vigyan Kendra	0	-	-

Data source: Primary data

Information was collected from the farmer households, regarding the sources of seed they have accessed. A good majority (70 per cent) of hybrid growers reported that they have obtained seed from government sources on full subsidy. Above 30 per cent of farmers growing hybrid seeds have responded that (table-3.5D) they have obtained seeds from private sources.

Table- 3.5D: Farmers accessing sources of seed for Hybrid rice cultivation

(For hybrid adopters only)

Sources of seed	2009-10		2010-11	
	Number of farmers reporting	Percent of farmers reporting	Number of farmers reporting	Percent of farmers reporting
Public on full subsidy	56	70.00	58	72.50
Public on partial subsidy	0	0.00	0	0.00
Private	24	30.00	22	27.50

Data source: Primary data

3.6 Determinants of Participation in Hybrid Rice Cultivation

In order to find out the determinants of participation in hybrid rice cultivation we have made an attempt to estimate the logit model using several combinations of farm and farmers – specific variables. In the model dummy participation in hybrid rice cultivation (participation = 1,

non-participation = 0) has been taken as dependent variable. The predictor variables (explanatory variables) used in the model are (a) age (b) education (c) household size (d) size of workers (e) farm size. The results are summarized in table 3.6A

Table 3.6A: Determinants of participation in hybrid rice cultivation (regression results of logit model estimates for adoption of hybrid rice)

Dependent variable: Dummy participation in hybrid rice cultivation (participation = 1, non-participation = 0)

Variable name	Coefficient	'Z' value	Standard error
Constant	3.119715	1.49	2.0923
Age	-0.0453283	-1.24	0.0366
Education	0.0969155	0.24	0.3980
Household size	-0.0062222	-0.02	0.2493
Size of worker	0.3651915	0.78	0.4710
Farm size	-0.5944593	-0.85	0.7014
Number of observations	91		
Pseudo R^2	0.0414		
Log likelihood	-32.1591		
LR $chi^2(5)$	2.78		

Note: Estimated coefficients are insignificant at 5% level of significance

Results show that education level of farmers had a positive relationship suggesting that higher the level of education of the farmers, higher the probability of extending more area under hybrid rice. Age of the participant is having negative impact on the farmers' participation in hybrid rice cultivation which suggested that higher the age, the lower is the probability of participation. Farm size has shown a negative association with the adoption of hybrid rice. It implied that small farmers – who make up the majority of all farmers are the potential adopters of hybrid rice in future in the state. The possible reason for this is that the primary objective of small farmers whose average farm size is very small, is to enhance household rice production from a small piece of land to feed their families. Therefore, they would go for hybrid rice technology since it's yield is 19-22 per cent higher than that of HYVs as observed in the study. On the other, the currently available hybrid rice is not attractive to the commercial farmers having larger sized land holdings. Further hybrid technology being labour intensive technology will have less probability success in the agrarian structure characterized by bigger sized land holdings. This is indicative from the fact that size of worker has shown a positive association with the adoption of hybrid rice. This suggests that higher the size of worker, higher is the probability of adoption of hybrid rice. More labour availability per unit of arable land owing to greater availability of family labour on smaller sized holdings is the phenomenon observed in a labour surplus economy like ours and is thus likely to associate positively with the adoption rate of hybrid rice technology. Household size has a negative coefficient suggesting that the larger

the household size, the lower is the probability of participation in hybrid rice cultivation. The overall specification of the model is judged by the log likelihood based chi square test which however suggests that the model used is not a good predictor model. The value of R^2 is also found to be low and thus the model requires inclusion of some more predictor variables.

The application of the logit model using the variables described above has the limited relevance to study the adoption behaviour of farmers. In the earlier estimate none of the variables turned out to statistically significant. Nevertheless we made further attempt to estimate logit model using some more farm and farmer-specific variables. Finally we included the following variables: (a) age (b) education (c) household size (d) size of worker (e) farm size (f) wage-paddy price ratio and (g) farm worker-arable land ratio. The results are summarized in table-3.6B

Table 3.6B: Determinants of participation in hybrid rice cultivation (logit function)
Dependent variables: Dummy participation in hybrid rice cultivation (participation = 1 non-participation = 0)

Variable Name	Co-efficient	'Z' Value	Standard Error
Age	-0.0303	-0.99	0.0306
Education	0.5323	1.42	0.3735
Household size	-0.3530	-1.53	0.2303
Size of worker	1.1890*	2.35	0.5064
Farm size	-0.7581	-1.03	0.7343
Wage-paddy price ratio	113.1789*	2.87	39.3885
Farm worker-arable land ratio	-0.0287	-0.87	0.0331
Intercept	-14.8844	-2.44	6.1001
Number of observations	100		
Pseudo R^2	0.2003		
Log likelihood	-40.0187		
LR $chi^2(7)$	20.04		

*indicates significant at 5 per cent level of significance

The estimated results show that the variables like age, education and farm size have the desired sign but the estimated coefficients turned out to be statistically insignificant. Education level of the farmers had a positive relationship with the probability of participation in hybrid rice cultivation. Age has the negative coefficient suggesting that higher the age, lower the probability of participation in hybrid rice cultivation. Farm size has shown a negative association with the participation in hybrid rice cultivation. It implied that higher the farm size, lower the probability of participation in hybrid rice cultivation. In other words, small farmers are the potential adopters of hybrid rice. The predictor variables which were found significant are size of worker in the family and wage-paddy price ratio. Size of worker has a positive coefficient suggesting that the larger is the size of worker, the higher is the probability of participation in hybrid rice cultivation. Hybrid rice production is more labour intensive as compared to conventional HYVs

(inbreeds) which requires additional mandays of labour per hectare. Hence hybrid technology will have less probability of success where labour is becoming a constraint for the farm sector. Smaller sized landholdings enjoy the advantage of growing hybrid rice owing to greater availability of family labour on such holdings. Further, farm wage-paddy price ratio is positively related to the farmers' participation in hybrid rice cultivation and also turned out to be statistically significant. In fact the ratio of farm wage-paddy price is likely to inversely associate with the participation in hybrid rice cultivation. But the estimated relation turned out to be positive which may be considered as a spurious correlation and bears no meaning.

CHAPTER-IV
Impact of Hybrid Rice Cultivation on Overall Production of Rice

Rice research programme in India over the past couple of years has largely centered on shifting the yield frontier which contributed significantly in achieving food security through increased rice production. Yield improvements in rice were major sources of output growth of rice largely due to widespread adoption of high yielding varieties of rice particularly in favourable irrigated environments. However yield advances in rice drastically slowed down in the early 1990s in India. Not only the growth in yield of rice was slowed down but also at the same time instability in yield growth was seen with fluctuating growth levels in different periods. The intensive rice growing states of Andhra Pradesh, Tamil Nadu, Punjab and Haryana, which performed significantly in terms of yield improvements until the 1980s, have been witnessing either a plateau or negative yield growth during the 1990s. The economically exploitable yield of existing high-yielding varieties (HYVs) of rice has almost reached the technical optimum with the universal adoption of HYVs. Inspired by the miraculous success of hybrid rice technology in China, policy makers and research scientists considered hybrid rice technology is a potential option to sustain the food security by shifting upward the yield frontier in the irrigated environments in India.

Hybrid rice was first commercially cultivated in China in 1976 and it was reported that hybrid rice in China had a 15 per cent yield gain over the inbreeds (Chengappa P G et al. 2003). In India there are evidences to show that farmers cultivating hybrid rice realised higher yield gains at 16 per cent over inbred varieties in Karnataka, Andhra Pradesh and West Bengal (Janaiah, 2002). But in Orissa and Tamil Nadu, hybrids gave lower yields due to pests and disease attack compared with inbred varieties. The survey undertaken by Chengappa, P G (2003) covering 98 sample adopters and 48 sample dropouts in Maharashtra, indicated that the yield realized by hybrid rice growers was higher by 13.34 per cent compared with inbred (HYV) rice growers. It is thus convincing that the yield realized on hybrid rice cultivation is higher than that in inbred varieties. The available research findings demonstrated that hybrid rice is associated with higher yield potential as compared to inbred varieties in farmers' fields although with wider variability across the regions of India. This technology has good potential to increase rice yields and overall rice production under normal farm conditions.

Based on farm level data from 13 sample villages covering 100 sample adopters (who grew hybrid rice in 2000-01) and 50 dropouts (who grew hybrid rice previously and dropped out in 2000-01) in Andhra Pradesh, it was found that hybrid rice had only 4 per cent yield gain over

the best inbred rice varieties during 2000-01 (Janaiah, 2003). For dropouts of hybrid rice cultivation there was a negative yield gain of about 5 per cent for hybrid rice compared with HYVs/inbreds. In the study, farm level performance of hybrid rice was also examined inter-temporarily. Only 10 per cent yield gain was reported for hybrid rice in on-farm trials conducted during 1993-95 crop years in farmers' fields. During 1997-98 about 22 per cent of yield gain for hybrid rice over inbred rice varieties was reported. That the hybrid rice has a distinct yield advantage over inbred varieties is also supported by our survey data and is shown in the following paragraphs.

4.1 Yield performance of hybrid and HYVs

Based on farmer's level survey data, collected in course of the present study table-4.1 summarizes the relative yield performances of the rice varieties (hybrids and HYVs) in farmer's fields over the periods 2009-10 and 2010-11. Overall, rice hybrid performed better with an average yield of 6408.53kg per ha than average yield of 5377.60kg per ha for HYVs during the 2009-10. During 2010-11, too hybrid rice recorded higher yield at 6551.28kg per ha as against 5340.89kg per ha for HYVs. Among various farm size groups, smaller sized holdings obtained highest yield in both the years. The mean yield of HYV rice however increased with the increase in the size of farm over the years. In other words, mean yield levels of HYVs were higher on larger sized holdings as compared to smaller ones in case of HYVs.

Table 4.1: Mean yield levels of hybrids and HYVs of rice by farm size on sample farms

(Hybrid adopters only)

Farm size classes (ha)	**2009-10**			**2010-11**		
	Mean yield (Kg/ha)		Percent difference	Mean yield (Kg/ha)		Percent difference
	Hybrid	HYVs		Hybrid	HYVs	
Below 1ha	6412.31	5217.36	22.90	6803.76	5330.83	27.63
1 – 2	6425.81	5414.06	18.69	6229.41	5299.83	17.54
2 – 4	6363.46	5671.43	12.20	6178.13	5429.75	13.78
4 – 10	-	-	-	-	-	-
10 ha and above	-	-	-	-	-	-
All sizes	6408.53	5377.60	19.17 (10.74)*	6551.28	5340.89	22.66 (18.45)*

*estimated 'paired t' values are significant at 5 per cent level of significance.

In comparing the yield performance of hybrids and conventional HYVs (inbred) grown by the same sample farmer, paired-t test was carried out to test the significance in the differences in yield between hybrids and HYVs since the same farmer grew both rice varieties under the same production environment. The pairing of the observations helped dissociate the effect of the

variation due to the agro-ecological difference of the farm and socio-economic characteristics of the farmer. Results of 'paired t' test show that the observed yield difference between hybrid and HYVs (inbred) is statistically significant at 5 per cent level of significance in both the years under study.

4.2 Yield Gain from Hybrid Rice over the Inbred Rice Varieties

The yield gain of hybrids over HYVs, is also presented in table-4.1. On an average the yield gain of hybrids over HYVs was 19.17 per cent in 2009-10. During 2010-11 it was about 22 per cent. Across farm sizes, smaller sized holdings obtained higher yield gain as compared to larger sized holdings in both the years under study. Thus based on farm level performance of hybrid rice over the period it is clearly indicative of the fact that hybrid rice technology has its higher yield potential under the production environments prevailing in West Bengal.

4.3 Factors Affecting the Yield of Hybrid and Inbred Rice:

Yield response function was estimated separately for hybrid and inbred rice varieties to determine the input factors affecting yield levels. Log linear models were fitted to identify the factors affecting the yield of two varieties of rice. The fitted model explained 75 per cent of the variation in yield in case of hybrid rice (table-4.2A).

Table 4.2A: Yield Response Function for Hybrid Rice – Log Linear Estimates

Variable	Regression Coefficient 'b'	Standard Error of 'b'	't' Ratios
Seed	-0.6225	0.5758	-1.0813
Manure	-0.0005	0.0018	-0.2589
Fertilizer	0.0464	0.0540	0.8591
Irrigation	-0.0237	0.0136	-1.7335
Human labour	0.0756	0.0746	1.0138
Machinery labour	0.3168	0.4571	0.6930
Plant protection chemicals	-0.0167	0.0101	-1.6500
Constant	3.0681*	1.0685	2.8715
R^2 0.7524			

Note: *Significant at 5 per cent level of significance

The estimated coefficients indicated that fertilizer, human labour and machinery labour influenced the yield levels in hybrid rice. Among them, the coefficient of human labour and machinery labour were of higher magnitude in case of hybrid rice indicating that the marginal efficiency of these two inputs was higher for hybrid rice. This implies that yields of hybrid rice respond more to these inputs. The positive coefficients for human labour and machinery labour

indicate that there is still scope for expanding the use of human and machinery labour in hybrid rice cultivation. The positive coefficient of fertilizer input indicated that higher the level of fertilizer use, higher the yield of hybrid rice. Obviously, the availability of fertilizer at a reasonable price will help in pushing up the yield levels and consequently the production of hybrid rice.

Table 4.2B: Yield Response Function for Inbred Rice – Log Linear Estimates (for Hybrid Adopters only)

Variable	Regression Coefficient 'b'	Standard Error of 'b'	't' Ratios
Seed	0.0139	0.1780	0.0779
Manure	0.0062*	0.0024	2.5416
Fertilizer	-0.0337	0.0839	-0.4014
Irrigation	-0.0147	0.0093	-1.5863
Human labour	0.0396	0.0745	0.5316
Machinery labour	-0.0638	0.0764	-0.8360
Plant protection chemicals/pesticides	0.0054	0.0050	1.0789
Constant	3.9430*	0.4151	9.4990
R^2 0.2015			

Note: *Significant at 5 per cent level of significance

Table 4.2C: Yield Response Function for Inbred Rice – Log Linear Estimates: (Hybrid Adopters and Non-Adopters Combined)

Variable	Regression Coefficient 'b'	Standard Error of 'b'	't' Ratios
Seed	0.0678	0.1584	0.4283
Manure	0.0043*	0.0019	2.2970
Fertilizer	-0.0060	0.0675	-0.0895
Irrigation	-0.0175	0.0074	-2.3623
Human labour	0.0298	0.0671	0.4443
Machinery labour	-0.0935	0.0677	-1.3818
Plant protection chemicals	0.0064	0.0046	1.3953
Constant	3.8809*	0.3442	11.2739
R^2 0.2299			

Note: *Significant at 5 per cent level of significance

Hybrid rice yield being human labour responsive, the availability of labour in the farm sector is an important determinant of hybrid rice adoption at the farm level. Owing to the greater availability of labour, smaller sized holdings gained more in terms of yield in case of hybrid rice cultivation as discussed in the preceding paragraphs. Further labour intensive character of hybrid technology is the major factor favouring its adoption on smaller sized holdings.

For inbred rice, the fitted model explained 22 per cent of the variation in yield (table 4.2C). The estimated coefficients indicated that seed and human labour influenced the yield levels to a great extent. This clearly shows that yield of HYVs rice respond more to these inputs. The positive coefficients of these inputs indicate that there exists scope to expand the use of these two inputs in inbred rice cultivation. Among positive coefficients, the coefficient of

manure turns out to be statistically significant both for hybrid adopters and non-adopters. This implied that greater use of manure would lead to increase in productivity of HYVs (inbred).

CHAPTER-V
Comparative Economics of Hybrid and Inbred Rice Cultivation

The adoption of a new technology in a market economy is basically an economic decision of the farmers. The present chapter thus aims to study the comparative economics of hybrid and inbred rice cultivation. More precisely the chapter examines the profitability of hybrid rice cultivation compared with inbred or conventional HYVs. Needless to say, the profitability of any technology is the ultimate factor that determines the long run sustainability of its adoption by farmers. The details of costs and returns for hybrids and HYVs are shown in the following paragraphs.

The product value and farm-operating surplus are the ultimate factors that would determine reallocation of rice land from the existing inbred to the new hybrid varieties. Three basic factors determine the relative profitability of a new variety/hybrid over the conventional one – yield gain, additional input cost and higher/lower market price. Average yield gain, input costs and market price of grain were taken into account to compute economic returns in hybrid and inbred rice cultivation. In analyzing costs and returns different cost concepts are usually used viz. cost A_1, cost A_2, cost B_1, cost B_2, cost C_1, cost C_2 and cost D. In the present study cost A_1 concept is used in arriving at net return per hectare. Cost refers to all actual expenses, in cash and kind, incurred in production by the operator. Cost items included seed (both farm produced and purchased), manure (owned and purchased), chemical fertilizer, insecticides/pesticides, irrigation cost (both owned and hired), machinery charges, hired human labour charges, bullock labour (owned and hired).

5.1 Input Use Pattern for Cultivation of Hybrid and HYV Rice

Table-5.1 summarizes the average amount of inputs used for the cultivation of hybrid and inbred rice. Input use pattern is furnished separately for hybrid and HYVs. Importantly seed rate (kg/ha) is significantly lower for the hybrid than for HYVs. This is because hybrids required only one or two seedlings per hill for transplanting. Seed rate for hybrids is 11.51 kg per hectare where as it is 68.57 kg per hectare for HYVs. In case of non-adopter more or less similar seed rate is used. Organic manure use for hybrids was nearly 5 times higher than that for HYVs. The use of chemical fertilizer is 14.38 per cent higher than that for HYVs. In comparison with non-adopters, it is higher by 5 per cent. The number of pesticides sprays is relatively lower for hybrid varieties than HYVs showing hybrids relatively less sensitive to pest attack. But irrigation is almost the same for the hybrid and the inbred varieties. Labour use is significantly higher for the

hybrid than for HYVs. Within the group of hybrid adopters the intensity of human labour use is about 168 days per hectare for hybrids as compared to 145 days per hectare for HYVs.

Table 5.1: Input Use Pattern of Cultivation of Hybrid and Inbred Rice (2010-11)

Inputs	Hybrid Adopters		Non-adopters
	Hybrid	HYVs	HYVs
Seed (kg/ha)	11.51	68.57	68.37
Manure (tonne/ha)	1.39	0.29	0.26
Chemical fertiliser (kg/ha)	347.82	304.09	330.82
Pesticide (no. of sprays)	2.26	3.14	2.68
Irrigation (no. of application)	4.39	3.90	3.95
Human labour (days/ha)	167.50	145.08	148.24
Bullock labour (days/ha)	4.29	2.68	3.20

Data source: Primary data

For non-adopters, it is 148 days for HYVs as against 168 days for hybrids as experienced by the adopters of hybrids. Bullock labour use in terms of days per hectare is significantly higher for hybrids than HYVs for the hybrid adopters those who cultivated HYVs along with hybrids. For non-adopters, bullock labour use for HYVs is marginally lower than that for hybrids.

5.2 Operation-wise Labour Absorption in Hybrid and HYV Rice

Farm level data revealed that farmers had to incur higher labour for hybrids as compared to HYVs. Higher labour use associated with hybrid cultivation as compared to HYVs was mainly for transplanting the seedlings of paddy since it involved a cumbersome method of planting one or two seedlings per hill unlike multiple seedlings per hill in inbred varieties. Operation-wise labour use pattern presented in table-5.2A indicated that labour requirement is highest in post harvesting operations followed by harvesting and transplantation operations respectively both in hybrids and HYVs.

However, more labour is used in transplantation operation for hybrids (34.84 days) as compared to HYVs (32.11 days). In addition for hybrid paddy, more labour is used for ploughing, spraying plant protection chemicals and for irrigation. More importantly, hybrid rice cultivation involves greater use of female labour in the transplantation operation including uprooting of seedlings in comparison with the cultivation of conventional varieties of HYVs or inbreeds (table-5.2B). Hybrid rice cultivation is thus likely to generate additional employment opportunities for female workers in rural areas. Further operations associated with higher labour content involved more of hired labour as compared to family labour both in case of hybrids and HYVs.

Table 5.2A: Operation-wise Human Labour Use in Hybrid and HYV Rice: 2010-11

(for hybrid adopters only)

Type of operation	Hybrid rice			HYV Rice		
	Family labour (days/ha)	Hired labour (days/ha)	Total labour (days/ha)	Family labour (days/ha)	Hired labour (days/ha)	Total labour (days/ha)
Ploughing	3.43	1.99	5.42	1.89	3.00	4.89
Uprooting of seedlings	12.34	5.61	17.95	7.12	14.72	21.83
Transplantation of seedlings						
a) Single seedlings per hill	21.67	13.17	34.84	0.00	0.00	0.00
b) Multiple seedlings per hill	0.00	0.00	0.00	9.23	22.89	32.11
Manu ring	1.47	1.33	2.80	1.63	0.91	2.54
Application of chemical fertilizer	2.23	2.10	4.33	2.54	1.94	4.48
Spraying plant protection chemicals	4.20	4.36	8.56	2.64	0.91	3.55
Irrigation	7.34	4.90	12.24	3.79	1.13	4.93
Harvesting	22.92	14.84	37.76	10.12	24.96	34.96
Post-harvesting	24.98	18.62	43.61	14.12	21.40	35.51
All operations	100.58	66.92	167.50	53.25	91.83	145.08

Data source: Primary data

Table 5.2B: Female Labour Use per hectare (2010-11)

(for hybrid adopters only)

Type of operation	Hybrid rice			HYV Rice		
	Female labour (days/ha)	Total labour (days/ha)	Percent of female labour days used	Female labour (days/ha)	Total labour (days/ha)	Percent of female labour days used
Ploughing	0.00	5.48	0.00	0.00	4.50	0.00
Uprooting of seedlings	15.35	17.48	87.78	10.30	19.05	54.09
Transplantation of seedlings						
a) Single seedlings per hill	19.15	35.78	53.53	14.93	31.74	47.02
b) Multiple seedlings per hill	0.00	0.00	0.00	0.00	0.00	0.00
Manu ring	0.00	3.01	0.00	0.00	3.14	0.00
Application of chemical fertilizer	0.00	4.39	0.00	0.00	4.23	0.00
Spraying plant protection chemicals	0.00	10.37	0.00	0.00	9.93	0.00
Irrigation	2.49	14.61	17.02	0.00	13.78	0.00
Harvesting	11.46	38.62	29.68	14.54	39.31	36.99
Post-harvesting	4.53	46.10	9.82	5.25	46.29	11.34
All operations	52.97	175.84	30.13	45.02	171.97	26.18

Data source: Primary data

5.3 Cost of Inputs Incurred on Hybrid and HYVs of Rice

During 2010-11 the average cost of production of hybrid rice worked out at Rs.28,887.40 per hectare while for inbred rice (HYVs) it was Rs.23,549.66 (table-5.3B). Among the components of total cost, expenditure on human labour formed the single largest item and accounted for 39.38 per cent and 46.82 per cent of the total cost for hybrid and inbred varieties respectively. Machinery charges accounted for the next most important item at about 16-17 per cent of the total cost in hybrid and HYVs respectively. The cost incurred on fertilizer was the

next one which formed about 13 per cent of total cost for both hybrids and HYVs. Manure and fertilizer together formed about 19 per cent of the total cost in case of hybrids as against 17 per cent for HYVs. The cost of irrigation, seeds and pesticides were significantly higher in hybrid rice production. Cost of irrigation was 12.49 per cent of total cost in hybrid rice while it was 9.33 per cent for inbred (HYVs) rice. The seed accounted for 5.90 per cent of total cost for HYVs while it was 7.18 per cent of total cost for hybrids. Pesticide use was significantly higher for hybrid rice. It was about 2.05 per cent and 1.07 per cent of the total cost for hybrid and inbred rice respectively. Pesticide use was significant for hybrid rice implying that hybrid rice varieties did not possess adequate resistance to pest and diseases and are more susceptible pests and diseases.

Evidently thus as recorded in 2010-11, the total cost of inputs was about 22.66 per cent higher for hybrids than for HYVs (table-5.3B). The largest difference in cost items between the hybrids and the inbreds was on account of seeds, pesticides and irrigation charges. The total seed cost for hybrid varieties was 1.50 times that for HYVs. This was due to the large difference in seed prices of hybrid and inbred rice although the seed rate for the hybrids were substantially lower (about 6 times). The cost of hybrid seed per kg being much higher than that of HYV seeds of rice, discourages farmers from taking advantage of the hybrid technology unless it is compensated by additional yield gains. Notably the cost structure does not vary much over the years under study.

Table 5.3A: Comparison of Costs and Returns for Hybrid and Inbred Rice (2009-10)

(Rs./ha)

Sl. No.	Particulars	Hybrid Adopters		Non-adopters
		Hybrid	HYVs	HYVs
A.	Costs:			
1.	Seed (both farm produced and purchased)	1766.33 (6.14)	1000.78 (4.26)	1013.60 (4.31)
2.	Manure (owned and purchased)	2950.13 (10.25)	1714.82 (7.31)	1411.01 (6.01)
3.	Chemical fertilisers	2924.54 (10.16)	2751.85 (11.71)	2875.94 (12.24)
4.	Insecticides & Pesticides	499.12 (1.73)	409.87 (1.74)	425.84 (1.81)
5.	Irrigation charges (both owned and hired)	5285.08 (18.37)	3052.34 (12.99)	3690.34 (15.71)
6.	Machinery charges	4315.98 (15.00)	3805.04 (16.20)	3795.22 (16.15)
7.	Hired human labour charges	10242.72 (35.60)	10161.97 (43.25)	9665.17 (41.14)
8.	Bullock labour (owned and hired)	789.06 (2.75)	596.53 (2.54)	616.85 (2.63)
9.	Total cost (1 to 8)	28772.95 (100.00)	23493.20 (100.00)	23493.98 (100.00)
10.	Unit cost of production (Rs. Per Kg.)	4.49	4.37	4.36
B.	Returns:			
1.	Yield of paddy (qtl/ha)	64.09	53.78	53.90
2.	Market price (Rs./qtl)	912.10	941.23	932.56
3.	Value of grain yield (Rs./ha)	58452.18	50615.67	50261.18
4.	Value of straw yield (qtl/ha)	5862.07	11260.03	10855.04
5.	Total value of the produce (gross return)	64314.25	61875.70	61116.23
6.	Net return (5 – 9)	35549.76	38383.69	37618.73
7.	Benefit cost ratio:	**2.24 : 1**	**2.63 : 1**	**2.60:1**

Data source: Primary data

Table 5.3B: Comparison of Costs and Returns for Hybrid and Inbred Rice (2010-11)

(Rs./ha)

Sl. No.	Particulars	Hybrid Adopters		Non-adopters
		Hybrid	HYVs	HYVs
A.	Costs:			
1.	Seed (both farm produced and purchased)	2073.24 (7.18)	1389.99 (5.90)	1367.73 (5.83)
2.	Manure (owned and purchased)	1866.67 (6.46)	835.10 (3.55)	757.71 (3.23)
3.	Chemical fertilisers	3795.90 (13.14)	3148.61 (13.37)	3186.18 (13.58)
4.	Insecticides & Pesticides	591.99 (2.05)	252.18 (1.07)	282.33 (1.20)
5.	Irrigation charges (both owned and hired)	3608.33 (12.49)	2198.05 (9.33)	2672.00 (11.39)
6.	Machinery charges	4727.56 (16.37)	4163.95 (17.68)	4128.11 (17.61)
7.	Hired human labour charges	11378.21 (39.38)	11025.53 (46.82)	10419.93 (44.43)
8.	Bullock labour (owned and hired)	845.51 (2.93)	536.23 (2.28)	640.57 (2.73)
9.	Total cost (1 to 8)	28887.40 (100.00)	23549.66 (100.00)	23454.57 (100.00)
10.	Unit cost of production (Rs. Per Kg.)	4.41	4.41	4.38
B.	Returns:			
1.	Yield of paddy (qtl/ha)	65.51	53.41	53.55
2.	Market price (Rs./qtl)	931.01	939.46	936.39
3.	Value of grain yield (Rs./ha)	60993.24	50175.30	50139.94
4.	Value of straw yield (qtl/ha)	6590.27	11152.02	10930.50
5.	Total value of the produce (gross return)	67583.51	61327.32	61070.45
6.	Net return (5 – 9)	38696.10	37776.32	37621.44
7.	Benefit cost ratio:	**2.34 : 1**	**2.60 : 1**	**2.60 : 1**

Data source: Primary data

5.4 Economic Returns to Hybrid and Inbred Rice Cultivation

The net returns or profitability of any technology is the ultimate factor that determines the long run sustainability of its adoption by the farmers. The details of the costs and returns for hybrids and HYVs are shown in table-5.3A and 5.3B for the two consecutive years viz. 2009-10 and 2010-11 respectively. During the year 2010-11 the farmers growing hybrid rice realised a gross return of Rs.67,583.51 per hectare while the gross return realised in inbred varieties was Rs.61,327.32. Thus the gross return was 10.20 per cent higher in hybrid rice cultivation. However the profit (net return) realised in hybrid rice and inbred rice was of the order of Rs.38,696.10 and 37,776.32 per hectare respectively. Thus the profit gain realised in hybrid rice production was only Rs.919.78 per hectare or 2.43 per cent over inbred varieties of rice. Consequently the benefit cost ratio was also lower in hybrid rice cultivation (2.34:1) in comparison with that for inbred rice (2.60 : 1). Inter-temporarily net return from hybrids over the reference periods has increased from Rs.35,549.76 per hectare in 2009-10 to Rs.38,696.10 per hectare in 2010-11. Correspondingly for inbred rice, the net return decreased from Rs.38,383.69 per hectare to Rs.37,776.32 during the same period. The net result has been increase in benefit cost ratio for hybrid rice cultivation from 2.24: 1 in 2009-10 to 2.34 : 1 in 2010-11. Correspondingly, there has been decline in benefit cost ratio from 2.63 : 1 to 2.60 : 1 during the same period.

What are the factors that accounted for the lower profit margin in case of hybrid rice cultivation? Of course the lower profit margin in hybrid rice cultivation is a matter of concern since the adoption of a new technology depends much on profitability. As can be seen from table 5.3B, hybrid rice growers incurred additional costs for all the inputs. Hybrid rice growers incurred an additional expenditure of Rs.683.25 per hectare on seed alone. Similarly hybrid growers incurred higher expenditure on labour (Rs.352.68) per hectare for performing various cultural operations. More expenditure on fertilizer (Rs.647.29), irrigation (Rs.1410.28) and pesticides (Rs.339.81) also contributed to pushing up the cost of production of hybrid rice. Coupled with higher production cost was low market price realisation for hybrid paddy. On an average, during the year 2010-11 the hybrid rice growing farmers realised a sale price of Rs.931.01 per quintal of paddy sold in the market which was lesser by Rs.8.45 per quintal realised for inbred rice. The product price difference was quite sharp during 2009-10 and during the year, price per quintal of hybrid paddy was lesser by Rs.29.13 compared with inbred rice. During the year 2010-11, hybrid rice was more profitable by Rs.919.78 per ha (2.43 per cent) than HYVs, while in 2009-10, the net return (profit) realized in hybrid rice cultivation was lower by Rs. 2833.93 per hectare as compared to HYVs.

Higher costs of production along with lower market price realization have contributed to lower profit margin of hybrid rice cultivation as compared to HYVs even with higher grain yield gain of 22.66 per cent for hybrid rice over inbred rice varieties. This calls for improvement in technology to reduce costs of cultivation and enhancing the quality attributes of hybrid rice.

CHAPTER-VI
Grain Quality Considerations and the Aspect of Marketing

Rice is used almost exclusively as a food item. Cooking and eating quality traits therefore assume special significance. For consumer acceptance, it is essential that the hybrids developed possess good quality characteristics apart from high yield potential. Preferences for quality vary from region to region. Best quality type of one region may not be liked at all by another region. Therefore breeding for better quality hybrids depending upon the local requirement assumes added significance. Acceptance of hybrids by consumers is primarily determined by cooking and eating quality characteristics. The price for volume of marketing for farmer's produce is also determined by quality traits. The present chapter therefore deals with grain quality consideration of hybrid rice vis-à-vis conventional HYVs and also studies the different aspects of marketing including output and sale of paddy, both husked and unhusked and seasonal flow of marketing.

6.1 Grain Quality Traits of Hybrid and HYV Rice

A frequently raised concern on the prospects of large-scale adoption of hybrid rice is the acceptability of the quality of hybrid rice grain among consumers. Consumer acceptance is the ultimate factor that determines the price of the product and the marketability of the product which ultimately affects the gross revenues particularly for those who sell the product in the market. The role of consumer acceptance assumes much significance where rice farming is highly commercialised and considered a market-oriented farm enterprise. An important criterion for farmers in selecting a seed variety of rice is consumer demand in the market and their willingness to pay a premium price for the product. Hence quality considerations are of paramount importance for the popularization and large-scale adoption of hybrid rice. We had collected information from the farmers regarding the grain quality characteristics of hybrid rice vis-à-vis the popular inbred varieties. Which are documented in the following paragraphs?

The mechanical processing of the rice grain usually comprises two steps. First the hull is removed from the grain to obtain brown rice which is the least processed edible form of rice. The rice grain is usually further processed by additionally removing the bran layer to obtain milled rice. This is done in commercial milling due to consumers' preferences. The predominant form of rice found on today's markets is milled rice. During the process there occurs a good deal of broken rice. Thus high turnout of whole grain (head) i.e. head rice recovery is an important consideration from the view point of quality of rice. A hybrid should possess a good turnout of

whole grain i.e. head rice and also total milled rice for the popularization of hybrid rice at the farmers' level. In the following analyses grain quality traits of hybrid rice vis-à-vis conventional inbreds of rice are presented.

The quality of grain is judged from the view point of three ratios viz. hulling ratio, milling ratio and head rice recovery ratio. Grain quality features of hybrids vis-à-vis HYVs are furnished in tables 6.1A and 6.1B for the two consecutive years viz. 2009-10 and 2010-11 respectively. It is evident that hybrids have grain quality features by and large on par with those of varieties of conventional HYVs. Hybrids have milling and head rice recovery ratios of 61 per cent and 54 per cent respectively. The corresponding figures for HYVs were estimated at 61 per cent and 55 per cent respectively. Over the years under study, the ratios remained unaltered. All these suggest that the parameters that primarily influence the adoption of hybrid rice cultivation are almost same across hybrid and inbred varieties of rice.

Table 6.1A: Grain quality traits of Hybrid rice vis-a-vis HYVs 2009-2010

Grain quality traits	Adopters		Non-Adopters
	Hybrid	HYVs	HYVs
Hulling ratio	-	-	-
Milling ratio	60.71	61.36	61.55
Head rice recovery ratio	54.57	55.41	56.00

Data source: Primary data

Table 6.1B: Grain quality traits of Hybrid rice vis-a-vis HYVs 2010-2011

Grain quality traits	Adopters		Non-Adopters
	Hybrid	HYVs	HYVs
Hulling ratio	-	-	-
Milling ratio	60.56	61.20	61.65
Head rice recovery ratio	54.26	55.51	55.85

Data source: Primary data

6.2 The Volume of Marketing

The growth and development of an economy is always associated with an increase in the volume of marketed output in the agricultural sector. It is thus necessary to look into the quantum of marketing of the produce in the market. In the context of the 'lingering' nature of hybrid rice spread in our country, one major concern being raised is; Is hybrid rice grain acceptable to traders and millers? The answer to this question would largely be met by examining the volume of marketing of the hybrid rice produce vis-a-vis those of inbred varieties. On the farmer-producers' side, volume of marketing would indicate their motivation towards

Table 6.2A: Output and sale of paddy (un husked) by size groups of land holdings (2009-10)

Size group (Ha)	Crop	Hybrid Adopters				Hybrid Non-adopters			
		Output quantity (qtl) per farm	Sale quantity (qtl) per farm	% of Output sold	Average price received (Rs per Qtl.)	Output quantity (qtl) per farm	Sale quantity (qtl) per farm	% of Output sold	Average price received
Below 1ha	Hybrid	6.95 (60)	4.94 (60)	71.14	890.46	-	-	-	-
	HYVs	25.71 (60)	14.48 (60)	56.33	873.60	35.88 (16)	22.43 (16)	62.53	860.77
1 – 2	Hybrid	12.45 (16)	9.75 (16)	78.31	855.26	-	-	-	-
	HYVs	77.04 (16)	59.99 (16)	77.87	880.90	70.73 (03)	54.89 (03)	77.61	883.17
2 – 4	Hybrid	27.58 (04)	23.50 (04)	85.22	846.81	-	-	-	-
	HYVs	188.58 (04)	159.65 (04)	84.66	893.65	173.00 (01)	162.44 (01)	93.90	920.00
4 – 10	Hybrid	-	-	-	-	-	-	-	-
	HYVs	-	-	-	-	-	-	-	-
10 ha and above	Hybrid	-	-	-	-	-	-	-	-
	HYVs	-	-	-	-	-	-	-	-
All Sizes	Hybrid	9.08 (80)	6.83 (80)	75.24	872.90	-	-	-	-
	HYVs	44.12 (80)	30.84 (80)	69.91	881.63	47.96 (20)	34.30 (20)	71.52	880.17

Data source: Primary data

Note: Figures in brackets indicate number of farms

Table 6.2B: Output and sale of paddy (un husked) by size groups of land holdings (2010-11)

Size group (Ha)	Crop	Hybrid Adopters				Hybrid Non-adopters			
		Output quantity (qtl) per farm	Sale quantity (qtl) per farm	% of Output sold	Average price received(Rs per Qtl.)	Output quantity (qtl) per farm	Sale quantity (qtl) per farm	% of Output sold	Average price received
Below 1ha	Hybrid	10.13 (60)	7.59 (60)	74.93	887.84	-	-	-	-
	HYVs	23.63 (60)	12.43 (60)	52.61	857.98	34.69 (16)	20.78 (16)	59.89	865.34
1 – 2	Hybrid	17.65 (16)	14.19 (16)	80.38	839.07	-	-	-	-
	HYVs	65.14 (16)	48.76 (16)	74.86	846.14	66.33 (03)	50.49 (03)	76.12	875.71
2 – 4	Hybrid	32.95 (04)	31.13 (04)	94.46	820.36	-	-	-	-
	HYVs	164.25 (04)	133.08 (04)	81.02	867.87	149.00 (01)	138.44 (01)	92.91	910.00
4 – 10	Hybrid	-	-	-	-	-	-	-	-
	HYVs	-	-	-	-	-	-	-	-
10 ha and above	Hybrid	-	-	-	-	-	-	-	-
	HYVs	-	-	-	-	-	-	-	-
All Sizes	Hybrid	12.78 (80)	10.09 (80)	78.95	863.71	-	-	-	-
	HYVs	38.97 (80)	25.73 (80)	66.04	856.05	45.15 (20)	31.12 (20)	68.92	877.80

Data source: Primary data

Note: Figures in brackets indicate number of farms

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Table 6.2C: Output and sale of paddy (Husked) by size groups of land holdings (2009-10)

Size group (Ha)	Crop	Hybrid Adopters				Hybrid Non-adopters			
		Output quantity (qtl) per farm	Sale quantity (qtl) per farm	% of Output sold	Average price received(Rs per Qtl.)	Output quantity (qtl) per farm	Sale quantity (qtl) per farm	% of Output sold	Average price received
Below 1ha	Hybrid	4.22 (60)	0.19 (60)	4.49	1473.92	-	-	-	-
	HYVs	15.71 (60)	0.70 (60)	4.46	1520.95	22.06 (16)	1.19 (16)	5.38	1510.00
1 – 2	Hybrid	7.54 (16)	0.16 (16)	2.07	1350.00	-	-	-	-
	HYVs	47.27 (16)	0.13 (16)	0.26	1520.00	43.63 (03)	0.00 (03)	0.00	0.00
2 – 4	Hybrid	16.64 (04)	1.00 (04)	6.01	1400.00	-	-	-	-
	HYVs	117.87 (04)	0.00 (04)	0.00	0.00	110.72 (01)	0.00 (01)	0.00	0.00
4 – 10	Hybrid	-	-	-	-	-	-	-	-
	HYVs	-	-	-	-	-	-	-	-
10 ha and above	Hybrid	-	-	-	-	-	-	-	-
	HYVs	-	-	-	-	-	-	-	-
All Sizes	Hybrid	5.50 (80)	0.22 (80)	4.06	1440.00	-	-	-	-
	HYVs	27.13 (80)	0.55 (80)	2.03	1520.91	29.73 (20)	0.95 (20)	3.20	1510.00

Data source: Primary data
Note: Figures in brackets indicate number of farms

Table 6.2D: Output and sale of paddy (Husked) by size groups of land holdings (2010-11)

Size group (Ha)	Crop	Hybrid Adopters				Hybrid Non-adopters			
		Output quantity (qtl) per farm	Sale quantity (qtl) per farm	% of Output sold	Average price received (Rs per Qtl.)	Output quantity (qtl) per farm	Sale quantity (qtl) per farm	% of Output sold	Average price received
Below 1ha	Hybrid	6.11 (60)	0.35 (60)	5.73	1587.38	-	-	-	-
	HYVs	14.42 (60)	0.79 (60)	5.49	1590.00	21.51 (16)	1.44 (16)	6.68	1664.13
1 – 2	Hybrid	10.73 (16)	0.50 (16)	4.66	1568.75	-	-	-	-
	HYVs	40.14 (16)	0.38 (16)	0.93	1650.00	40.64 (03)	0.00 (03)	0.00	0.00
2 – 4	Hybrid	20.31 (04)	0.00 (04)	0.00	0.00	-	-	-	-
	HYVs	100.43 (04)	0.00 (04)	0.00	0.00	93.87 (01)	0.00 (01)	0.00	0.00
4 – 10	Hybrid	-	-	-	-	-	-	-	-
	HYVs	-	-	-	-	-	-	-	-
10 ha and above	Hybrid	-	-	-	-	-	-	-	-
	HYVs	-	-	-	-	-	-	-	-
All Sizes	Hybrid	7.74 (80)	0.36 (80)	4.68	1582.24	-	-	-	-
	HYVs	23.87 (80)	0.67 (80)	2.80	1596.73	27.99 (20)	1.15 (20)	4.11	1664.13

Data source: Primary data
Note: Figures in brackets indicate number of farms

Table 6.3A: Seasonal flow of marketing (sales) of paddy (un husked) (2009-10)

(Sales quantity in qtl.)

Month	Adopters		Non-Adopters
	Hybrid	HYVs	HYVs
January	45.72 (8.37)	231.32 (9.38)	44.26 (6.45)
February	60.96 (11.16)	231.32 (9.38)	33.19 (4.84)
March	6.53 (1.20)	33.05 (1.34)	11.06 (1.61)
April	8.71 (1.59)	66.09 (2.68)	11.06 (1.61)
May	43.55 (7.97)	198.27 (8.04)	55.32 (8.06)
June	45.72 (8.37)	231.32 (9.38)	77.45 (11.29)
July	52.25 (9.56)	253.35 (10.27)	88.52 (12.90)
August	10.89 (1.99)	55.08 (2.23)	22.13 (3.23)
September	47.90 (8.76)	220.30 (8.93)	55.32 (8.06)
October	69.67 (12.75)	319.44 (12.95)	99.58 (14.52)
November	106.69 (19.52)	473.65 (19.20)	143.84 (20.97)
December	47.90 (8.76)	154.21 (6.25)	44.26 (6.45)

Data source: Primary data

Note: Figures in brackets indicate percentages of total sales

Table 6.3B: Seasonal flow of marketing (sales) of paddy (un husked) (2010-11)

(Sales quantity in qtl.)

Month	Adopters		Non-Adopters
	Hybrid	HYVs	HYVs
January	80.52 (9.98)	218.53 (10.61)	53.62 (8.62)
February	87.84 (10.88)	242.81 (11.79)	32.17 (5.17)
March	3.66 (0.45)	9.71 (0.47)	10.72 (1.72)
April	5.49 (0.68)	24.28 (1.18)	21.45 (3.45)
May	76.86 (9.52)	184.53 (8.96)	42.90 (6.90)
June	38.43 (4.76)	106.83 (5.19)	10.72 (1.72)
July	87.84 (10.88)	218.53 (10.61)	107.24 (17.24)
August	9.15 (1.13)	14.57 (0.71)	10.72 (1.72)
September	75.03 (9.30)	174.82 (8.49)	64.34 (10.34)
October	113.46 (14.06)	291.37 (14.15)	96.52 (15.52)
November	151.88 (18.82)	378.78 (18.40)	96.52 (15.52)
December	76.86 (9.52)	194.25 (9.43)	75.07 (12.07)

Data source: Primary data

Note: Figures in brackets indicate percentages of total sales

adopting hybrid rice cultivation. Table 6.2 (A&B) gives statistics of the output of the unhusked hybrid and inbred (HYVs) rice crop and the quantity sold in the market across size classes of operational land holdings during the years 2009-10 and 2010-11.

The usual notion is larger the volume of the produce is, larger is the output marketed, Increase in receipt increases marketable surplus and stimulate increase in actual marketing. Evidently for hybrid rice, volume of output sold is higher in comparison with the receipt of paddy per farm.

While, the percentage of paddy output sold was 75.24 per cent in the case of hybrid rice, it was 69.91 per cent for conventional HYVs during the year 2009-10 (table 6.2A). Similar is the phenomenon observed in 2010-11 (table 6.2B). Across size classes of land holdings, the proportion of output sold increases unmistakably with increase in the size of holdings. During the year 2009-10, in the case of hybrid rice, the proportion of output sold rose from 71.14 per cent in the group below 1 ha to 85.22 per cent in the group 2-4 hectares. During the year 2010-11, proportion of output sold increased from 74.93 in below 1 ha group to 94.46 per cent in the size group 2-4 hectares. The same tendency is noticeable in the case of HYV rice for the years under study where proportions of output sold is consistently on the rise with the increase in the size of holdings.

In case of hybrid non-adopters, of the total output, 71.52 per cent was sold during the year 2009-10 which, however fell to 68.92 per cent in 2010-11. Across size classes of land holdings, the proportion of output sold increased with the increase in the size of holding.

The price fetched in the market for hybrid paddy grain was lower as compared to inbred varieties of rice during the year 2009-10. However, during the year 2010-11 hybrid rice received somewhat higher price in comparison with inbred varieties of rice. On an average, during the year 2009-10 the hybrid rice farmers realised a sale price that was Rs.872.90 per quintal of paddy sold in the market as against Rs.881.63 per quintal for HYVs. During 2010-11 price fetched by the farmers was relatively lower both for hybrid and inbred rice with a marginally higher market price realization for hybrid paddy (Rs.863.71) as compared to HYVs (Rs.856.05).

In case of sales of husked paddy (table 6.2C), of the total outturn of hybrid rice, only 4.06 per cent was sold in the market during the year 2009-10. The corresponding proportion of output of husked paddy sold in the market was estimated at 2.03 per cent for HYVs. Similarly for hybrid non-adopters the comparable figure was 3.20 per cent. What follows therefore is that processed paddy is marginally sold in the market.

Size-group wise analysis shows that in case of hybrid rice, bigger sized holdings sold relatively higher proportion of outturn of rice as compared to smaller sized holdings. With regard

to price received for milled rice, it is found that on an average hybrid adopters realized a sale price of Rs.1440 per quintal for hybrid rice against the corresponding sale price of Rs.1520.91 for HYVs. Thus during the year 2009-10 hybrid adopting farmers realized a sale price of hybrid rice that was Rs.80.91 (5.62 per cent) lesser per quintal of rice sold in the market compared with inbred rice.

During the year 2010-11 (table 6.2D), the proportion of outturn of rice sold in the market accounted for 4.68 per cent, in case of hybrid rice which was marginally (0.62 per cent) higher than what it was in 2009-10. For HYVs the corresponding proportion accounted for 2.80 per cent which is again marginally higher by 0.77 per cent as compared to the previous year 2009-10. On an average, in case of hybrids, a greater proportion of milled rice is marketed as compared to HYVs. Hybrid rice adopters received market price of Rs.1582.24 which is lesser by Rs.14.49 per quintal of rice sold in the market as compared to inbred rice. On a closer scrutiny of the figures, it appears that the proportion of milled rice sold in the market bears a fairly stable inverse relationship with the

size of holdings both in the case of hybrids and HYVs. The relationship holds similar to the one observed in the previous year 2009-10. It is thus possible to infer the inverse relationship between the size of holdings and the proportion of rice output sold.

6.3 Seasonal Flow of Marketing

Agricultural produce usually fetches lower price if sold just after the harvest and a higher price if sold during the lean period. Thus the account of sales will be incomplete without a picture of the seasonal flow of marketing. Month-wise flow of marketing of paddy (un-husked) for the years 2009-10 and 2010-11 presented in tables 6.3A and 6.3B respectively revealed that hybrid adopters sold relatively greater proportion of paddy output immediately after the harvest in the months of October and November, although the marketing was spread over the months. This is discernible both in the case of hybrids and HYVs, which indicated that immediate cash needs compelled them to sell immediately after the harvest. During the year 2009-10, across months, the proportion of sales in the months of October and November ranged between 12.75 and 19.52 per cent for hybrid paddy. Almost similar proportion of sales occurred in the months of October and November in the case of HYV paddy. For non-adopters, the corresponding proportion of sales of paddy accounted for 14.52 per cent and 20.97 per cent respectively. During the year 2010-11, in case of hybrid adopters, 14.06 per cent and 18.82 per cent of total annual sales of hybrid paddy occurred in the months of October and November as against the

corresponding proportions of 14.15 per cent and 18.40 per cent respectively for HYVs. The proportion of sales took place in each of these two months for non-adopters accounted for 15.52 per cent of total annual sales. The proportion of sales in the lean months viz. during March, April and August was rather small in case of hybrids and HYVs during both the reference years. This is indicative of the fact that sample farmers (both hybrid adopters and non-adopters) have not been able to take advantage of the high prices ruling at this time of the year. In contrast, greater proportion of sales in the months of October and November was mainly effected by the small sized landholders who compelled to sell their produce to meet their bare requirements.

CHAPTER-VII
Problems and Prospects for increasing hybrid rice cultivation

To assess farmers' own perceptions regarding their experience with hybrid rice cultivation, farmers' level responses were collected from the sample hybrid growers through personnel interviews with the help of a structured questionnaire. Farmers' awareness about hybrid rice technology, farmers' access to inputs including credit, perception of farmers on hybrid rice cultivation, problems faced by the farmers in marketing were obtained. Reaction of non-participants with regard to reasons for non-adoption of hybrid rice cultivation was also ascertained through administering a structured questionnaire. Here in this chapter, based on the responses received from the participants and non-participants, attempt has been made to elicit the response of farmers regarding the overall perception about hybrid rice cultivation.

7.1 Farmers' awareness about hybrid rice technology

With regard to hybrid adopters' awareness about hybrid rice technology, the qualitative questions asked to sample hybrid growers included the source of knowledge about hybrid rice technology, whether frontline demonstration programme were organized whether the government organized, training programe, whether farmers had participated in the programmes etc. The answers to these questions are documented in table 7.1.

Table 7.1: Questions related to Hybrid Adopters' Awareness about Hybrid Rice Technology

Sl. No.	Particulars	Answers	% of farmers reporting
1.	How has he become aware about hybrid rice technology?	1. Source – Govt. Ext. Worker 2.Source – News paper 3.Source- Other cultivators	71.25 10.00 18.75
2.	If yes have you participated in the programme?	Yes No	70.00 30.00
3.	Whether front line demonstration programme is organized in your area by the Government to create awareness about the hybrid rice technology?	Yes No	65.00 35.00
4.	Name the hybrids demonstrated and indicate the extent of yield advantage as demonstrated.	Hybrid –1 KRH-II,Yield advantage over HYV(80%) Hybrid –2 DRRS-II,Yield advantage over HYV(70%) Hybrid –3PAC – 835, Yield advantage over HYV(65%)	44.00 38.00 36.00
5.	Whether the government organised training programmes for farmers?	Yes No	100.00 0.00
6.	If yes, had he participated?	Yes No	73.75 26.25
7.	If participated mention the number of training programmes participated and their duration.	Trainings participated Duration : one day : two days	 83.00 17.00

Data source: Primary data

When asked how has he become aware about hybrid rice technology, 71.25 percent of the sample farmers reported extension worker of the state department of agriculture as their source of awareness about the hybrid rice technology. The other sources were reported to be news paper (10.00 percent) and cultivators (18.75 percent). When asked whether front line demonstration programme was conducted in the area, majority of the respondents (65 percent) reported that frontline demonstration programme was organized by the government in order to create awareness about hybrid rice technology. With regard to their participation in the demonstration programme, 70 per cent of the farmers reported affirmative. Rice hybrids, demonstrated for the popularization hybrid rice cultivation included KRH – II (as reported by 44 per cent) having yield advantage of 80 per cent over HYVs, DRRS-II (38 per cent) with 70 percent yield advantage and PAC-835 (36 per cent) with 65 percent yield advantage.

Asked whether the government organized training programme for the farmers, cent percent of the farmers held the view that training programme was organized by the government and of them 73.75 per cent reported their participation in the training programme, majority of those being one day duration.

7.2 Problems faced by the farmers in input accessibility, production and marketing

Easy availability of seeds of reasonable prices in right time is one of the pre conditions for the promotion of new variety of technology in any crop. Thus regarding accessibility to hybrid seed input, information were asked from the farmers regarding sources of seed, quality of seed, yield gain from hybrid seed and replacement of seed over the years. One of the easily available policy options on the part of government to promote hybrid rice cultivation is subsidizing the seed supply at the initial stage of adoption. Thus when asked what is the usual source of seed for the farmers a total of 77.50 percent of farmers reported government supply as source of seed (table 7.2A). However, seeds available during planting time were reported only by 41.25 per cent of farmers. Importantly seeds were not available at reasonable price. It was only 8.75 per cent of farmers who reported availability of seeds at reasonable price. As far as quality of seeds is concerned, a total of 48.75 per cent of farmers reported to be satisfied with the quality of seeds. Asked whether hybrid seed is easily available in the area, only 36.25 percent of farmers reported affirmative and from the rest 63.75 per cent of farmers, negative responses were received. In response to the question related to yield superiority of hybrid rice over conventional HYVs, hybrid adopters unanimously (100.00 per cent) reported that hybrid seed yields better results than the inbred seeds. A total of 11.25 percent of respondent farmers reported yield gain of 10 – 15 percent over conventional inbred varieties. Yield gain of 15 – 20 percent in hybrid

rice production was reported by 43.75 per cent of farmers. Yield realized in hybrid rice higher by 20 percent and above as compared to inbred (HYV) rice was reported by 45.00 percent of farmers. The adoption of hybrid seeds prevented traditional practice of saving and exchanging of seeds. When asked how often did they replace hybrid seed varieties, 80 percent of the hybrid adopters indicated that they are replacing seeds every year while the rest 20 percent reported replacing seeds every alternative year.

We may thus infer from the above analyses that the higher yield potential of hybrid rice is clearly demonstrated in farmers' fields. This technology has good potential to increase rice yield provided quality seeds are made available at reasonable prices in right time. Although, government is the major source of supply of seed, poor germination of seed makes seeds costlier resulting in enhancement of cost of cultivation. Higher seed cost in turn reduces the profitability of hybrid rice cultivation. Thus the availability of quality hybrid seed at reasonable price is crucial to the success of hybrid rice technology. For the popularization of hybrids there is a case for government sector intervention in quality seed production and distribution.

Table 7.2A: Questions related to Hybrid Adopting Farmers' access to Hybrid Seed input

Sl. No.	Particulars	Answers	% of farmers reporting
1.	Have you used hybrid seed?	Yes No	100.00 0.00
2.	If yes, why used -	Reason 1 Higher yield Reason 2 Free supply of hybrid seed	100.00 100.00
3.	Is the hybrid seed easily available?	Yes No	36.25 63.75
4.	What is the usual source of your seeds?	Source 1 Govt. supply Source 2 Pvt. supply	77.50 22.50
5.	Is the quality hybrid seeds available in your area?	Yes No	45.00 55.00
6.	If yes, do you get seeds (a) during planting time and (b) at a reasonable price	Available during planting time Available at reasonable price	41.25 8.75
7.	Are you satisfied with quality of seed?	Yes No	48.75 51.25
8.	If no, reasons there for (poor germination etc.)	Reason 1 Poor germination Reason 2	100.00 0.00
9.	Are you convinced that hybrid seed yield better results than the inbred seeds?	Yes No	100.00 0.00
10.	If yes, indicate the percentage of yield increase.	5-10% 10-15% 15-20% 20% & Above	0.00 11.25 43.75 45.00
11.	If Hybrid seeds bring lesser yields, indicate the percentage of yield loss due to hybrid rice.	5-10% 10-15% 15-20%	0.00 0.00 0.00
12.	Do you purchase new seeds of hybrid varieties every crop season/year?	Yes No	100.00 0.00
13.	Do you feel that adoption of hybrid seeds prevented traditional practice of saving and exchanging of seeds?	Yes No	100.00 0.00
14.	How often do you replace hybrid seed varieties?	replacing every year replacing every alternative year replacing every 3 years replacing after 3 years or more	80.00 20.00 0.00 0.00

Data source: Primary data

The questions related to hybrid adopters' access to fertilizer input and its use are documented in table 7.2B . All the sample hybrid adopters unanimously reported that they have used fertilizer input in hybrid rice cultivation. Asked whether they have received information from any source regarding what to use and the required doses, a good majority of the farmers (87.50 percent) reported affirmative. A good proportion (84.15 percent) of sample farmers also reported to have used fertilizer input in recommended doses. Of the sample farmers those who

Table 7.2B: Questions related to Hybrid Adopting Farmers access to Fertiliser input and its use

Sl. No.	Particulars	Answers	% of farmers reporting
1.	Have you used chemical fertilizer?	Yes No	100.00 0.00
2.	Whether received information from any source regarding what to use and the required doses?	Yes No	87.50 12.50
3.	If yes, have you applied recommended doses of fertilizer?	Yes No	84.15 15.85
4.	If not, state reasons there for	Reason 1 Financial constrain Reason 2 Lack of knowledge	46.43 53.57
5.	If fertilizer not used at all what are the reasons	Reason 1 Reason 2	0.00 0.00
6.	Is fertiliser easily available?	Yes No	100.00 0.00
7.	If yes, the source where it is available	Source : Pvt. Outlet at market	100.00
8.	Do you feel that hybrid seeds require more fertilizer than inbred seeds	Yes No	100.00 0.00

Data source: Primary data

have not used fertilizer in recommended doses, cited lock of knowledge (53.57 percent) and financial bottlenecks (43.43 percent) as the reasons for non-application of recommended doses of fertilizer. Easy availability of fertilizer is reported by cent percent of the farmers, the source of fertilizer being private traders as reported by them. When asked whether hybrid seeds require more fertilizer than inbred seeds, all the sample hybrid adopters unanimously reported affirmative. Overall, hybrid adopting farmers have good access to fertilizer input as revealed from the responses relating to access to fertilizer input.

The responses of questions relating to hybrid adopters' access to pesticide input and its use are presented in table 7.2C. Sometimes it is argued that hybrid adapts well to varying agro-climatic situations and have resistance to pests and disease attacks. Farmers' level responses received in course of this study do not support this argument. Asked whether hybrid rice crop are more susceptible to pests and diseases, a good majority of the farmers (86.25percent) reported that hybrid rice varieties are more susceptible to pests and diseases. Notably however 86 percent of the sample farmers reported to have used pesticides. Of those who had not applied pesticides,

cent percent reported lack of money as the reason for non-application of pesticides. It is encouraging to note that majority of the farmers know the correct way of using and doses of plant protection pesticides in general and for hybrid seeds in particular. When asked whether farmers know the correct does of pesticides for hybrid rice varieties, a total of 81.25 percent of farmers reported affirmative. All the sample farmers unanimously reported that pesticides are easily available in the area.

A total of 81.25 percent of farmers (table 7.2C) were of the view that hybrid rice cultivation is highly sensitive to crop management practices-use of key inputs and time bound operations. Also all the sample farmers believe that the extent of yield loss due to pests and diseases for inbred variety is lower as compared to hybrids.

Table 7.2C: Questions related to Hybrid Adopting Farmers access to Pesticide input and its use

Sl. No.	Particulars	Answers	% of farmers reporting
1	Whether hybrid rice crop or any other variety of rice crops was attacked with pests and diseases?	Yes No	100.00 0.00
2	If yes, which variety (Hybrid/ Hyvs) with area	Hybrid (area) HYVs (area)	100.00 100.00
3	Have you applied pesticides?	Yes No	86.00 14.00
4	If not, why not used?	Reason: Lack of money	100.00
5	Is the pesticide easily available?	Yes No	100.00 0.00
6	Do you know the correct way of using and doses of plant protection pesticides?	Yes No	88.75 11.25
7	Do you feel that hybrid rice varieties are more susceptible to pests and diseases?	Yes No	86.25 13.75
8	Do you know the correct does of pesticides for hybrid seed varieties ?	Yes No	81.25 18.75
9	Do you feel that hybrid rice cultivation is highly sensitive to crop management practices - use of key inputs and time bound operations?	Yes No	81.25 18.75
10	Do you feel that the extent of yield loss due to pests and diseases for inbred variety is lower as compared to hybrids	Yes No	100.00 0.00

Data source: Primary data

Table 7.2D: Questions related to Hybrid Adopting Farmers' access to credit

Sl. No.	Particulars	Answers	% of farmers reporting
1)	Do you require more credit for using hybrid seed?	Yes-1 No-2	26.25 73.75
2)	Do you get required credit from the Co. Credit Society or any other institutional sources?	Yes-1 No-2	54.17 45.83
3)	If yes, which source	Source-1 Bank Source-2 Co-operative	66.67 33.33
4)	If not, what are the problems in getting credit	Problem-Security	23.61

Data source: Primary data

Farmers' response relating to their access to credit are summarized in table7.2D. Hybrid rice cultivation being costlier than inbred varieties demand more capital compared to that for

HYVs. Thus farmers' level responses were obtained regarding hybrid adopting farmers' accessibility to credit. When asked whether they would require more credit for using hybrid seed, a good majority of respondents (73.25 percent) reported to be negative. Of those who require credit, 54.17 percent reported that they get credit from the institutional sources, either commercial banks or co-operatives. Farmers in major (66.67 percent) receive credit from commercial banks. Farmers those who are not availing of credit encountered one major problem of procedural formalities as perceived by 76.39 percent of farmers apart from the problem of collateral (23.61 percent).

A frequently raised concern on the spread of hybrid rice is the acceptability of the quality of hybrid rice grain among consumers. Consumer acceptance is the ultimate factor that determines the price of the product as also marketability of the product. Thus to study the issue of marketing farmers' level responses were collected regarding their perception about marketing of hybrid rice. Asked whether they face problems in marketing of hybrid rice produce, all the hybrid adopting farmers unanimously reported that they face problems in marketing of hybrid rice. Lack of consumer demand for hybrid rice grain, lower head rice recovery and ultimately lower price received in the market were the major problems faced by the hybrid growers. All the sample farmers reported these problems in the field of marketing of hybrid rice (table 7.2E).

Table 7.2E: Questions related to Hybrid Adopters' Perception about Marketing of Hybrid Rice

Sl. No.	Particulars	Answers	% of farmers reporting
1.	Do you face problems in marketing of hybrid rice produce?	Yes No	100.00 0.00
2.	If yes, state the nature of the problem faced	i. Lower market price ii. Poor cooking and keeping quality iii. Lower head – rice recovery (percentage of clean rice after milling) iv. More broken rice after milling v. Lack of consumer demand for hybrid rice grain vi. Poor grain quality and as a result lack of market acceptance vii. Traders not accepting hybrid rice grain lack of demand from millers and consumers	100.00 83.75 100.00 56.25 100.00 86.25 83.75

Data source: Primary data

Other problems reported by the adopters included poor cooking and keeping quality (83.75 percent), poor grain quality and as a result lack of market acceptance (86.25 percent), traders not accepting hybrid rice grain lack of demand from milliers and consumers (83.75 percent) and more broken rice after milling (56.25 percent).

7.3 Famers' overall perception of hybrid rice cultivation

The responses of farmers regarding overall perception of hybrid rice cultivation were elicited. These are documented in table 7.3. When asked whether there is any yield gain from cultivation of hybrids over the best popular inbred rice varieties, all the sample farmers (cent percent) unanimously reported that there was yield gain in hybrids over connectional HYVs (inbred). Also hybrid rice production was reported to be profitable as conceived by 78.75 percent of sample farmers.

Hybrid rice varieties till now are inferior to currently available inbred varieties. Nearly 96 percent of the sample farmers reported that grain quality of hybrid rice is poor compared with the grain quality of the existing popular HYVs of rice. A total of 63.75 percent of farmers felt hybrid rice is not suitable for their taste. Many farmer respondents (81.25 percent) said hybrid rice has poor cooking quality. High stickiness of cooked rice is also reported by majority of the farmers (85.00 percent). Asked whether hybrid rice grain is acceptable to traders and millers, a total of 80.00 percent of farmers respondent reported that traders and millers do not want to accept hybrid rice grain from them on account of its poor grain qualitie. Farmers are however convinced with the economic viability of hybrid rice cultivation. A good majority (75 percent) of the farmers reported that they are convinced with the economic viability of hybrid rice cultivation. Those who are not convinced cited reasons comprised of less/ non-availability of seeds and higher cost of cultivation (25.00 per cent), more susceptible to pest and diseases (15.00 per cent), poor quality of grain (35.00 per cent) and poor knowledge about hybrid cultivation, technology and management (25.00 per cent). Among hybrid growers 7.50 per cent were not in favor of continuing cultivation of hybrid rice. A total of 92.50 of hybrid adopters expressed their intention to continue cultivating the hybrid variety rice mostly (92.50 per cent) because of higher yield of hybrid rice. Some of them (31.25 per cent) are expecting new hybrids with better quality in future. In short, analysis of farmers' overall perception about hybrid rice cultivation hinted that future research on hybrid rice development should focus on improvement of grain quality besides yield in the next generation hybrids.

7.4 Reasons for non-adoption of hybrid rice cultivation (non-adopters' experience)

When we asked non-adopters of hybrid rice cultivation about their experiences, (table-7.4) 35 per cent of sample non-adopters indicated that they have not heard any of the new hybrid varieties of rice. However, a total of 65 per cent of the non-adopting farmers reported that they have heard about few varieties of hybrids and such varieties are KRH – II as reported by 67.86 per cent of farmers DRRS – II (53.57 per cent) and PAC – 835 (69.05 per cent). When asked

whether they have heard of the government's hybrid rice promotion programme, nearly 55.00 per cent of the farmers reported affirmative. Asked whether they have seen any standing rice crop of hybrid variety, negative responses were received from a total of 55 per cent of non-adopting farmers.

Table 7.3: Hybrid Adopting Farmers' overall Perception about Hybrid Rice Cultivation

Sl. No.	Particulars	Answers	% of farmers reporting
1.	Is there any yield gain from cultivation of hybrids over the best popular inbred rice varieties?	Yes No	100.00 0.00
2.	Is hybrid rice production profitable?	Yes No	78.75 21.25
3.	Do consumers perceive hybrid as inferior to inbred in respect of grain quality?	**Hybrids inferior in respect of** a) Poor grain quality b) No taste c) Poor cooking quality **d)** Stickiness of cooked rice	 96.25 63.75 81.25 85.00
4.	Is hybrid rice grain acceptable to traders and millers?	Yes No	20.00 80.00
5.	Is he convinced with the economic viability of hybrid rice cultivation?	Yes No	75.00 25.00
6.	It no, reasons therefore	Reason – 1: Less/non availability of seeds, higher cost of cultivation, Reason – 2: More susceptible to pest and diseases, Reason – 3:Poor quality of grain, Reason – 4:Poor knowledge about hybrid cultivation, technology and management	25.00 15.00 35.00 25.00
7.	Do you like to continue cultivating of hybrid rice?	Yes No	92.50 7.50
8.	If yes, reasons for continuing hybrid rice production	**Reasons for continuing hybrid rice cultivation** a) Expecting to get new hybrids with better quality in the near future b) Higher yield of hybrid rice	 31.25 92.50

Data source: Primary data

35 per cent of the sample non-adopters reported that nobody had suggested to grow hybrid variety of rice on their farms. Among those (65.00 per cent) who received suggestions from any source, majority (54.77 per cent) reported that they have received suggestions from Agricultural

Table7.4: Questions related to Reasons for non-adoption of hybrid rice (reaction of non-participants)

Sl. No.	Particulars	Answers	% of farmers reporting
1	Have you heard of any of the new hybrid varieties of rice?	Yes-1 No-2	65.00 35.00
2	If yes, what are they?	KRH-II DRRS-II PAC - 835	67.86 53.57 69.05
3	Have you heard of the Govts. Hybrid rice promotion programme?	Yes-1 No-2	55.00 45.00
4	Have you seen any standing rice crop of hybrid variety in your area?	Yes-1 No-2	45.00 55.00
5	Did anybody suggest you to grow this variety?	Yes-1 No-2	65.00 35.00
6	If yes, state who suggested?	a) V.L.W b) BDO c) AEO d) Relative e) Other cultivators f) Known from government demonstration g) Others (Media)	39.29 7.15 54.77 15.48 15.48 7.14 30.95
7	Will you be growing this variety next year?	Yes No	70.00 30.00
8	What are the reasons for your not using this year?	i. Not heard of the variety ii. Not heard of the Govt. assistance for expansion of hybrid rice seeds. iii. Non-availability of seed a. Not at all b. Not in time c. Pure hybrid seed not available iv. Seed is too costly v. Seed available, but at too far a distance vi. Pre-treatment of seed is necessary and have never done it before. vii. Govt. Seed germination rate too low viii. Not convinced that the seed is of high quality ix. Not convinced that its yield is sufficiently high x. Lower yield for hybrid than for inbred xi. Yield gain but lower profitability of Hybrid rice xii. Variety too coarse xiii. Higher risks xiv. Will fetch lower price as compared to inbred variety xv. Needs too much of fertilizers xvi. Soil type not suitable xvii. Not insects pests and disease resistant. xviii. The extent of yield loss due to pests and diseases is higher for hybrids. xix. Needs more water xx. Fodder quality not good xxi. Credit – not available in time xxii. Credit not at all available xxiii. Restrictions on disposal i.e. should be sold to a particular agency xxiv. Any other (Specify)	35.00 35.00 15.00 0.00 0.00 20.00 0.00 0.00 0.00 10.00 20.00 0.00 10.00 0.00 25.00 75.00 0.00 0.00 25.00 30.00 0.00 0.00 0.00 0.00 0.00 0.00
9	Are you ready to accept new hybrid rice varieties in future considering superior grain quality and higher yield potential?	Yes No	100.00 0.00
10	If no, reasons therefore.	Reasons – 1 Reasons – 2	- -

Data source: Primary data

Extension Officer (AEO) of the state department of agriculture. The next in importance from whom suggestion was received was village level worker (VLW).

A total of 70 per cent of the sample non-adopters had expressed their willingness to grow the hybrid variety of rice next year. According to non-adopting farmers, lower price of hybrid rice as compared to inbred variety is the major (75 per cent) reason for non-adoption of hybrid rice. Among other reasons, 35 per cent of the non-adopters reported that they are completely unaware about the hybrid seed variety, another 35 per cent of the non-adopting farmers reported that they are not at all aware about the government assistance for the promotion of hybrid seeds, non-availability of seeds at all is reported by 15 per cent of non-adopters, a total of 20 per cent of non-adopters reported that seed is too costly, reportedly 10 per cent of the farmers are not convinced that the seed is of high quality, a total of 20 per cent of non-adopters are not convinced that hybrid yield is sufficiently high, higher yield gain but lower profitability of hybrid rice is reported by 10 per cent of non-adopters, hybrid rice cultivation involves higher risks as reported by 25 per cent of non-adopters and hybrids are not insects, pests and disease resistant variety as reported by 25 per cent of non-adopting farmers. A total of 30 per cent of non-adopters reported that the extent of yield loss due to pests and diseases is higher for hybrids. Also all the non-adopting farmers unanimously reported that they are ready to accept new hybrid rice varieties in future considering higher yield potential.

In short, the main reasons for non-adoption of hybrids were lower price of hybrid rice as compared to inbred, poor extension activities by the government for the popularization of hybrids, un-availability of quality hybrid seed, higher seed cost, higher yield loss for hybrids due to pests and diseases and higher risks associated with hybrid rice cultivation. Though higher seed cost is considered a constraint, it was given the least importance compared with other constraints. The foremost constraint confronting the diffusion of hybrid rice technology is poor grain quality and as a result lack of market acceptance leading to lower price fetched for hybrid rice as compared to inbred variety.

CHAPTER-VIII
Summary and Policy Recommendations

7.1 Background

Hybrid rice is any genealogy of rice produced by crossbreeding different kinds of rice. As with other types of hybrids, hybrid rice typically displays heterosis (or hybrid vigor) such that when it is grown under the same conditions as comparable high-yielding inbred rice varieties it can produce up to 30% more rice. High-yield crops, like hybrid rice, are one of the most important tools for combating world food crises. The earliest high-yield rice was cultivated by Henry 'Hank' Beachellin 1966, but it was not until the 1974 that the first hybrid rice varieties were released in China.

In crop breeding, although the use of heterosis in first-generation seeds (or F_1) is well known, its application in rice was limited because of the self-pollination character of that crop. In 1974, Chinese scientists successfully transferred the male sterility gene from wild rice to create the cytoplasmic genetic male-sterile (CMS) line and hybrid combination. The first generation of hybrid rice varieties were three-line hybrids and produced yields that were about 15 to 20 percent greater than those of improved or high-yielding varieties of the same growth duration.

At the present time, Yuan Longping, the "Father of Hybrid Rice", may be the most famous in research on hybrid rice. In the 1970s, he made his seminal discovery of the genetic basis of heterosis in rice. This was a unique discovery because it had been previously thought that heterosis was not possible for self-pollinating crops such as rice. In China, hybrid rice is estimated to be planted on more than 50% of rice-growing land there and it is credited with helping the country increase its rice yields, which are among the highest within Asia. Hybrid rice is also grown in many other important rice producing countries including Indonesia, Vietnam, Myanmar, Bangladesh, India, Sri Lanka, Brazil, USA, and the Philippines. A 2010 study published by the International Rice Research Institute (IRRI), reports that the profitability of hybrid rice in three Indian states varied from being equally profitable as other rice to 34% more profitable. Outside of China other institutes are also researching hybrid rice, including the International Rice Research Institute, which also coordinates the Hybrid Rice Development Consortium.

Encouraged by the success of hybrid rice technology in enhancing the rice production and productivity in China, the Indian Council of Agricultural Research (ICAR) initiated a national program for development and large scale adoption of hybrid rice in the country in

December 1989. The project was implemented through a National Network comprising research, seed production and extension networks. The hybrid rice research network consisted of 11 research centres and many voluntary centres spread across the country. The seed production network consisted of public sector seed production agencies such as National Seed Corporation, State Farms Corporation of India and the State Seed Development Corporations in addition to many private sector seed companies. The extension network consisted of state departments of Agriculture, extension wings of the SAUs, Krishi Vignan Kendras (Farm science centres) and the NGOs. Effective linkages were established within the different sub-components of the network. The entire project was co-ordinated and implemented by the Directorate of Rice Research (DRR), Hyderabad. The project initiated by the ICAR, was strengthened by the technical support from IRRI Philippines, FAO, the financial support from the UNDP, Mahyco Research Foundation (MRF), World Bank funded National Agricultural Technology Project (NATP) and IRRI/ADB Project on Hybrid Rice.

The spread of the newer varieties replacing the older varieties need to be closely monitored to take advantage of the superior characters of these newer varieties released by various Research Institutions. This will help to break the yield plateau that has been experiencing in rice crop in the recent past and to increase the production and productivity of the crop. Though a number of steps are being taken by the Government to popularize these varieties like Frontline Demonstration, minikit supply, organising training programmes (1-21 days) for farmers, farm women, seed growers, seed production personnel of public and private seed agencies, extension functionaries of state departments of agriculture, officials of state agricultural universities and NGOs, there is no concrete data to prove that the newer varieties of rice are spreading faster and replacing the older ones. Therefore, it is essential to conduct a study to assess the actual spreading of these newer varieties in terms of area with simultaneous reduction in the area under older varieties for rice crop and the increases in the average yield/ha. This will help the Government of India to draw a plan for augmenting the spread of the superior newer varieties in place of the age old varieties.

7.2 Objectives of the Study

The specific objectives of the study are

1. to indicate the extent of adoption and the level of participation by the different categories of farmers in the cultivation of hybrid rice;
2. to assess the overall impact on rice production and productivity of hybrid rice cultivation;
3. to study the economics of cultivation of hybrid rice varieties vis-a-vis inbred varieties;

4. to identify factors determining the adoption of hybrid rice varieties;
5. to address various constraints and outline the prospects for increasing hybrid rice cultivation and
6. to suggests policy measures for expansion of hybrid rice cultivation.

7.3 Data Base and Methodology

The study is based on both secondary and primary data. Secondary data obtained from government publications relating to area, production and productivity of rice, viz. Statistical Abstract, Government of West Bengal and Economic Review, Government of West Bengal are used to arrive at the trends in area, production and productivity. For the sake of comparison, it is usual to compare the performance of rice in the pre-introduction period of hybrid rice with that in post-introduction period as a whole. Keeping in mind that the first hybrids was developed and released for commercial cultivation in India in 1994, the study period was thus divided into three sub-periods viz. 1984-85 to 1993-94, 1994-95 to 2003-04 and 2004-05 to 2009-10. The period-I viz. 1984-85 to 1993-94 refers to the pre-introduction period of hybrid rice while other two period's viz. period-II & III correspond to post-introduction periods.

Primary survey is confined to the National Food Security Mission (NFSM) districts in the state. The two districts viz. Howrah and Uttar Dinajpur having relatively higher concentration of hybrid seeds cultivation within the group of NFSM districts are chosen for the present study. In each of the district, two representative blocks are taken and within each block two villages are selected. In each village, a complete list of cultivating households growing hybrid rice varieties and inbred varieties are prepared and stratified according to four standard land size groups such as marginal (less than 1 hectare), small (1 to 2 hectares), medium (2 to 4 hectares) and large (more than 4 hectares) including SC, ST and women farmers. In each district, 40 hybrid rice growers from the list of hybrid rice growing cultivators are drawn at random from different land size groups on the basis of their proportion in the universe. In addition to this sample, 10 inbred variety (traditional HYVs) rice growers but non-adopters of hybrid rice are selected randomly from the different land size groups amongst inbred rice growing cultivators following the same procedure. Thus altogether, 50 rice growing cultivators are selected from each selected district. In all, 100 rice growing cultivators in the state equally spread over two selected districts constitute the size of the sample in the study.

For the primary survey, the reference years are 2009-10 and 2010-11. Accordingly, 2 kharif seasons and 2 rabi seasons for the rice crop are covered in the study. Primary data are obtained by administering a structured schedule/questionnaire.

7.4 Major Findings

Rice is the primary crop in West Bengal. The three major rice seasons are *Aus* (May to September), *Aman* (*Kharif*, from June to November) and *Boro* (*Summer*, from March to June). Traditionally the *Aman* crop has been the most important of the three rice growing seasons in terms of output and acreage. Over time the *Boro* rice has grown in significance. We can see the performance of rice in three different periods separately (i) 1984-85 to 1993-94 a period preceding the impact of hybrid technology and (ii) 1994-95 to 2003-04 and (iii) 2004-05 to 2009-10, the periods marked by post hybrid periods.

Aman, the *Kharif* rice is the most important of the three rice growing seasons both in terms of acreage sown and production. In 2009-10, *Aman* rice accounted for 66.9 per cent of total rice output and 70.8 per cent of total area cultivated under rice. The importance of *Aman* rice output in total production has however fallen from 76.1 per cent in 1984-85 to 66.9 per cent in 2009-10 while that of *Boro* crop has risen significantly from 17.9 per cent in 1984-85 to 29.8 per cent in 2008-09 exceptionally at 17.9 per cent in 2009-10. Decline in share in output in case of *Aman* is due to decline in share in acreage from 78.8 per cent in 1984-85 to 70.8 per cent in 2009-10. For *Summer* rice, increased share in production is attributable to increase in both area and production. The relative importance of *Autumn (Aus)* rice has also sharply fallen both in terms of acreage planted and production. The relative share of *Autumn* rice in total production declined from 8.2 per cent in 1984-85 to 3.3 per cent in 2009-10. The *Boro* or *Summer* rice was introduced in the 1960s and area cultivated with *Boro* increased rapidly thereafter. The share of *Boro* (*Summer* rice) in total rice acreage increased from 9.1 per cent in 1984-85 to 25.4 per cent in 2009-10 as against the figure of 26.2 per cent in 2008-09. As *Boro* has always been an irrigated crop based on high yielding varieties of seed, yields have always been relatively high and yield growth has been a major contributor to growth of output. It is important to note that average rice yield in West Bengal increased to 2547kg per hectare in 2009-10 which was 2061kg in 1993-94 and 1556kg in 1984-85, the period when rice crop of the state was yet to switch over to the hybrid technology. In case of *Summer* rice, yield rate increased from 2698kg per ha. in 1984-85 to 3101kg in 1993-94, which again increased to 2991kg per ha. in 2009-10. For *Winter* rice (*Aman*) yield level increased from 1504kg per ha. in 1984-85 to 2407kg in 2009-10 through 1885kg in 1993-94. *Autumn* rice recorded yield levels of 2179kg per ha. in 2009-10 which was 1683kg in 1993-94 as against 1046kg in 1984-85. In short, there has been overall increase in rice production during the period under study 1984-85 to 2009-10. Such an increase in production is driven by increases in productivity of rice of three major rice seasons whereas *Summer* rice (*Boro*) contributed to the enhancement of rice output both in terms of acreage and production.

In the case of *Aus* and *Aman* rice the major contributor to increased production of rice was growth in yield. Yield increases are likely due to changes in input use including greater use of high yielding variety seeds. The following is thus an attempt to analyze the trend and composition of HYV rice in the state. Notably data pertaining to the area under HYVs are only available in published from obtainable from Economic Review, Government of West Bengal. It is evident that the coverage of HYV seeds in *Aman*, *Aus* and *Boro* rices increased over the time span of 1995-96 to 2009-10. In 1995-96, 97 per cent of area under *Aus* and 63 per cent of area under *Aman* was sown with HYV seeds. In 2009-10, the corresponding figures were 99.4 per cent and 87.7 per cent respectively. *Boro* rice experienced rapid adoption of high yielding variety technology during the period. Evidently, 100 per cent of the *Boro* crop was planted with HYV seeds. For rice produced grown in the three seasons combined, HYVs accounted for over 90 per cent of the total area under rice in 2009-10 which was 73.1 per cent in 1995-96. Thus in terms of coverage of HYV seeds in *Aus*, *Aman* and *Boro* rice cultivation, all the varieties of rice experienced increase in acreage under HYVs. Now if we take 1994-95 as the beginning of hybrid technology, there is no instance of declining area coverage under HYVs, both in absolute and relative terms, after the introduction of hybrid rice cultivation in the state. Importantly, however data pertaining to area, production and yield of hybrid rice were not available at all by virtue of which one can guess the rate of substitutability between HYVs and hybrid rice in total rice cultivation.

In order for understanding the growth performance of HYVs, time series data pertaining to area under HYVs for the period 1995-96 to 2009-10 were used. It was the period when the rice crop of the state switched over to hybrid rice technology. Compound growth rates were estimated on the basis of such data. The fitted semi-log trend revealed that rice crop that came under the green revolution technology in the mid-sixties was now (1995-96 to 2009-10) growing only at the rate of 1.24 per cent per annum. This rate was higher at 2.35 per cent during the period 1995-96 to 2003-04 but subsequently the rate of growth in acreage slowed down to 1.51 per cent per year during the period 2004-05 to 2009-10 making an overall increase of 1.24 per cent in acreage under HYVs during the time span of 1995-96 to 2009-10. There was thus a deceleration in the growth of HYVs during the period experiencing hybrid rice technology. Might be that hybrid rice occupied the area previously occupied by HYVs which however has not been possible to explore due to non-availability of data on area coverage under hybrid rice.

West Bengal agriculture is small farm dependent where the marginal (below 1ha) and small (1ha – 2ha) sized land holdings form the bulk of the farm holdings in the state. These two size classes together accounted for more than 95 per cent of the total holdings. In the rural economy of West Bengal, the absence of alternative opportunities of gainful employment has compelled the farm families to depend primarily on agriculture and land being the primary

resource in agriculture, its possession determines their accessibility to other resources and hence their production decisions as to how much to invest in land, what crops to grow and how intensively to cultivate land. Thus knowing the pattern of land distribution is crucial for understanding the position of rural households in the farm economy.

The land distribution pattern in West Bengal reflects the preponderance of small and marginal farmers. The two sample districts chosen for the study namely Howrah and Uttar Dinajpur are no exception to this as revealed from our survey data. It can be seen that small and marginal farmers together account for 97.50 per cent of the total sample farmers among hybrid adopters. The incidence of such farmers among non-adopters is 95 per cent of total sample farmers. As between small and marginal farmers, the latter constitute more in both the categories of sample farm households accounting for 75 and 80 per cent among hybrid adopters and non-adopters respectively.

A close look at the demographic profile of the respondents reveals that the size of the household varies among adopters and non-adopters. The relatively larger size is to be found among the adopters who have an average size of 6 members per household. In contrast, non-adopters have an average size of 5. The average number of males is 3 and females are 2 per household in case of hybrid adopters. The pattern of distribution is somewhat different across adopters and non-adopters. The number of workers is estimated at 3.04 per adopter household whereas for non-adopters the figure comes to 2.55. Average education of majority of the adopters (56.25 per cent) and non-adopters (65.00 per cent) is up to secondary level. A total of 37.50 per cent of adopters studied up to primary standard as against 30 per cent of non-adopters.

Caste composition of households reveals that 25 per cent of adopter households belong to scheduled castes, 1.25 per cent of the households belong to other backward castes whereas the balance 73.75 per cent of the households goes to general castes. Caste composition of non-adopter households is not exactly similar to those of adopter households. For such households, there is no such household which may be categorized as OBCs. The proportion of scheduled caste and general caste is of the order of 25 per cent and 75 per cent respectively. There was thus preponderance of general castes both among the hybrid adopters and non-adopters. Judging by the primary occupation of the head of the households, our survey data reveals that among the adopter households, 88.75 per cent have the main occupation farming, 8.75 per cent are salaried, 1.25 per cent is engaged in business and the rest 1.25 per cent are wage earners working as agricultural labourers. Within the group of non-adopters, 90 per cent are engaged in farming and the rest 10 per cent are employed in self business. The average size of ownership holdings works out to 0.72 ha for adopter households and 0.67 ha for non-adopters. The average size of holdings as measured by the size of operational holdings is estimated at 0.77 ha for adopters as against 0.71 ha for non-adopters. The average size of irrigated land (all seasons combined) is estimated

to be 1.39 ha for adopter households as against 1.11 ha for non-adopters. Out of the total gross irrigated area, about 60 per cent of area receives irrigation during *rabi/summer* seasons in case of adopter households while the corresponding figure stood at 54.88 per cent for non-adopters.

A perusal of the data indicates that rice, maize wheat, betel leaf (pan), jute and maskalai are dominant crops in order of importance amongst the hybrid adopters in the study area. These crops together covered 98.13 per cent of the gross cropped area. During the period under review i.e. between 2009-10 and 2010-11, aggregate share of these crops in the total gross cropped area increased marginally from 97.98 per cent in 2009-10 to 98.13 per cent in 2010-11. It is however noticeable that the share of hybrid rice in the total gross cropped area increased from 1.13 per cent in 2009-10 to 2.60 per cent in 2010-11 during *kharif* season. During summer (*boro*) season too, hybrid rice increased their share in the cropping pattern from 9.57 per cent in 2009-10 to 12.28 per cent in 2010-11. In contrast, there has been decline in the share of conventional varieties of HYV (inbred rice) during the period under review. Inbred rice shared 35.77 per cent of gross cropped area during *kharif* in 2010-11 which was 37.26 per cent in 2009-10. During summer season the share of inbred rice declined from 24.76 per cent in 2009-10 to 19.91 per cent in 2010-11. Hybrid rice is thus mainly grown during summer and upgraded its status in the cropping pattern over the period under study.

Kharif rice and summer rice being the two components of total rice jointly demonstrated decline in their area share from 72.72 per cent in 2009-10 to 70.56 per cent in 2010-11. However within rice crop, inbred rice (conventional HYVs) constituted the major where about 55.68 per cent of the gross cropped area was covered by inbred rice as recorded in 2010-11. The corresponding figure was 62.02 per cent in 2009-10 and thus inbred rice suffered loss in acreage during the reference period. Correspondingly, hybrid rice gained in share in acreage in gross cropped area from 10.70 per cent in 2009-10 to 14.88 per cent in 2010-11. Hence loss in acreage under inbred rice is to a large extent compensated by the gain in acreage under hybrid rice and the overall marginal changes in the cropping pattern that occurred during the reference period was due to fall in acreage under inbred rice and correspondingly compensatory increase in acreage under hybrid rice.

Among the non-adopters the staple crop is rice which is raised on an area accounting for 78.94 per cent of gross cropped area in 2010-11. The corresponding figure was 83.29 per cent in 2009-10. Thus during the reference period land given up to rice declined by 4.35percentage points. The bulk of the rice crop is sown in the kharif and its percentage share remained constant at 45.25 per cent during both the periods whereas the corresponding proportion for the rice sown in the rabi had declined from 38.04 per cent in 2009-10 to 33.69 per cent in 2010-11. The net effect is thus the loss in relative share of rice in the cropping pattern in case of non-adopters of hybrid seeds. Other crops grown on the field of non-adopters are maize, wheat, mustard and

maskalai in order of importance. Aggregate share of these crops in the total gross cropped area marginally decreased from 12.95 per cent in 2009-10 to 12.91 per cent in 2010-11. Within the food grain group, maize occupying the position after rice improved its share significantly from 5.94 per cent in 2009-10 to 7.16 per cent in 2010-11. Wheat suffered a loss in their percentage share from 3.74 per cent in 2009-10 to 2.81 per cent in 2010-11. Acreage sown to other crops remained stationery during both the periods.

It can be seen that during the year 2009-10 the proportion of rice area allocated to hybrid rice accounted for 18.03 per cent in marginal sized land holdings which declines consistently with the rise in the size of holding to 11.52 per cent. Such a decline in the ratio of hybrid rice area to total rice area is accompanied by the corresponding increase in the harvested area under HYVs as a ratio to the total area allocated to rice. Similar relationship is also observed during the year 2010-11. Considering all the farm sizes together, the percentage of rice area allocated to hybrid rice is 21.09 per cent in 2010-11, which was 14.72 per cent in 2009-10. Thus the adoption of hybrid rice at the farm level in rather low but showed an increasing tendency in the proportion of harvested rice area allocated to hybrid rice over the years. It has picked up during the reference period obviously because of increasing popularity amongst the farmers. Over the farm sizes, the currently available hybrid rice is not so attractive to the larger sized land holdings those who are commercially motivated and produce rice mainly for the market. On the contrary, small and marginal farmers who produce mainly for household consumption have shown interest in hybrid rice. The smaller sized farms have an advantage over the larger ones in regard to the traditional labour intensive farming where as hybrid rice cultivation is more labour intensive as compared to conventional HYVs. Needless to say, hybrid technology has vast potential for improving the level of productivity of rice. But the dissemination of hybrid rice technology at the farm level is much more important.

Evidently, among the sources, the most popular one was the extension worker of the state department of agriculture (81.25 per cent) followed by training programme organized by the government (76.25 per cent). When asked about the quality of information received among those accessing the source, mixed response was received in case of both the sources.

Farmer households when asked whether they adopted recommended package of practices in rice cultivation, 58 per cent of the hybrid rice adopters obtaining knowledge from the training programme undertaken by the government held the view that they have adopted package of practices as recommended by the source. About 57 per cent of hybrid growers those who have accessed information from the extension worker of the state department of agriculture reported that they have followed the recommended package of practices.

Information was collected from the farmer households, regarding the sources of seed they have accessed. A good majority (70 per cent) of hybrid growers reported that they have obtained

seed from government sources on full subsidy. Above 30 per cent of farmers growing hybrid seeds have responded that they have obtained seeds from private sources.

In order to find out the determinants of participation in hybrid rice cultivation we have made an attempt to estimate the logit model using several combinations of farm and farmers – specific variables. In the model dummy participation in hybrid rice cultivation (participation = 1, non-participation = 0) has been taken as dependent variable. The predictor variables (explanatory variables) used in the model are (a) age (b) education (c) household size (d) size of workers (e) farm size.

Results show that education level of farmers had a positive relationship suggesting that higher the level of education of the farmers, higher the probability of extending more area under hybrid rice. Age of the participant is having negative impact on the farmers' participation in hybrid rice cultivation which suggested that higher the age, the lower is the probability of participation. Farm size has shown a negative association with the adoption of hybrid rice. It implied that small farmers – who make up the majority of all farmers are the potential adopters of hybrid rice in future in the state. The possible reason for this is that the primary objective of small farmers whose average farm size is very small, is to enhance household rice production from a small piece of land to feed their families. Therefore, they would go for hybrid rice technology since it's yield is 19-22 per cent higher than that of HYVs as observed in the study. On the other, the currently available hybrid rice is not attractive to the commercial farmers having larger sized land holdings. Further hybrid technology being labour intensive technology will have less probability success in the agrarian structure characterized by bigger sized land holdings. This is indicative from the fact that size of worker has shown a positive association with the adoption of hybrid rice. This suggests that higher the size of worker, higher is the probability of adoption of hybrid rice. More labour availability per unit of arable land owing to greater availability of family labour on smaller sized holdings is the phenomenon observed in a labour surplus economy like ours and is thus likely to associate positively with the adoption rate of hybrid rice technology. Household size has a negative coefficient suggesting that the larger the household size, the lower is the probability of participation in hybrid rice cultivation. The overall specification of the model is judged by the log likelihood based chi square test which however suggests that the model used is not a good predictor model. The value of R^2 is also found to be low and thus the model requires inclusion of some more predictor variables.

The application of the logit model using the variables described above has the limited relevance to study the adoption behaviour of farmers. In the earlier estimate none of the variables turned out to statistically significant. Nevertheless we made further attempt to estimate logit model using some more farm and farmer-specific variables. Finally we included the following

variables: (a) age (b) education (c) household size (d) size of worker (e) farm size (f) wage-paddy price ratio and (g) farm worker-arable land ratio.

The estimated results show that the variables like age, education and farm size have the desired sign but the estimated coefficients turned out to be statistically insignificant. Education level of the farmers had a positive relationship with the probability of participation in hybrid rice cultivation. Age has the negative coefficient suggesting that higher the age, lower the probability of participation in hybrid rice cultivation. Farm size has shown a negative association with the participation in hybrid rice cultivation. It implied that higher the farm size, lower the probability of participation in hybrid rice cultivation. In other words, small farmers are the potential adopters of hybrid rice. The predictor variables which were found significant are size of worker in the family and wage-paddy price ratio. Size of worker has a positive coefficient suggesting that the larger is the size of worker, the higher is the probability of participation in hybrid rice cultivation. Hybrid rice production is more labour intensive as compared to conventional HYVs (inbreeds) which requires additional mandays of labour per hectare. Hence hybrid technology will have less probability of success where labour is becoming a constraint for the farm sector. Smaller sized landholdings enjoy the advantage of growing hybrid rice owing to greater availability of family labour on such holdings. Further, farm wage-paddy price ratio is positively related to the farmers' participation in hybrid rice cultivation and also turned out to be statistically significant. In fact the ratio of farm wage-paddy price is likely to inversely associate with the participation in hybrid rice cultivation. But the estimated relation turned out to be positive which may be considered as a spurious correlation and bears no meaning.

Overall, rice hybrid performed better with an average yield of 6408.53kg per ha than average yield of 5377.60kg per ha for HYVs during the 2009-10. During 2010-11, too hybrid rice recorded higher yield at 6551.28kg per ha as against 5340.89kg per ha for HYVs. Among various farm size groups, smaller sized holdings obtained highest yield in both the years. The mean yield of HYV rice however increased with the increase in the size of farm over the years. In other words, mean yield levels of HYVs were higher on larger sized holdings as compared to smaller ones in case of HYVs.

In comparing the yield performance of hybrids and conventional HYVs (inbred) grown by the same sample farmer, paired-t test was carried out to test the significance in the differences in yield between hybrids and HYVs since the same farmer grew both rice varieties under the same production environment. The pairing of the observations helped dissociate the effect of the variation due to the agro-ecological difference of the farm and socio-economic characteristics of the farmer. Results of 'paired t' test show that the observed yield difference between hybrid and HYVs (inbred) is statistically significant at 5 per cent level of significance in both the years under study.

On an average the yield gain of hybrids over HYVs was 19.17 per cent in 2009-10. During 2010-11 it was about 22 per cent. Across farm sizes, smaller sized holdings obtained higher yield gain as compared to larger sized holdings in both the years under study. Thus based on farm level performance of hybrid rice over the period it is clearly indicative of the fact that hybrid rice technology has its higher yield potential under the production environments prevailing in West Bengal.

Yield response function was estimated separately for hybrid and inbred rice varieties to determine the input factors affecting yield levels. Log linear models were fitted to identify the factors affecting the yield of two varieties of rice. The fitted model explained 75 per cent of the variation in yield in case of hybrid rice.

The estimated coefficients indicated that fertilizer, human labour and machinery labour influenced the yield levels in hybrid rice. Among them, the coefficient of human labour and machinery labour were of higher magnitude in case of hybrid rice indicating that the marginal efficiency of these two inputs was higher for hybrid rice. This implies that yields of hybrid rice respond more to these inputs. The positive coefficients for human labour and machinery labour indicate that there is still scope for expanding the use of human and machinery labour in hybrid rice cultivation. The positive coefficient of fertilizer input indicated that higher the level of fertilizer use, higher the yield of hybrid rice. Obviously, the availability of fertilizer at a reasonable price will help in pushing up the yield levels and consequently the production of hybrid rice.

Hybrid rice yield being human labour responsive, the availability of labour in the farm sector is an important determinant of hybrid rice adoption at the farm level. Owing to the greater availability of labour, smaller sized holdings gained more in terms of yield in case of hybrid rice cultivation as discussed in the preceding paragraphs. Further labour intensive character of hybrid technology is the major factor favouring its adoption on smaller sized holdings.

For inbred rice, the fitted model explained 22 per cent of the variation in yield. The estimated coefficients indicated that seed and human labour influenced the yield levels to a great extent. This clearly shows that yield of HYVs rice respond more to these inputs. The positive coefficients of these inputs indicate that there exists scope to expand the use of these two inputs in inbred rice cultivation. Among positive coefficients, the coefficient of manure turns out to be statistically significant both for hybrid adopters and non-adopters. This implied that greater use of manure would lead to increase in productivity of HYVs (inbred).

Input use pattern is furnished separately for hybrid and HYVs. Importantly seed rate (kg/ha) is significantly lower for the hybrid than for HYVs. This is because hybrids required only one or two seedlings per hill for transplanting. Seed rate for hybrids is 11.51 kg per hectare where as it is 68.57 kg per hectare for HYVs. In case of non-adopter more or less similar seed

rate is used. Organic manure use for hybrids was nearly 5 times higher than that for HYVs. The use of chemical fertilizer is 14.38 per cent higher than that for HYVs. In comparison with non-adopters, it is higher by 5 per cent. The number of pesticides sprays is relatively lower for hybrid varieties than HYVs showing hybrids relatively less sensitive to pest attack. But irrigation is almost the same for the hybrid and the inbred varieties. Labour use is significantly higher for the hybrid than for HYVs. Within the group of hybrid adopters the intensity of human labour use is about 168 days per hectare for hybrids as compared to 145 days per hectare for HYVs.

For non-adopters, it is 148 days for HYVs as against 168 days for hybrids as experienced by the adopters of hybrids. Bullock labour use in terms of days per hectare is significantly higher for hybrids than HYVs for the hybrid adopters those who cultivated HYVs along with hybrids. For non-adopters, bullock labour use for HYVs is marginally lower than that for hybrids.

Farm level data revealed that farmers had to incur higher labour for hybrids as compared to HYVs. Higher labour use associated with hybrid cultivation as compared to HYVs was mainly for transplanting the seedlings of paddy since it involved a cumbersome method of planting one or two seedlings per hill unlike multiple seedlings per hill in inbred varieties. Operation-wise labour use pattern indicated that labour requirement is highest in post harvesting operations followed by harvesting and transplantation operations respectively both in hybrids and HYVs.

However, more labour is used in transplantation operation for hybrids (34.84 days) as compared to HYVs (32.11 days). In addition for hybrid paddy, more labour is used for ploughing, spraying plant protection chemicals and for irrigation. More importantly, hybrid rice cultivation involves greater use of female labour in the transplantation operation including uprooting of seedlings in comparison with the cultivation of conventional varieties of HYVs or inbreeds. Hybrid rice cultivation is thus likely to generate additional employment opportunities for female workers in rural areas. Further operations associated with higher labour content involved more of hired labour as compared to family labour both in case of hybrids and HYVs.

During 2010-11 the average cost of production of hybrid rice worked out at Rs.28,887.40 per hectare while for inbred rice (HYVs) it was Rs.23,549.66. Among the components of total cost, expenditure on human labour formed the single largest item and accounted for 39.38 per cent and 46.82 per cent of the total cost for hybrid and inbred varieties respectively. Machinery charges accounted for the next most important item at about 16-17 per cent of the total cost in hybrid and HYVs respectively. The cost incurred on fertilizer was the next one which formed about 13 per cent of total cost for both hybrids and HYVs. Manure and fertilizer together formed about 19 per cent of the total cost in case of hybrids as against 17 per cent for HYVs. The cost of irrigation, seeds and pesticides were significantly higher in hybrid rice production. Cost of irrigation was 12.49 per cent of total cost in hybrid rice while it was 9.33 per cent for inbred (HYVs) rice. The seed accounted for 5.90 per cent of total cost for HYVs while it was 7.18 per

cent of total cost for hybrids. Pesticide use was significantly higher for hybrid rice. It was about 2.05 per cent and 1.07 per cent of the total cost for hybrid and inbred rice respectively. Pesticide use was significant for hybrid rice implying that hybrid rice varieties did not possess adequate resistance to pest and diseases and are more susceptible pests and diseases.

Evidently thus as recorded in 2010-11, the total cost of inputs was about 22.66 per cent higher for hybrids than for HYVs. The largest difference in cost items between the hybrids and the inbreds was on account of seeds, pesticides and irrigation charges. The total seed cost for hybrid varieties was 1.50 times that for HYVs. This was due to the large difference in seed prices of hybrid and inbred rice although the seed rate for the hybrids were substantially lower (about 6 times). The cost of hybrid seed per kg being much higher than that of HYV seeds of rice, discourages farmers from taking advantage of the hybrid technology unless it is compensated by additional yield gains. Notably the cost structure does not vary much over the years under study.

The net returns or profitability of any technology is the ultimate factor that determines the long run sustainability of its adoption by the farmers. During the year 2010-11 the farmers growing hybrid rice realised a gross return of Rs.67,583.51 per hectare while the gross return realised in inbred varieties was Rs.61,327.32. Thus the gross return was 10.20 per cent higher in hybrid rice cultivation. However the profit (net return) realised in hybrid rice and inbred rice was of the order of Rs.38,696.10 and 37,776.32 per hectare respectively. Thus the profit gain realised in hybrid rice production was only Rs.919.78 per hectare or 2.43 per cent over inbred varieties of rice. Consequently the benefit cost ratio was also lower in hybrid rice cultivation (2.34:1) in comparison with that for inbred rice (2.60 : 1). Inter-temporarily net return from hybrids over the reference periods has increased from Rs.35,549.76 per hectare in 2009-10 to Rs.38,696.10 per hectare in 2010-11. Correspondingly for inbred rice, the net return decreased from Rs.38,383.69 per hectare to Rs.37,776.32 during the same period. The net result has been increase in benefit cost ratio for hybrid rice cultivation from 2.24: 1 in 2009-10 to 2.34 : 1 in 2010-11. Correspondingly, there has been decline in benefit cost ratio from 2.63 : 1 to 2.60 : 1 during the same period.

What are the factors that accounted for the lower profit margin in case of hybrid rice cultivation? Of course the lower profit margin in hybrid rice cultivation is a matter of concern since the adoption of a new technology depends much on profitability. As can be seen, hybrid rice growers incurred additional costs for all the inputs. Hybrid rice growers incurred an additional expenditure of Rs.683.25 per hectare on seed alone. Similarly hybrid growers incurred higher expenditure on labour (Rs.352.68) per hectare for performing various cultural operations. More expenditure on fertilizer (Rs.647.29), irrigation (Rs.1410.28) and pesticides (Rs.339.81) also contributed to pushing up the cost of production of hybrid rice. Coupled with higher production cost was low market price realisation for hybrid paddy. On an average, during the

year 2010-11 the hybrid rice growing farmers realised a sale price of Rs.931.01 per quintal of paddy sold in the market which was lesser by Rs.8.45 per quintal realised for inbred rice. The product price difference was quite sharp during 2009-10 and during the year, price per quintal of hybrid paddy was lesser by Rs.29.13 compared with inbred rice. During the year 2010-11, hybrid rice was more profitable by Rs.919.78 per ha (2.43 per cent) than HYVs, while in 2009-10, the net return (profit) realized in hybrid rice cultivation was lower by Rs. 2833.93 per hectare as compared to HYVs.

Higher costs of production along with lower market price realization have contributed to lower profit margin of hybrid rice cultivation as compared to HYVs even with higher grain yield gain of 22.66 per cent for hybrid rice over inbred rice varieties. This calls for improvement in technology to reduce costs of cultivation and enhancing the quality attributes of hybrid rice.

The quality of grain is judged from the view point of three ratios viz. hulling ratio, milling ratio and head rice recovery ratio. It is evident that hybrids have grain quality features by and large on par with those of varieties of conventional HYVs. Hybrids have milling and head rice recovery ratios of 61 per cent and 54 per cent respectively. The corresponding figures for HYVs were estimated at 61 per cent and 55 per cent respectively. Over the years under study, the ratios remained unaltered. All these suggest that the parameters that primarily influence the adoption of hybrid rice cultivation are almost same across hybrid and inbred varieties of rice.

The usual notion is larger the volume of the produce is, larger is the output marketed, Increase in receipt increases marketable surplus and stimulate increase in actual marketing. Evidently for hybrid rice, volume of output sold is higher in comparison with the receipt of paddy per farm. While, the percentage of paddy output sold was 75.24 per cent in the case of hybrid rice, it was 69.91 per cent for conventional HYVs during the year 2009-10. Similar is the phenomenon observed in 2010-11. Across size classes of land holdings, the proportion of output sold increases unmistakably with increase in the size of holdings. During the year 2009-10, in the case of hybrid rice, the proportion of output sold rose from 71.14 per cent in the group below 1 ha to 85.22 per cent in the group 2-4 hectares. During the year 2010-11, proportion of output sold increased from 74.93 in below 1 ha group to 94.46 per cent in the size group 2-4 hectares. The same tendency is noticeable in the case of HYV rice for the years under study where proportions of output sold is consistently on the rise with the increase in the size of holdings.

In case of hybrid non-adopters, of the total output, 71.52 per cent was sold during the year 2009-10 which, however fell to 68.92 per cent in 2010-11. Across size classes of land holdings, the proportion of output sold increased with the increase in the size of holding.

The price fetched in the market for hybrid paddy grain was lower as compared to inbred varieties of rice during the year 2009-10. However, during the year 2010-11 hybrid rice received somewhat higher price in comparison with inbred varieties of rice. On an average, during the

year 2009-10 the hybrid rice farmers realised a sale price that was Rs.872.90 per quintal of paddy sold in the market as against Rs.881.63 per quintal for HYVs. During 2010-11 price fetched by the farmers was relatively lower both for hybrid and inbred rice with a marginally higher market price realization for hybrid paddy (Rs.863.71) as compared to HYVs (Rs.856.05).

In case of sales of husked paddy of the total outturn of hybrid rice, only 4.06 per cent was sold in the market during the year 2009-10. The corresponding proportion of output of husked paddy sold in the market was estimated at 2.03 per cent for HYVs. Similarly for hybrid non-adopters the comparable figure was 3.20 per cent. What follows therefore is that processed paddy is marginally sold in the market.

Size-group wise analysis shows that in case of hybrid rice, bigger sized holdings sold relatively higher proportion of outturn of rice as compared to smaller sized holdings. With regard to price received for milled rice, it is found that on an average hybrid adopters realized a sale price of Rs.1440 per quintal for hybrid rice against the corresponding sale price of Rs.1520.91 for HYVs. Thus during the year 2009-10 hybrid adopting farmers realized a sale price of hybrid rice that was Rs.80.91 (5.62 per cent) lesser per quintal of rice sold in the market compared with inbred rice.

During the year 2010-11, the proportion of outturn of rice sold in the market accounted for 4.68 per cent, in case of hybrid rice which was marginally (0.62 per cent) higher than what it was in 2009-10. For HYVs the corresponding proportion accounted for 2.80 per cent which is again marginally higher by 0.77 per cent as compared to the previous year 2009-10. On an average, in case of hybrids, a greater proportion of milled rice is marketed as compared to HYVs. Hybrid rice adopters received market price of Rs.1582.24 which is lesser by Rs.14.49 per quintal of rice sold in the market as compared to inbred rice. On a closer scrutiny of the figures, it appears that the proportion of milled rice sold in the market bears a fairly stable inverse relationship with the size of holdings both in the case of hybrids and HYVs. The relationship holds similar to the one observed in the previous year 2009-10. It is thus possible to infer the inverse relationship between the size of holdings and the proportion of rice output sold.

Agricultural produce usually fetches lower price if sold just after the harvest and a higher price if sold during the lean period. Thus the account of sales will be incomplete without a picture of the seasonal flow of marketing. It has been revealed that hybrid adopters sold relatively greater proportion of paddy output immediately after the harvest in the months of October and November, although the marketing was spread over the months. This is discernible both in the case of hybrids and HYVs, which indicated that immediate cash needs compelled them to sell immediately after the harvest. During the year 2009-10, across months, the proportion of sales in the months of October and November ranged between 12.75 and 19.52 per cent for hybrid paddy. Almost similar proportion of sales occurred in the months of October and

November in the case of HYV paddy. For non-adopters, the corresponding proportion of sales of paddy accounted for 14.52 per cent and 20.97 per cent respectively. During the year 2010-11, in case of hybrid adopters, 14.06 per cent and 18.82 per cent of total annual sales of hybrid paddy occurred in the months of October and November as against the corresponding proportions of 14.15 per cent and 18.40 per cent respectively for HYVs. The proportion of sales took place in each of these two months for non-adopters accounted for 15.52 per cent of total annual sales. The proportion of sales in the lean months viz. during March, April and August was rather small in case of hybrids and HYVs during both the reference years. This is indicative of the fact that sample farmers (both hybrid adopters and non-adopters) have not been able to take advantage of the high prices ruling at this time of the year. In contrast, greater proportion of sales in the months of October and November was mainly effected by the small sized landholders who compelled to sell their produce to meet their bare requirements.

With regard to hybrid adopters' awareness about hybrid rice technology, the qualitative questions asked to sample hybrid growers included the source of knowledge about hybrid rice technology, whether frontline demonstration programme were organized whether the government organized, training programme, whether farmers had participated in the programmes etc. When asked how has he become aware about hybrid rice technology, 71.25 percent of the sample farmers reported extension worker of the state department of agriculture as their source of awareness about the hybrid rice technology. The other sources were reported to be news paper (10.00 percent) and cultivators (18.75 percent). When asked whether front line demonstration programme was conducted in the area, majority of the respondents (65 percent) reported that frontline demonstration programme was organized by the government in order to create awareness about hybrid rice technology. With regard to their participation in the demonstration programme, 70 per cent of the farmers reported affirmative. Rice hybrids, demonstrated for the popularization hybrid rice cultivation included KRH – II (as reported by 44 per cent) having yield advantage of 80 per cent over HYVs, DRRS-II (38 per cent) with 70 percent yield advantage and PAC-835 (36 per cent) with 65 percent yield advantage. Asked whether the government organized training programme for the farmers, cent percent of the farmers held the view that training programme was organized by the government and of them 73.75 per cent reported their participation in the training programme, majority of those being one day duration.

Easy availability of seeds of reasonable prices in right time is one of the pre conditions for the promotion of new variety of technology in any crop. Thus regarding accessibility to hybrid seed input, information were asked from the farmers regarding sources of seed, quality of seed, yield gain from hybrid seed and replacement of seed over the years. One of the easily available policy options on the part of government to promote hybrid rice cultivation is subsidizing the seed supply at the initial stage of adoption. Thus when asked what is the usual

source of seed for the farmers a total of 77.50 percent of farmers reported government supply as source of seed. However, seeds available during planting time were reported only by 41.25 per cent of farmers. Importantly seeds were not available at reasonable price. It was only 8.75 per cent of farmers who reported availability of seeds at reasonable price. As far as quality of seeds is concerned, a total of 48.75 per cent of farmers reported to be satisfied with the quality of seeds. Asked whether hybrid seed is easily available in the area, only 36.25 percent of farmers reported affirmative and from the rest 63.75 per cent of farmers, negative responses were received. In response to the question related to yield superiority of hybrid rice over conventional HYVs, hybrid adopters unanimously (100.00 per cent) reported that hybrid seed yields better results than the inbred seeds. A total of 11.25 percent of respondent farmers reported yield gain of 10 – 15 percent over conventional inbred varieties. Yield gain of 15 – 20 percent in hybrid rice production was reported by 43.75 per cent of farmers. Yield realized in hybrid rice higher by 20 percent and above as compared to inbred (HYV) rice was reported by 45.00 percent of farmers. The adoption of hybrid seeds prevented traditional practice of saving and exchanging of seeds. When asked how often did they replace hybrid seed varieties, 80 percent of the hybrid adopters indicated that they are replacing seeds every year while the rest 20 percent reported replacing seeds every alternative year.

We may thus infer from the above analyses that the higher yield potential of hybrid rice is clearly demonstrated in farmers' fields. This technology has good potential to increase rice yield provided quality seeds are made available at reasonable prices in right time. Although, government is the major source of supply of seed, poor germination of seed makes seeds costlier resulting in enhancement of cost of cultivation. Higher seed cost in turn reduces the profitability of hybrid rice cultivation. Thus the availability of quality hybrid seed at reasonable price is crucial to the success of hybrid rice technology. For the popularization of hybrids there is a case for government sector intervention in quality seed production and distribution.

All the sample hybrid adopters unanimously reported that they have used fertilizer input in hybrid rice cultivation. Asked whether they have received information from any source regarding what to use and the required doses, a good majority of the farmers (87.50 percent) reported affirmative. A good proportion (84.15 percent) of sample farmers also reported to have used fertilizer input in recommended doses. Of the sample farmers those who have not used fertilizer in recommended doses, cited lock of knowledge (53.57 percent) and financial bottlenecks (43.43 percent) as the reasons for non-application of recommended doses of fertilizer. Easy availability of fertilizer is reported by cent percent of the farmers, the source of fertilizer being private traders as reported by them. When asked whether hybrid seeds require more fertilizer than inbred seeds, all the sample hybrid adopters unanimously reported

affirmative. Overall, hybrid adopting farmers have good access to fertilizer input as revealed from the responses relating to access to fertilizer input.

Sometimes it is argued that hybrid adapts well to varying agro-climatic situations and have resistance to pests and disease attacks. Farmers' level responses received in course of this study do not support this argument. Asked whether hybrid rice crop are more susceptible to pests and diseases, a good majority of the farmers (86.25percent) reported that hybrid rice varieties are more susceptible to pests and diseases. Notably however 86 percent of the sample farmers reported to have used pesticides. Of those who had not applied pesticides, cent percent reported lack of money as the reason for non-application of pesticides. It is encouraging to note that majority of the farmers know the correct way of using and doses of plant protection pesticides in general and for hybrid seeds in particular. When asked whether farmers know the correct does of pesticides for hybrid rice varieties, a total of 81.25 percent of farmers reported affirmative. All the sample farmers unanimously reported that pesticides are easily available in the area.

A total of 81.25 percent of farmers were of the view that hybrid rice cultivation is highly sensitive to crop management practices-use of key inputs and time bound operations. Also all the sample farmers believe that the extent of yield loss due to pests and diseases for inbred variety is lower as compared to hybrids. Thus farmers' level responses were obtained regarding hybrid adopting farmers' accessibility to credit. When asked whether they would require more credit for using hybrid seed, a good majority of respondents (73.25 percent) reported to be negative. Of those who require credit, 54.17 percent reported that they get credit from the institutional sources, either commercial banks or co-operatives. Farmers in major (66.67 percent) receive credit from commercial banks. Farmers those who are not availing of credit encountered one major problem of procedural formalities as perceived by 76.39 percent of farmers apart from the problem of collateral (23.61 percent).

A frequently raised concern on the spread of hybrid rice is the acceptability of the quality of hybrid rice grain among consumers. Consumer acceptance is the ultimate factor that determines the price of the product as also marketability of the product. Thus to study the issue of marketing farmers' level responses were collected regarding their perception about marketing of hybrid rice. Asked whether they face problems in marketing of hybrid rice produce, all the hybrid adopting farmers unanimously reported that they face problems in marketing of hybrid rice. Lack of consumer demand for hybrid rice grain, lower head rice recovery and ultimately lower price received in the market were the major problems faced by the hybrid growers. All the sample farmers reported these problems in the field of marketing of hybrid rice.

Other problems reported by the adopters included poor cooking and keeping quality (83.75 percent), poor grain quality and as a result lack of market acceptance (86.25 percent),

traders not accepting hybrid rice grain lack of demand from milliers and consumers (83.75 percent) and more broken rice after milling (56.25 percent).

The responses of farmers regarding overall perception of hybrid rice cultivation were elicited. When asked whether there is any yield gain from cultivation of hybrids over the best popular inbred rice varieties, all the sample farmers (cent percent) unanimously reported that there was yield gain in hybrids over connectional HYVs (inbred). Also hybrid rice production was reported to be profitable as conceived by 78.75 percent of sample farmers. Hybrid rice varieties till now are inferior to currently available inbred varieties. Nearly 96 percent of the sample farmers reported that grain quality of hybrid rice is poor compared with the grain quality of the existing popular HYVs of rice. A total of 63.75 percent of farmers felt hybrid rice is not suitable for their taste. Many farmer respondents (81.25 percent) said hybrid rice has poor cooking quality. High stickiness of cooked rice is also reported by majority of the farmers (85.00 percent). Asked whether hybrid rice grain is acceptable to traders and millers, a total of 80.00 percent of farmers respondent reported that traders and millers do not want to accept hybrid rice grain from them on account of its poor grain qualities. Farmers are however convinced with the economic viability of hybrid rice cultivation. A good majority (75 percent) of the farmers reported that they are convinced with the economic viability of hybrid rice cultivation. Those who are not convinced cited reasons comprised of less/ non-availability of seeds and higher cost of cultivation (25.00 per cent), more susceptible to pest and diseases (15.00 per cent), poor quality of grain (35.00 per cent) and poor knowledge about hybrid cultivation, technology and management (25.00 per cent). Among hybrid growers 7.50 per cent were not in favour of continuing cultivation of hybrid rice. A total of 92.50 of hybrid adopters expressed their intention to continue cultivating the hybrid variety rice mostly (92.50 per cent) because of higher yield of hybrid rice. Some of them (31.25 per cent) are expecting new hybrids with better quality in future. In short, analysis of farmers' overall perception about hybrid rice cultivation hinted that future research on hybrid rice development should focus on improvement of grain quality besides yield in the next generation hybrids.

It has been found that 35 per cent of sample non-adopters indicated that they have not heard any of the new hybrid varieties of rice. However, a total of 65 per cent of the non-adopting farmers reported that they have heard about few varieties of hybrids and such varieties are KRH – II as reported by 67.86 per cent of farmers DRRS – II (53.57 per cent) and PAC – 835 (69.05 per cent). When asked whether they have heard of the government's hybrid rice promotion programme, nearly 55.00 per cent of the farmers reported affirmative. Asked whether they have seen any standing rice crop of hybrid variety, negative responses were received from a total of 55 per cent of non-adopting farmers. 35 per cent of the sample non-adopters reported that nobody had suggested to grow hybrid variety of rice on their farms. Among those (65.00 per

cent) who received suggestions from any source, majority (54.77 per cent) reported that they have received suggestions from Agricultural Extension Officer (AEO) of the state department of agriculture. The next in importance from whom suggestion was received was village level worker (VLW).

A total of 70 per cent of the sample non-adopters had expressed their willingness to grow the hybrid variety of rice next year. According to non-adopting farmers, lower price of hybrid rice as compared to inbred variety is the major (75 per cent) reason for non-adoption of hybrid rice. Among other reasons, 35 per cent of the non-adopters reported that they are completely unaware about the hybrid seed variety, another 35 per cent of the non-adopting farmers reported that they are not at all aware about the government assistance for the promotion of hybrid seeds, non-availability of seeds at all is reported by 15 per cent of non-adopters, a total of 20 per cent of non-adopters reported that seed is too costly, reportedly 10 per cent of the farmers are not convinced that the seed is of high quality, a total of 20 per cent of non-adopters are not convinced that hybrid yield is sufficiently high, higher yield gain but lower profitability of hybrid rice is reported by 10 per cent of non-adopters, hybrid rice cultivation involves higher risks as reported by 25 per cent of non-adopters and hybrids are not insects, pests and disease resistant variety as reported by 25 per cent of non-adopting farmers. A total of 30 per cent of non-adopters reported that the extent of yield loss due to pests and diseases is higher for hybrids. Also all the non-adopting farmers unanimously reported that they are ready to accept new hybrid rice varieties in future considering higher yield potential.

In short, the main reasons for non-adoption of hybrids were lower price of hybrid rice as compared to inbred, poor extension activities by the government for the popularization of hybrids, un-availability of quality hybrid seed, higher seed cost, higher yield loss for hybrids due to pests and diseases and higher risks associated with hybrid rice cultivation. Though higher seed cost is considered a constraint, it was given the least importance compared with other constraints. The foremost constraint confronting the diffusion of hybrid rice technology is poor grain quality and as a result lack of market acceptance leading to lower price fetched for hybrid rice as compared to inbred variety.

7.5 Policy Implications

Hybrid rice technology is considered as a readily available option to shift the yield frontier upward where rice yields are either stagnant or declining. Although this technology has got potential to increase rice yields, it has not been accepted by the farmers on a larger scale due to various constraints as discussed above. The adoption hybrid rice is not being popular in the farmers' fields largely because of inferior grain quality compared with the popular conventional

HYVs (inbred). A few implications from the findings of the present study are drawn for policy interventions.

Higher yield potential alone does not induce farmers to adopt hybrid variety as shown by the experience of hybrid rice growing farmers. It is the profitability gains from production of hybrid that would motivate farmers, particularly, Commercial farmers to replace existing varieties of HYVs with new hybrids. Hybrid rice would not make the desired impact on the rice economy unless consumer demand for hybrid rice grain is created through grain quality improvement. Therefore hybrid rice research programme need to be reoriented towards the refinement of this technology with a focus on breeding for high value varieties of hybrids.

Hybrid rice is still at an introductory stage in the state of West Bengal. Still farmers devoted more area to inbred varieties. None of the farmers had previous experience in hybrid rice cultivation. Of the 80 farmers 58 (72.50 per cent) in 2010-11 and 56 (70.00 per cent) in 2009–10 obtained seeds from public source on full subsidy and the remaining from private source on payment. Thus subsidizing the seed supply for the popularization of hybrid is the policy option followed by the government. However, subsidy on hybrid seed would not add much extra value to hybrid rice production. What is crucial is the supply of quality seeds. The present study brings out that although, many of the farmers received seeds from government sources, quality hybrid seeds are not availed of by the farmers. Moreover seeds were not available during planting time and also at reasonable price. As a matter of policy it is thus essential to ensure easy availability of quality seeds in right time to achieve the overall goal of spreading of hybrid rice on a larger scale.

A critical assessment of hybrid adopting farmers' experiences with regard to hybrid rice adoption revealed that consumers perceive hybrid as inferior to inbred in respect of grain quality. Many of them (63.75 per cent) felt hybrid rice is not suitable for their taste. Majority of the respondents said hybrid rice has poor cooking quality and high stickiness of cooked rice. Obviously, all these would have useful implications on hybrid rice research and strategy and development which should lay more emphasis on improvement of grain quality apart from the improvement in yield. Research infra-structure should be strengthened for evolving farmer-consumer acceptable varieties of rice hybrids.

Considerable progress has been made in the development and release of new hybrids since the development and release of the first hybrids for commercial cultivation in the mid 1990s. Farmers are however still not convinced with the economic superiority of hybrid rice over the inbreds (conventional HYVs). Rice breeders should therefore develop and evolve input efficient hybrids to popularize the cultivation of hybrid rice. Higher cost of production and

lower market price realization has contributed to lower profitability of hybrid rice cultivation even though yield (19-22 percent) was higher. This calls for improvement of technology to reduce cost of cultivation and enhancing the quality attributes of hybrid rice.

Selected References

1. *Boyce, James K (1987): 'Agrarian Impasse in Bengal: Institutional constraints to technological change', Oxford university press, Oxford.*
2. *--------- (2003): 'Hybrid Rice in Andhra pradesh: Findings of a survey', Economic and political weekly, June21, 2003.*
3. *Chengappa, PG, Aldas Janaiah and MV Srinivasa Gowda: 'Profitability, of Hybrid Rice Cultivation: Evidence from Karnataka,' Economic and political weekly, June21, 2003.*
4. *Hossain, Mahabub, Aldas Janaiah and Muazzam Husain (2003): 'Hybrid Rice in Bangladesh: Farm-level performance', Economic and political weekly, June21, 2003.*
5. *Janaiah, A (2002): 'Hybrid Rice for Indian Farmers: Myths and Realities', Economic and political weekly, Vol 37 (42), October 19, 2002.*
6. *Janaiah, A, M I Ahmed and B C Viraktmath (1993): 'Hybrid Rice: An opportunity for Food Security in India', YoJana, Vol 37, No.20.*
7. *Khasnabis, Ratan (2008): 'The Economy of West Bengal', Economic and political weekly, December 27, 2008.*
8. *Kumar, P and Mark W Rosegrant (1994): 'Productivity and sources of Growth for Rice in India', Economic and political weekly, vol 29, No.53.*
9. *Mahendra Dev, S (1987): 'Growth and instability in Food grains production: An inter-state Analysis', Economic and political weekly, September 26, 1987.*
10. *Maji C C and T Haque (1995): 'Productivity and sources of growth for Rice in India: A few Comments' Economic and Political Weekly, Sept 23, 1995.*
11. *Ramasamy C, Aldas Janaiah, K N Selvaraj, and M Hossain (2003): 'Hybrid Rice in Tamil Nadu: Evaluation of Farmers' Experience' Economic and political weekly, June 21, 2003.*
12. *Rawal, Vikas and Madhura Swaminathan (1998): 'Changing Trajectories: Agricultural Growth in West Bengal, 1950 to 1996' Economic and political weekly, October 3, 1998.*
13. *Saha, Anamitra and Madhura Swaminathan (1994): 'Agricultural Growth in West Bengal in the 1980s: A disaggregation by Districts and crops' Economic and political weekly, March26, 1994*